

NUTRITION AND DIETETICS

(With Indian Case Studies)

Fourth Edition

About the Author



Shubhangini Joshi is a postgraduate in Foods & Nutrition from SNDT Women's University, Mumbai, and has been teaching subjects including Food Analysis, Food Chemistry, and Food Additives in the Department of Food Technology of her alma mater, Premlila Vithaldas Polytechnic for over three decades. Presently, she is the In-Charge of this department, besides having served as the In-Charge Principal. She served on the Senate of SNDT Women's University for two consecutive terms. Prof Joshi also holds a postgraduate diploma in Education Management from this university.

In addition to teaching, Prof Joshi has written several articles on topical issues related to food, nutrition, and consumer awareness for leading magazines. She is also associated with Mumbai Grahak Panchayat (MGP), a consumer-protection organization, and is a member of Consumers International (UK). She has given lectures related to Consumer Awareness and written several articles in *Grahak*, a magazine published by MGP. She has featured in several programmes on All India Radio and television channels of Mumbai. She has also interviewed eminent doctors as well as given talks on careers for students for All India Radio, Mumbai.

Prof Joshi is keenly involved in community activities, especially those concerned with self-employment and empowerment of women. She has also actively participated in developing foods aimed at improving the nutritional status of malnourished children as well as children affected by HIV and AIDS. She has been striving to emphasize the importance of nutrition awareness and nutrition intervention in HIV and AIDS.

She has participated in courses related to Continuing Education and also coordinated a course for polytechnic teachers in Documentation Technology.

Several students have benefited from her guidance on projects based on Nutrition and Food Technology; some of these projects have been well received at ICFOST, a national platform for Food Technology and Nutrition. She has a long-standing experience in interaction with food industries.

Prof Joshi was invited to participate in an international summit on 'Children, Poverty and Violence' in Montreal, Canada. She has also participated in the sub-regional workshop on 'Nutrition, Food Safety and Biotechnology' for SAARC countries. She has presented a paper at the national seminar on 'Malnutrition: Issues and Concerns', jointly organized by SNDT Women's University, Narotam Sekhsaria Foundation and Directorate of Health Services, Govt of Maharashtra. She has been a resource person in the National Symposium on HIV and AIDS organized by Harvard Medical International and Wockhardt. She has co-authored posters in HIV/AIDS presented at the International Congress of Nutrition at Thailand and Africa.

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Fourth Edition

Shubhangini A Joshi

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*Dedicated to my husband whose inspiration,
encouragement and guidance made
it possible to accomplish this task
which was otherwise difficult for a
working homemaker!*

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Foreword to the Fourth Edition



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It gives me great pleasure to write the foreword for the fourth edition of the book 'Nutrition & Dietetics' by Shubhangini Joshi.

India had a green revolution. What it needs now is not only an evergreen revolution but also a nutritional revolution. In that sense, I would say that the first edition of the book having been published in 1992, the author had fully understood the needs of the hour.

The book deals with the fundamentals of nutrition, with some emphasis on fitness and sports. The clinical aspects as applied in Dietetics/Therapeutic Nutrition are presented in a lucid manner. The grave problem of Malnutrition in India are being tackled with various Programs. They are dealt with in some depth. A good discussion on Food Commodities, their Safety aspects and various Food Laws follow. Various food handling practices are then discussed with some valuable insights into the ways of conserving the nutrients in foods by following good manufacturing practices.

India has always been a land of a variety of dietaries. I am very happy that the author has given due recognition to this fact. She has also given emphasis on the lesser used millets like Jowar, Bajra and Ragi (Nachni) their due attention.

Food security has gained a lot of attention all over the world and it is important that every individual consumer should be food secure. Not only does a person have the right to food but he must also have the right to the correct type of food. The problems of Over nutrition, Diabetes, Cardiovascular diseases and such other lifestyle diseases also have to be addressed to avoid them from becoming serious Public Health issues.

The author, in this, new edition, has paid special attention to Nutrigenomics or Nutrigenetics, which may help in alleviating the problems of Lifestyle diseases In future. She has paid special attention to aspects like breastfeeding for mothers especially those affected by HIV/AIDS as well as management of diabetes during pregnancy and lactation The New Recommended Dietary Allowances as per NIN/ICMR are included.

The book is replete with ready reckoner tables as well as quick references, solved case studies, review questions for students as well as the layman. I hope the book will enable not only students but also the allied healthcare and nursing professionals to better understand the Science and Practice of Nutrition Care.

I congratulate the publishers McGraw Hill Education Pvt. Ltd. for having reposed their faith in the author and consistently bringing out the editions revised with the latest information for the seeker.

The book, first published in 1992 has stood the test of time. This in itself is proof that the users have received it very well. My congratulations to the author for writing a book with such a longevity and making such a valuable contribution to this vital area, which will have a bearing on the much needed nutritional revolution in India.

Dr. Raghunath Mashelkar

Foreword to the Third Edition

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निदेशक

Dr. B. Sesikaran, MD
Director

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Dt. 3rd March, 2009

Despite a plethora of books on Nutrition and Dietetics, the fact that this particular book has stood the test of time with several reprints confirms its success. Nutrition and Dietetics are related, but many universities recommend them as varied subjects in their syllabus. Nutrition, as a subject, spans from Molecular Mechanisms to Epidemiology, from Physiology to Pharmacology, from Biochemistry to Clinical Medicine. Dietetics is the integration and application of Principles of Nutritional Science, Biochemistry, Physiology, Food Systems Management, Behavioral Science and Social Science with the objective of attaining or sustaining the health of individuals.

It is imperative that students have access to updated and comprehensive information relevant to the subject. The author has fully succeeded in addressing the needs of the students. Basic nutrition and clinical nutrition are dealt with equal efficacy. The chapter on 'Microorganisms and their applications in foods' offers unique insights. Food safety, an important area, is addressed appropriately. The appendices are invaluable resources for the readers.

Overall, this text is a ready reckoner, suitable not only for students but also for practising dietitians and nutritionists. The author, Ms Shubhangini Joshi and the publisher, McGraw Hill Education (India), together deserve a pat on their back for this contribution of an excellent textbook.

Dr B Sesikaran, MD
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Foreword to the Second Edition

This book on Nutrition and Dietetics is a timely contribution since all over the world, there is increased realisation on the critical linkages between nutrition and a productive and healthy life. Maternal foetal undernutrition has particularly serious consequences since this has an adverse impact on brain development of the child. Therefore, there is need to adopt a whole lifecycle approach to nutrition, starting with pregnant women and infants and extending up to old and infirm persons.

The first chapter of the book provides a valuable introduction to the multi-faceted nature of scientific nutrition. The book not only deals with the basic and applied aspects of dietetics but also covers important areas like nutrition and specific health problems like diabetics and ulcers. The approach is a food-based one and not one based on drugs. Therefore, this book will be very valuable to all concerned about building a community-centred nutrition security system. I, therefore, hope it will be widely read and used, particularly at the village level. Based on this book, a nutrition toolkit can be developed which will be of special value to the one million women members of elected Panchayats.

We owe a deep debt of gratitude to Ms Shubhangini Joshi for this scholarly book. Thanks are also due to McGraw Hill Education (India) for the user-friendly manner in which the book has been published.

M S Swaminathan
UNESCO Caustean Chair in Ecotechnology
and
Chairman, M S Swaminathan Research Foundation, Chennai

Preface to the Fourth Edition

Nothing can be more fulfilling than to see your work well accepted for more than two decades by the users, in my case students, teachers, doctors, nutritionists, dieticians, and, above all, the common person. Today, there are so many self-proclaimed diet ‘experts’ that the layperson is left in a state of confusion, what with some foods becoming ‘miracle’ foods overnight and the same foods becoming ‘dangerous for health’ in a short span of time! In the light of this, the book has stood the test of time for over 22 years because of the authenticity of information it contains.

The users and reviewers of my book inspire me to improve the knowledge in the book and I am greatly indebted to them for this. I hope they will continue to do so in future.

RATIONALE OF THE REVISED EDITION

The field of Nutrition and Dietetics is experiencing much more awareness, new information, and new developments. Some information becomes obsolete and needs to be revised. The book has thus been restructured and redesigned to update it with the current developments in the subject area. It is particularly well suited for students of Bachelors in Foods, Nutrition and Dietetics, BSc (Biochemistry, Nursing, Nutrition, Home Science, Food Service Management & Dietetics) Bachelors in Hotel Management and Catering Technology, MBBS, BA (Home Science) as well as Nutrition and Dietetics courses offered by IGNOU and other open universities. It is also useful for persons pursuing courses in Sports Nutrition and Fitness. Real-life case studies, interspersed with review questions, give useful insights into the field of nutrition and are useful for self-understanding.

SALIENT FEATURES

- Encompasses all the fundamentals of the subject—Role of Nutrients, Balanced Diet, Diet Therapy for Cardiovascular, Kidney, and Liver Diseases; Food Safety Measures
- Case Studies for students, teachers, practicing nutritionists and dietitians
- Use of tables to facilitate various concepts in nutrition
- The chapter on ‘Nutrition in HIV and AIDS’ is a special addition to this book, which will enable students understand the health and nutritional problems associated with this disease as well as the strategies for treatment
- The Appendices and Glossary serve as ready reckoners for students and make it a valuable reference guide
- Pedagogy includes
 - 10 Appendices on Statistics and Guidelines like RDA Exchange List, Standard weights and measures, ICMR Data on Sports Nutrition, Statistical Data on Malnutrition
 - More than 250 figures and tables
 - More than 175 Review Questions
 - About 100 Objective-Type Questions

NEW TO THE EDITION

The Recommended Dietary Allowances (RDAs) have been revised by ICMR and are included in this edition. The fast-emerging field of Nutrigenomics has been added. Disadvantages of breastfeeding vs. bottle-feeding are given more exhaustively; and the effects of fast foods on health are explored in-depth. Diabetes is on the rise and is emerging as one of the prominent lifestyle diseases in India. New information for nutritional management of diabetic mothers-to-be and pregnant diabetic mothers is included. Other problems in pregnancy such as pica, gestational diabetes and pre-eclampsia have also been dealt with in this edition. A new note on causes of high blood pressure is included. Updated information in the field of sports nutrition such as effective hydration and pre-event meals is given.

In Section II, the Health Care Team in a hospital setting is elaborated. New BMI Classification (as per WHO/NIH) is given. The chapter on diabetes mellitus has been revamped to a great extent, with inclusions such as alcohol guidelines for diabetics, medicinal plants useful in diabetes, etc. A brief note on lactose intolerance and cancer-fighting foods is also added.

WEB SUPPLEMENTS

The web supplements can be accessed at <http://highered.meducation.com/sites/9339220153> and contain Review Questions and Objective Type Questions.

USE OF TECHNOLOGY

In bringing out the fourth edition, the publishers and I have taken advantage of recent technological developments to create a wealth of useful information not present in the physical book. For students using **smartphones** and **tablets**, scanning **QR codes** located within the chapters gives them immediate access to more resources like **case studies**. Hence, the new edition is more in line with the digital revolution that we are experiencing now.



For the solution, just scan the QR code given here OR visit <http://qrcode.flipick.com/index.php/234>.

Also check out the MCQ's related to this case in the next QR code OR visit <http://qrcode.flipick.com/index.php/305>.



ACKNOWLEDGEMENTS

I am greatly indebted to Hon. Dr Raghunath Anant Mashelkar, former Director General of CSIR, who led India's crusade in the arena of Intellectual Property Rights, for having spared his invaluable time to write the foreword to my 4th edition. I consider myself blessed by the great contributors in the field of science and technology such as Dr M S Swaminathan, Dr B Sesikeran and now Dr R A Mashelkar, who have written the forewords to my 2nd, 3rd, and 4th edition, respectively.

The National Institute of Nutrition and ICMR have been kind in permitting me to use the information from their publication 'Nutritive Value of Indian Foods' edited by Dr C Gopalan, B V Rama Sastry, and S C Balasubramanian and revised and updated by B S Narasinga Rao, Y G Deosthale, K C Pant, and others. I am grateful to the World Health Organization for permitting me to use the data which is so important and relevant for my book.

The encouraging response of the users and detailed feedback of the reviewers of my book has continued to inspire me and kept me going forward in improving my work ever since the book was first published in 1992.

I am very thankful to Vibha Mahajan, Shalini Jha, Smruti Snigdha, Renu Upadhyay, Anjali Razdan, Sohini Mukherjee of McGraw Hill Education (India) and their entire team associated with printing the fourth edition of the book. Likewise, I am also grateful to the following reviewers for giving me useful suggestions:

Sheeba Jeyaraj

*Women's Christian College, Chennai,
Tamil Nadu*

Anooja Thomas

CMS College, Kottayam, Kerala

I owe special thanks to my family members who have stood by me in the entire process of bringing out this fourth edition. My daughter, Jidnyasa, helped in computerization of the text matter to a very great extent and lent her expertise in going through the text and fine-tuning it. My husband, Dr Ashok Joshi, has been a great source of strength ever since the first edition. The elders in my family have been a constant source of encouragement with their blessings in my endeavour.

FEEDBACK

Every care has been taken to make this book error free. However, readers are welcome to communicate constructive comments and point out mistakes in the text.

Shubhangini Joshi

PUBLISHER'S NOTE

McGraw Hill Education (India) invites suggestions and comments from you, all of which can be sent to info.india@mheducation.com (kindly mention the title and author name in the subject line).

Piracy-related issues may also be reported.

Preface to the First Edition

This book is written mainly for the undergraduate students of nutrition but it is expected to be valuable for all those who need basic training and introductory course in nutrition and dietetics. Health-conscious people, with or without a background of science, can gain an insight into this interesting subject related to our daily life.

This book is not for experts or students doing their masters with specialisation in this subject. It is not meant to be used as a standard reference book for nutrition or menu-planning for dietetics. It is meant to illustrate mainly the general principles of nutrition and diet therapy as well as the practical aspects involved in nutritional planning and management.

Each individual's dietary requirements differ from those of another because of many factors. Planning a diet of any kind for an individual calls for attention to several major and minor aspects. Some of these include age, sex, height, weight, cultural, social and economic background, mental and emotional state, food habits, nature of work, individual likes and dislikes towards foods, climatic conditions, family and medical history including genetic constitution or make-up with specific reference to congenital defects.

This shows that serious and scientific diet planning needs proper consultation and advice from an expert in the field.

Food is defined in various ways depending on the scientific, technical or legal requirement (e.g., food as defined by the Prevention of Food Adulteration Act, 1954).

I would like to define food as follows: "Food is a group of substances consumed normally in response to the stimulus of hunger and most of which is digested as well as assimilated in the body for growth and maintenance."

Experts may find this definition deficient or incomplete in one or more ways, but it must be noted that some philosophical outlook is imbibed in it. Everything that we eat is not to be considered as food. Food can qualify as a nutrient only when it nourishes the body. Food in excess, i.e., over and above your nutritional needs, can become a poison. Some people do not include or cover water in the definition of food. Can food exist without water? Water is an integral part of food right from the molecular level. Our body is made up of the food that we eat, and hence, acquires as well as reflects the qualities which are characteristic of the nature of food consumed.

In India, it is culturally imbibed to respect food as God's gift and the act of feeding is treated as an essential ritual rather than a daily routine. Voracious eating and wastage in the plate is discouraged. Disrespect towards food invites diseases, disabilities and debilities. Students ought to understand these very basic, fundamental, qualitative differences present, deeply buried at the root level of this science. Generalised, superficial concepts clash with these facts and contradict the common beliefs propagated through partial or incomplete education. Toxicity cases due to hypervitaminosis or excess nutrient and minerals and other such complications are the result of incomplete knowledge and its blind practical application, though a few may be accidental.

Food and feeding are one of the most lightly treated but important aspects of our life. Though it is well known that food is a saviour, but it can also be a killer, it is not given the attention it deserves. Of late, some signs of reversal in this trend have

been noticed. This book has been inspired with the hope of enhancing this awareness in the minds of the readers. This will help them cultivate good habits of proper food choice and dietary attention. This will go a long way to achieve and enjoy good health and physique.

There is a wonderful element of instinct in human beings for selecting their food. This has been experimentally proved in children of very young age. The increase in age and so-called knowledge blunts this edge of natural power. Having lost this natural wisdom, we need to take the help of external scientific knowledge from experts to plan our diet. The very need of this kind is the base for genesis of a work like this which is expected to educate the students of this young and developing science.

No single book can impart complete knowledge, and this book too does not claim to be perfect and complete. The interested students could refer to other titles on the subject for detailed or additional information. Some books are listed out at the end for easy reference.

If this book generates serious interest in a few students of nutrition, I will consider my sincere and humble efforts to have been rewarded.

SHUBHANGINI A JOSHI



Section 1 **NUTRITION**

- **Chapter 1** Introduction to Nutrition and Dietetics
- **Chapter 2** Food and Our Body
- **Chapter 3** Role of Nutrients
- **Chapter 4** Menu Planning and Meal Preparation
- **Chapter 5** Balanced Diet and Nutrition During Normal Life Cycle
- **Chapter 6** Nutrition for Fitness and Sports

Chapter

1



Introduction to Nutrition and Dietetics

1.1 INTRODUCTION

Food is the basic necessity of life. Everybody eats food and most people enjoy it. From the beginning, scientists were curious about the food they consumed, its passage in the body and its effects. This curiosity led to the development of the science of nutrition. Nutrition is defined as the scientific study of food and its relation to health. It can also be defined as the science which deals with those processes by which body utilizes food for energy, growth and maintenance of health.

The development of chemistry and other fields of science helped solve several unanswered questions about food. In the late 18th century, Lavoisier began studies in nutrition. He studied the role of respiration in metabolism of food. He is appropriately called “the father of nutrition science”. Other important scientists who made valuable contributions to the study of nutrition were Lusk, Atwater, McCollum, Benedict, Rose and Rubner.

In our country since ages, dietary treatment has been used in conjunction with or without medicine.

It has been practised by the *Vaidyas* (physicians) as they are termed in Ayurveda. Every patient was given medication after thorough examination and diagnosis of the disease and also asked to follow certain dietary practices at least till complete recovery. This was known as *pathya* (dietary management). Many do's and don'ts were prescribed which were tailored to suit his health and constitution. The role of diet as a part of treatment is increasing day-by-day with new observations and experience.

In Ayurveda, we find instructions regarding the appropriate choice of food for quick recovery as well as for preventing further diseases and complications.

Similarly, if we look into the recipes that have been used for generations, we find that a majority of them are nutritionally well-balanced and season-oriented. Today, in the light of nutrition education and scientific knowledge, we must appreciate the instinctive approach of our ancestors towards food.

In the beginning of this century, interest in nutrition was mainly related to the energy needs of the human body, i.e. how much energy is obtained from different constituents of foods like carbohydrates, proteins and fats. Minerals were studied in detail when they were discovered to be important nutrients. Along with minerals came the discovery of vitamins. To follow were amino acids, fatty acids, trace mineral elements and hormones.

Now nutrition is an important part of our life. We have realized that quality of our health depends upon the nourishment that we provide to our body. However, our dietary habits are influenced by many factors. This is shown in Fig. 1.1.

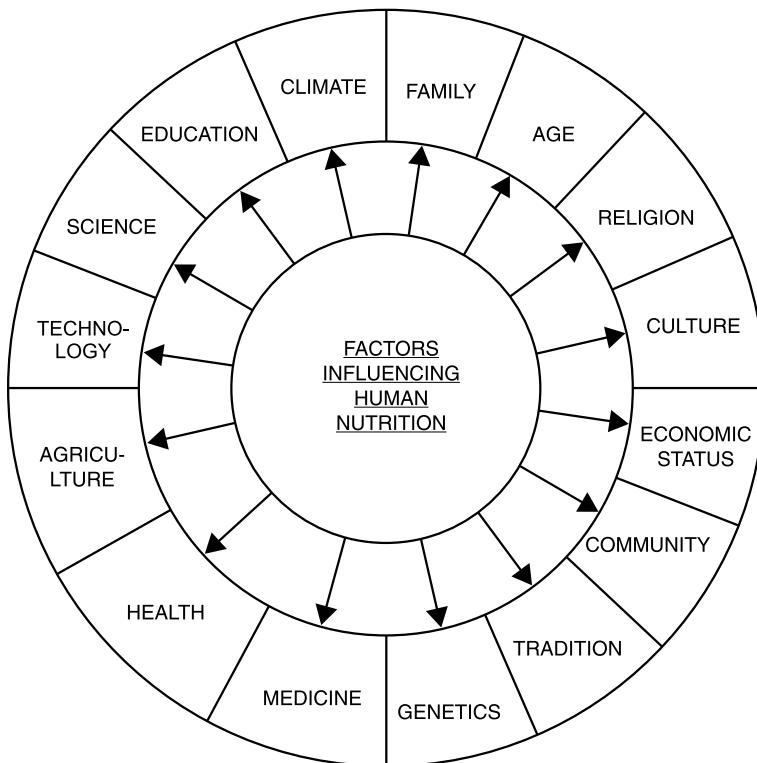


Fig. 1.1 Factors influencing human nutrition

Most people eat what they like or because it is a norm or out of habit. Their choice of food is not influenced by the awareness of its nutritive value. Few people know the way body utilizes food. It is also necessary to understand that a delicious dish is not necessarily a nutritious one.

1.2 **WHAT IS NUTRITION?**

As defined earlier, nutrition is the science of food and its interaction with an organism to promote and maintain health. Thus, nutrition is a combination of processes by which all parts of the body receive and utilize the materials necessary for the performance of their functions and for the growth and renewal of all the components (rejuvenation).

Food is the substance taken into the body that will help meet the body's needs for energy, maintenance of health, growth and reproduction.

Optimum nutrition means that a person is receiving and utilizing essential nutrients in proper proportions as required by the body while also providing a 'reserve'.

Nutritional status is the condition of the body as it relates to consumption and utilization of food. The nutritional status of a person may be either good or poor.

Good nutritional status refers to the intake of a well-balanced diet, which supplies all the essential nutrients to meet the body's requirements. Such a person may be said to be receiving optimum nutrition.

Poor nutritional status refers to an inadequate or even excessive intake or poor utilization of the nutrients to meet the body's requirements. Overeating can also result in poor nutritional status of a person.

Malnutrition refers to the physical effects on the human body of a dietary intake inadequate in quantity and/or quality.

Under nutrition refers to low food intake. *Basal Metabolic Rate* (BMR) is the minimum energy expenditure necessary for body maintenance at rest with no physical activity.

□ Signs of Good Nutritional Status

Shiny hair, smooth skin, clear eyes, alert expression and firm flesh on well-developed structure reflect good nutritional status of a person. One ought to be of correct weight in relation to one's height (see Appendix IV). His/Her physical and mental responses should be normal.

Good nutritional status of a person is also reflected by his/her stamina and resistance to diseases. Good nutrition also helps a person have regular sleep and elimination habits. It may increase a person's lifespan. In short, a person with a good nutritional status can enjoy life fully.

□ Signs of Poor Nutritional Status

The person has a poor physique, very little stamina, dull lifeless hair, dull eyes, slumped posture, fatigue and depression. He/She may be grossly overweight or underweight. The three important aspects namely those of diet, sleep and elimination habits are irregular. Clinical symptoms of nutritional deficiency may be evident in some. In most cases subclinical nutritional deficiencies may be present, but may not exhibit any symptoms.

1.3 THE FOOD GUIDE PYRAMID

In 1992, the US Department of Agriculture released the Food Guide Pyramid, featuring six food groups, designed to reflect the changing eating habits of consumers, and to give the department's official recommendation of what is good for the human body. From a broad base, the design narrows progressively towards the top. In the pyramid, the hierarchy and daily servings of the six food groups are as follows:

1. Six to eleven servings of bread, cereal and pasta
2. Three to five servings of vegetables
3. Two to four servings of fruits
4. Two to three servings of milk, yogurt and cheese
5. Two to three servings of meat, poultry, fish, beans, eggs and nuts
6. At the apex of the pyramid and occupying the smallest space are the fats, oils and sweets which are to be used sparingly.

In India, foods are divided into five groups. Table 1.1 and Fig. 1.2 depict their desirable intake in normal nutrition.

Table 1.1 Desirable intake of the five food groups

Food group	Percentage
Cereals and millets	60
Body-building foods	15
Other vegetables and fruits	10
Protective foods	10
Energy group	5

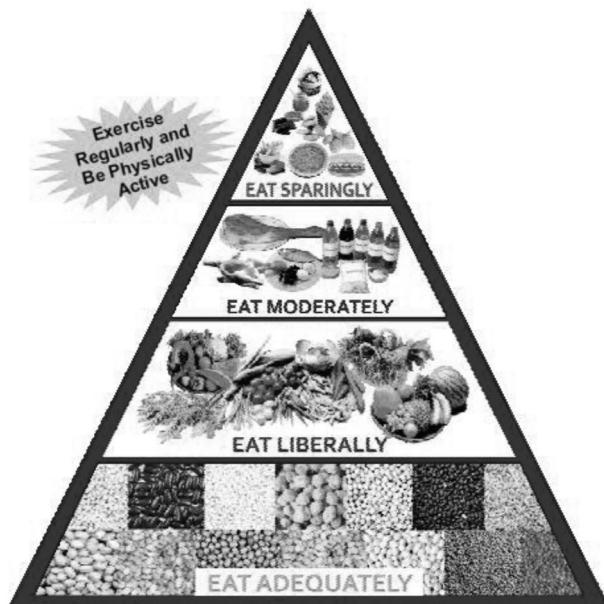


Fig. 1.2 Indian food guide pyramid

1.4 WHAT ARE NUTRIENTS?

Nutrients are chemical components of food that supply nourishment to the body. They are required by the body in the right amounts and they must be eaten regularly. Each nutrient—Proteins, Carbohydrates, Fats, Minerals, Vitamins and Water—performs a specific function in our body.

Let us look at the nutrients in Fig. 1.3.

Cellulose, though not a nutrient itself, plays an important role in the physiology of digestion. Hence, it is considered to be a vital nutritional factor.

□ Functions of Nutrients

A nutrient must accomplish at least one of the following three functions:

- Supply energy to the body
- Build and repair body tissues
- Regulate body processes

Carbohydrates and fats primarily supply energy. Proteins provide functional and structural materials and also supply energy when the dietary intake of carbohydrates and fats is low. Vitamins and minerals, along with water, help to regulate the body processes such as respiration, reproduction, circulation, metabolism, digestion, absorption and elimination. These processes take place continuously in our body without our being conscious of them.

Water, which constitutes about 58 percent of the body weight, is found in all the tissues. Its importance in the body cannot be underestimated. A man can live without food for several days but cannot survive without water for even a few days. It is a solvent and all enzymatic activities require water. Hence, metabolism in the body and all physiological processes require water. It plays an important role in carrying nutrients to all the tissues and removing wastes from them. Hence, an average person must drink at least six to eight glasses of water or its equivalent in a day.

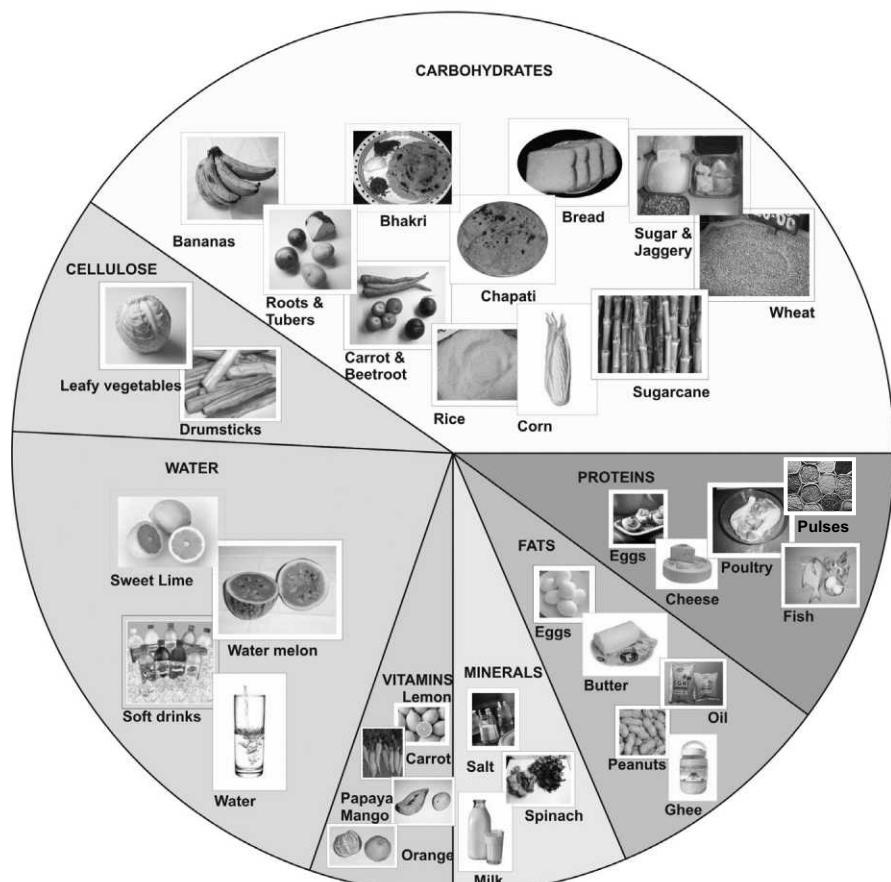


Fig. 1.3 The nutrient wheel

Cellulose, though not a digestible part of the diet, is an indispensable one. Cellulose or dietary fibre helps in the process of elimination of wastes in the form of stools. It does so by binding the stools, along with water, and also stimulates the gastro-intestinal tract which helps early defecation.

1.5 WHAT IS MALNUTRITION?

Malnutrition is a state in which a prolonged lack of one or more nutrients retards physical development or causes specific clinical disorders, e.g. iron deficiency anaemia, goitre, etc. Malnutrition can also be defined as an impairment of health resulting from a deficiency, excess or imbalance of nutrients. It includes undernutrition and overnutrition. *Kwashiorkor*, a protein-deficiency disease, highlights this fact since in most cases of *kwarshiorkor* the cause is intake of poor quality protein rather than inadequate quantity over a prolonged period of time. More recently malnutrition is defined as an unintentional weight loss of more than 10 percent, associated with a serum albumin level below 3.2 g/dl.

Some characteristics of people suffering from malnutrition are dull lifeless hair, greasy pimpled facial skin, dull eyes, slumped posture; fatigue and depression are easily evident by their spiritless expression and behaviour, and lack of interest in their surroundings. Such people may be underweight or overweight. Sleep may be affected, and also the elimination habits. Constipation is a common problem.

The problem of malnutrition cannot be taken lightly as it may sometimes prove fatal. It may also cripple a person for the whole life, e.g. deficiency of vitamin A in children leads to blindness.

A disease which results from lack of a certain nutrient is known as a *deficiency disease*, e.g. iron-deficiency anaemia, is a very common deficiency disease in women and young girls.

Menstrual losses and increased needs in pregnancy are some of the causes of anaemia.

Persons prone to malnutrition are infants, pre-school children, adolescents, pregnant women and elderly people. Pregnant women are especially prone to malnutrition if they are adolescents and not mature enough to bear children.

Infants and pre-school children are dependent on their mother for nourishment and if her selection of foods for them is incorrect, they may suffer from malnutrition. During the process of weaning, most poor children are a prey to faulty nourishment since they may be fed *sago kanji* (gruel) as a substitute for milk and no other foods providing good-quality protein. *Sago kanji* supplies carbohydrates but very little proteins, and lack of proteins in the diet may result in severe wasting of body tissues. This may lead to multiple deficiencies and *kwashiorkor* results. This, in many cases, is fatal or if the child on treatment does survive, it may leave its effect in the form of an under-developed brain. Hence, the period of infancy, i.e. from birth to 18 months is a very crucial period and thus protein quality and quantity in the diet should be taken care of.

Usually, adolescents eat often but irregularly and mostly the wrong kind of food. Snack items such as potato wafers, popcorn, cakes, soft drinks, candies, pepsi-colas are their favourite foods. These foods not only supply very limited

nutrients but also cause a feeling of fullness. Such *hollow* or *empty calorie* foods should not be allowed liberally. However, at this age what their friends eat and do is what matters most to them. *Crash* diets are also commonly seen in this age group. The resulting malnutrition due to wrong choice/selection of foods is evident in an adolescent either in the form of anaemia or lack of stamina and their school work is affected.

Pregnancy and lactation are stress periods in a woman's life. The woman's appetite increases remarkably and so does the need for nutrients. The fast-growing foetus has to be continuously nourished. This stress has to be even more carefully managed when the mother-to-be is an adolescent. Her own growing needs as well as those of the foetus put a burden on her body. The birth weight and health of a newborn is influenced by its mother's nutritional well-being during pregnancy. Lactation also needs careful attention to food intake and its quality, since the quality of the mother's milk and the length to which she can satisfactorily breast-feed her child depends on it.

Old people are also malnourished many a times as they may be unwell or not properly looked after. Poor eating may result in poor nutritional status in them. Dietary restrictions due to some disorders such as diabetes, high blood pressure, etc. may add to this.

Malnutrition results in most of us since we do not heed to our body's daily requirements. As mentioned in the definition, malnutrition is evident as a deficiency disease, e.g. rickets in children due to calcium-vitamin D deficiency. Also, malnourished people are prone to continuous bouts of some illness or the other which affects their work very often. This condition can be easily set right if we eat the right food in the right amount daily, i.e. if we consume a *balanced diet* everyday, and develop good eating habits for good health.

A balanced diet, in short, is a diet which contains all the nutrients in the right amounts as required by an individual's body needs.

What then are the guidelines for good health?

1.6 GUIDELINES FOR GOOD HEALTH

The general guidelines to good health that may be followed are:

1. Maintain regularity in your routine.
2. Eat as much natural foods as you can.
3. Consume seasonal foods as far as possible.
4. Eat well but do not 'overeat'.
5. Avoid excessive salt and spices.
6. Avoid too much sweets, especially sugar.
7. Eat foods which contain carbohydrates, especially starch and fibre.
8. Avoid foods that contain large amounts of cholesterol and saturated fats.
9. Watch your weight and maintain ideal weight.
10. Avoid eating the same kind of foods all the time. Eat a variety of foods.

Let us look at each of these in detail.

□ Maintain Regularity in Your Routine

Our body can adapt to changes, but it has its own *biological clock* which is adapted to our daily routine and also changes with seasons. Once you have conditioned your body to a certain routine, it is necessary to maintain it. Regularity in maintaining your routine presents certain advantages in determining regular sleeping habits, elimination habits and at least two proper meals. People who suffer from constipation or sleeplessness are those who do not listen to their *biological clock*.

□ Eat Fresh, Natural Foods

Most natural foods are more nutritious than their preserved counterparts. A glass of lime juice contains more vitamin C than lemon squash flavoured artificially. It must be remembered that natural foods do not contain any additives which may be natural or synthetic ingredients added to a food to increase its acceptability. All natural foods with the exception of fruits and salads have to be processed. Cooking is a method of processing which destroys microorganisms, softens foods making them easier to chew and digest and also, in case of some foods, destroys the anti-nutritional factors. Hence, most foods *must* be cooked and processed so as to enable the consumer to benefit from them. Lathyrism, a debilitating disease, can be easily prevented if the *dal*, *Lathyrus sativus*, is boiled before consumption. So, although some foods are best consumed in their natural state, most foods require processing. In the processed foods available in the market some amount of additives are added in order to enhance the quality of the product or preserve it for a longer period. Some of these are synthetic while some are natural. *Saccharin*, an artificial sweetener, is used in many carbonated beverages. Therefore, excessive consumption of any food containing synthetic additives must be avoided.

So next time you buy *burfi*, buy the one without colour added to it. Prefer natural foods to those which resemble natural foods, e.g. soft-drink concentrates should not replace your glass of fruit juice. Stress on consumption of all types of natural foods has been laid down by naturopaths.

□ Adapt Yourself to Seasonal Variations

Changes in seasons have a tremendous impact on our body and this affects our health. If the diet is modified according to the climatic conditions, our body suffers minimum shock and adapts very easily to seasonal variations.

During summer, since sweat loss is much more than that in winter, one must consume more water and electrolytes to replace the lost fluid. If the intake of fats and carbohydrates is increased during winter, it helps in providing for the required additional generation of heat by the body.

□ Eat But Do Not Overeat

Eat three to four meals a day and at each meal eat well but do not overeat. According to Ayurvedic practice, a meal should be eaten at the right time. Its quantity also should be such that two parts of the stomach are occupied by the food, one part by water and one part should be left empty in order to permit the flow of gastric juices and the contents of the stomach to be churned so as to avoid indigestion. This will explain very easily the main cause of indigestion.

Good health can be maintained if at any given meal one does not overeat, be it a snack or a dinner. Eating while watching TV, talking or reading can result in overeating. Many readers must have experienced overeating during a buffet dinner. Overeating, even if a little, can lead to overweight and obesity in the long run.

□ Avoid Excessive Salt and Spices

Anything that is done in moderation cannot harm the body, but a slight excess everyday can be harmful for the body in the long run.

A simple example is salt, a substance whose daily intake varies from person to person. Salt which contains large amounts of sodium must be carefully handled, more so by people who have a tendency towards high blood pressure. Clinically, a definite correlation has been established between sodium and hypertension.

Table salt is the main source of sodium. In order to avoid consuming too much sodium, a small amount of salt should be used while cooking and only a little salt may be used at the table. Foods which are highly salted are salted peanuts, potato chips, potato wafers, and salted popcorn. *Masalas*, pickles, cheese, brined vegetables, tomato sauce and ketchup, brined onions, and soya sauce contain added sodium. It is necessary to read the food labels carefully before consuming processed foods.

One can learn to enjoy the flavour of foods without salt by discrete use of lime juice, black pepper powder, coriander, etc. Very spicy foods must be avoided since they are harmful to the delicate lining of the gastro-intestinal tract.

□ Avoid Excessive Consumption of Sweets, Especially Sugar

Excessive consumption of sweets must be avoided. Sucrose has been proved to be one of the causative agents of *dental caries*. Fresh fruits should be preferred to canned fruits. Consumption of concentrated sugar sources like jams, jellies, marmalades must be minimized.

□ Eat Foods that Contain Adequate Carbohydrates, Especially Starch and Fibre

Consumption of complex carbohydrates, such as starches present in cereals, is more advisable than that of the simpler sugars found in honey, fruits, table sugar and milk. This is because the digestion of the complex sugars is relatively slower than that of the simpler ones.

Starches can be substituted for fats and sugars, and foods that are a rich source of fibre, such as whole-grain cereals, green leafy vegetables, pulses and legumes, should be included in the diet. Fibre in the diet lowers blood cholesterol. Avoidance of fibre or consumption of a fibre-free diet has proved to be a definite cause of rectal disorders, poor bowel habits, colon cancer and chronic constipation.

□ Avoid Foods that Contain Large Amounts of Fat, Cholesterol and Saturated Fats

This can be achieved by eating moderately, foods rich in cholesterol, such as meat, fish, poultry, organ meats and eggs. Vegetable oils may be used. Controlled consumption of

sweetmeat prepared in pure ghee, butter and vanaspati is necessary. It is essential to restrict consumption of fried foods and high-sugar foods.

Only moderate consumption of these foods is the key to good health.

□ Watch Your Weight and Maintain Ideal Weight

It is always better to be slightly underweight than to be overweight. Every gram of excess weight is a burden on the heart and vital body resources. If loss of weight is advised then it should be done at the rate of half to one kg a week until your ideal weight is reached. Weight loss should never be drastic as it may lead to major health problems and can even be fatal. The process of losing weight depends on good eating habits, i.e. eating slowly, chewing the morsel thoroughly, preparing smaller portions and helpings. It is important to increase certain physical activities which help you to lose weight, eat less fat and starchy foods, avoid *empty* calories such as those in alcohol and soft drinks, and avoid sweets and sweetmeats. Appendix IV shows the ideal weight for men and women.

□ Avoid a Monotonous Diet—Eat a Variety of Foods

Most foods contain several nutrients, but no single food provides nutrients in the right quantity for good health, e.g. milk is a complete food yet it is a poor source of iron and vitamin C, so it is necessary to include citrus fruits which are a rich source of vitamin C. This is not sufficient as it does not provide sufficient iron, hence supplementation of diet with leafy vegetables or liver is necessary. This example only goes to show that more the variety of foods in the diet, the better is the nutritional value and lesser is the chance of nutritional deficiency. The following major food groups may be used as a guide for selecting at least one food from each group.

- Milk, dal, meat, fish, egg
- Fresh fruits and vegetables
- Cereals and cereal products
- Oils, fats, sugar and jaggery.

1.7 DIETETICS AND ITS SCOPE

Dietetics is the branch of therapeutics which puts into practice the application of the principles of nutrition to diet in relation to health.

It can also be defined as the science of applying the principles of nutrition to the planning and preparation of foods and also regulation of the diet in relation to health and disease.

The American Dietetics Association defines dietetics as “a profession in which there is the integration and application of principles derived from the sciences of food, nutrition, management, communication, biological, physiological, behavioural and social sciences to achieve and maintain optimal human health.”

A *dietitian* is a person qualified in the field of nutrition and dietetics from a recognised national institution or university. He/She applies the science of nutrition to the feeding and education of people in both health as well as disease.

A dietitian is also a multifaceted person who besides having the technical knowledge in the field of nutrition must have additional knowledge and performance competencies in the following areas:

- Nutritional diagnosis and implementation of nutritional care process.
- Counselling and behaviour management
- General business management such as managing staff, interdisciplinary teams, negotiations, generating revenue, communication skills, etc.
- Practice management such as legal and ethical issues, cost-benefit, determining value of products and services, marketing, reimbursement, etc.
- Leadership
- Knowledge about food such as cultural foods, product development, impact of food processing on nutrient value, environmental and agricultural issues
- Outcomes of research and evidence-based practice
- Genetics
- Other areas as needed to meet the current and future needs.



SUMMARY

Good nutrition is a goal which can be achieved by anyone who desires it. Moderation in everything that we eat is the key to success. It is necessary to select wisely from the different foods available in the market. A large variety of convenience foods are meant to ease the burden of the modern housewife who may also be a working woman. They may be used only as accompaniments to the daily diet. Always remember that no single food can be the complete health food for healthy living. Opt for natural foods and eat foods to fulfil your nutritional requirements.



CASE STUDIES

You are invited to address a group of adolescent boys and girls in a college.

1. List the points that you will need to emphasize for this age group.
2. Give day-to-day examples for healthy living.
3. How will you explain the importance of the Food Guide Pyramid to them?



REVIEW QUESTIONS

1. Define the following terms: nutrition, food, optimum nutritional status, mal-nutrition, under-nutrition, over-nutrition, nutrients.
2. What are the signs of good nutritional status?
3. What are the signs of poor nutritional status?
4. List the functions of nutrients, giving examples.
5. What is the nutrient wheel? Which food group occupies the most space in the wheel and which group the least?
6. What is the Food Pyramid? Which food group is at the apex and why?
7. List out the guidelines for good health.

Chapter

2



Food and Our Body

The questions that spring to our mind after reading about nutrition and malnutrition in the first chapter are:

- How do we decide our nutritional requirements?
- What food should we eat?
- How much food do we need? and
- How does the body utilize the food that we eat?

Answers to these questions are obtained from studies that have been carried out. The composition of food is studied either by chemical analysis or by biological assay.

□ Chemical Analysis

Chemical analysis enables one to obtain useful data regarding the approximate content of carbohydrates, fats, proteins, minerals, vitamins and water in any given food. It also enables us to determine with fair accuracy the amounts of mineral elements, such as iron, calcium, phosphorus, sulphur, sodium and chlorine, present in different foods. Vitamins can also be determined by chemical analysis, but other techniques such as physical methods which measure absorption spectra, fluorescence, turbidity, etc. or microbiological assay (influence of a particular vitamin on growth of bacteria) can be used.

Figure 2.1 illustrates some instruments used in chemical analysis of food.

□ Bioassay

In most common methods of bioassay, laboratory animals are first depleted of the particular vitamin being studied by being fed a diet lacking in it. Then some of the depleted animals are divided into different groups and fed graded doses of the known vitamin, with each group receiving one of the doses in the series. The response of the animals to the intake, in growth and/or other appropriate criteria, is measured and recorded in a standard response curve. Simultaneously, a second set of depleted animals is divided into different groups and fed increasing amounts of the food being assayed, and the responses of each of these groups is recorded. Then, the vitamin potency of the product being tested is estimated by comparing the responses of the second set of the animals with the standard response curve of the first group.

Biological assays are laborious, time-consuming and costly. Large numbers of samples are needed to produce statistically reliable results; the animals should be of approximately the same age, sex and weight; it takes time to produce nutrient-deficient animals; and quite often the data obtained are highly variable. In addition, the data from one species are not always relevant to another species.



Fig. 2.1 Some Instruments used in Food Analysis. 1. *Chemical balance*—It is used for weighing samples less than 100 grams with accuracy up to 0.1 milligrams. 2. *Rough balance*—It is used for weighing samples less than 1 kilogram with accuracy up to 500 milligrams. 3. *Muffle furnace*—It is used for preparing the ash of samples to estimate the mineral content. 4. *Oven*—The air oven and the vacuum oven are used for determining moisture in samples or for drying samples. 5. *Soxhlet extraction apparatus*—It is used when determining the lipids, crude fat, fat-soluble vitamins and other such organic solvent-extracted materials in samples. 6. *Kjeldahl apparatus*—It is used when computing the protein content of samples on the basis of their nitrogen content. 7. *Photoelectric colourimeter*—It is used for estimating the minerals, vitamins and other substances whose amount in samples is proportionate to the colour they produce with certain reagents. 8. *Chromatography or Adsorption Analysis*—It is a technique widely adapted for estimating amino acids, sugars, lipids, dyes and flavours in samples.

The fundamental value of the biological assay is that it gives positive proof of biological activity. It is still the basis of comparison or standardization for new microbiological or chemical methods.

Bioassay of vitamins A and D is usually done. For vitamin D, rats and chicks are used as test animals; rats respond equally well to D₂ and D₃, whereas chicks respond only to D₃. The assays measure the alleviation (*curative test*) or the development (*prophylactic test*) of vitamin D deficiency in terms of the degree of rickets produced.

A bioassay method known as the "line test" uses stained longitudinal sections of the distal end of radius bones to evaluate calcification.

The empirical composition of the body is dependent on the quality of the food eaten. *You are what you eat.*

2.1 BODY COMPOSITION

The body is structurally made up of organs, tissues and cells. These in turn are made up of different chemical elements held together in varying combinations.

The predominating chemical elements in the body are 65 percent oxygen, 18 percent carbon, 10 percent hydrogen and 3 percent nitrogen. Together they represent about 96 percent of body weight and account for the principal constituents of the body, namely water, proteins, fats and a small amount of glycogen. The remaining 4 percent of body weight is made up of mineral elements, of which calcium and phosphorus account for three-fourths.

Water is present in all body tissues and accounts for 55 to 70 percent of body weight. The water content varies inversely with the amount of fat in the infant bodies which have a low fat content and a high water content. Lean adults have a higher body water content than obese adults.

About three-fourths of the body water is in the intracellular compartment (fluid within the cells) and one-fourth is in the extracellular compartment, which includes the blood circulation, the lymph and the interstitial fluids that bathe all cells. Tissues vary considerably in their water content, with bones, teeth and adipose tissue, for example, containing appreciably less water than muscle and nervous tissue.

Proteins account for about 18 percent body weight. The normal body fat content is 7 to 15 percent for men and 12 to 25 percent for women. Body fat content in excess of 20 percent for men and 30 percent for women is generally regarded as obesity. A gradual increase in body fat content occurs in both sexes with aging.

Only about 300 g carbohydrate in the form of glycogen is present in the body, with very small additional amounts involved in the structure of various tissues. Many of the important body constituents such as vitamins, hormones and enzymes are present in such small amounts that they have no significant effect on total body weight.

The approximate chemical composition of our body is shown in Table 2.1 and the distribution of the mineral elements is shown in Table 2.2.

The chief constituent elements of almost all organic compounds are carbon, hydrogen and oxygen. They may be found in varying amounts but occur in the body especially in carbohydrates, fats and proteins. Nitrogen is an essential constituent of proteins. Some proteins also contain sulphur, phosphorus and iron. These four elements, namely carbon, hydrogen, oxygen and nitrogen, make up about 96 percent

of body weight. They are supplied to the body by carbohydrates, fats, proteins and water present in the foods that we eat, water and beverages that we drink and oxygen that we breathe.

Table 2.1 Percentage of total body weight

<i>Body Component</i>	<i>Man</i>	<i>Woman</i>
Protein	17.0	8.5
Fat	13.5	22.0
Carbohydrate	1.5	1.5
Water	62.0	62.0
Minerals	6.0	6.0
Total	100.0	100.0

Table 2.2 Mineral elements in our body

<i>Mineral</i>	<i>Proximate percentage</i>	<i>Mineral</i>	<i>Proximate percentage</i>
Calcium	2.3–3.4	Iron	0.004
Phosphorus		Manganese	0.0003
Potassium	0.95 percent	Copper	0.00015
Sulphur		Iodine	0.00004
Chlorine			
Sodium			
Magnesium			

The constitution of each living being is governed by its genetic make up, although the basic building material (food) is the same. The basic molecules of the food consumed by all living beings are identical. However, these molecules are converted into body tissues which are specific not only to the various species but also to different individuals within a species. Hence, no two individuals are alike.

2.2 CHOICE OF FOOD

The basic misconception about food is that we crave for the food which our body needs. We very often hear ‘Let him eat it (whatever food he likes most). If he likes it so much, may be he needs it more.’

Human beings are considered to be the most advanced when their intelligence is compared to that of animals, but as far as food selection is concerned, *man* does not retain this position. Choice of foods relating to the body's requirement is more accurate in the case of animals. The food choice of a human being is influenced by his social life and cultural background as well as his learning. Learning profoundly influences our food selection. It is interesting to note that infants show a natural ability to select foods needed by their body. This ability is lost as the child grows up.

2.3 RECOMMENDED DIETARY ALLOWANCES FOR INDIANS

The Nutrition Advisory Committee of Indian Research Association, now Indian Council of Medical Research recommended for the first time, dietary allowances for Indians of energy, proteins, iron, calcium, vitamin A, thiamine, ascorbic acid and vitamin D. These recommendations were revised in 1958 in respect of energy and protein. The Nutrition Expert Group of the Indian Council of Medical Research revised in 1968 the earlier recommendations of nutrient allowances for Indians in respect of all nutrients, except energy. This Committee also considered the desirable levels of intake of additional nutrients like folic acid, vitamin B₁₂, vitamin D and fat. In making these recommendations, the committee was guided by the safe allowances of various nutrients suggested by the experts group of the Food and Agricultural Organisation (FAO) and the World Health Organisation (WHO) and data on nutrient requirement of Indians. These recommendations were again revised in 1978 by an Expert Group of the ICMR and allowances were again examined in detail by an Expert Committee of the ICMR in April 1988 and detailed recommendations with respect to safe levels of intake of all nutrients were made. The basis of these recommendations is discussed in detail in the Report of the Committee.

The recommended intakes are given in Appendix III and the points on which they are based and guidelines to use them are described below

1. Body Weight

- (a) *Reference man and woman:* On the basis of height of adult, body weight of 60 kg and 55 kg for reference man and reference woman should be used in arriving at RDA, instead of 55 kg and 40 kg used earlier.
- (b) In case of growing infants and children, desirable body weights are to be used. In the absence of Indian data, NCHS standards will be used for the time-being.

2. Energy Allowance

- (a) Energy requirement is expressed in terms of BMR values which are derived from the body weight of Indians using the equation given by FAO, 1980 and the values reduced by 5% to allow the lower BMR of Indians.
- (b) Energy allowance for children and adolescents are for normally growing healthy Indian children. Allowance is made for the age and no correction for actual body weight of children needs to be made.

3. Protein Allowance Protein allowance are given in terms of mixed vegetable proteins contained in Indian diets, the NPU of which is assumed to be 65. Adult protein requirement is 1 g/kg body weight.

4. Fat Requirement Fat requirement was examined in great details and more realistic estimates of minimum intakes have been given. In arriving at fat requirements, the total invisible fat content of cereal-based diets eaten in India and the minimum EFA requirement of various groups were considered.

5. Minerals Iron requirements have been arrived at using the factorial approach taking into account the basal loss in case of men, basal loss + menstrual loss in case of women, basal loss + growth requirement in case of children. Dietary iron requirements are given at levels of absorption of 5%, 3% and 2% applicable respectively to the diet based on rice, based on mixed cereals (rice + wheat) and based wholly on wheat or millets.

(a) Calcium and Phosphorus Because of close relationship of Ca and P, allowances for both these nutrients are given. The desirable ratio of Ca:P is 1:5 in case of infants and 1:1 in case of other groups.

(b) Trace Elements Desirable daily intakes of some trace elements have been suggested for an adult: 65 µg chromium, 2.2 mg copper and 5.5 µg manganese, 15.5 µg zinc and 500 µg molybdenum.

6. Vitamins

(a) Vitamin A The recommended level of vitamin A (retinol) for adult is 600 µg. In terms of beta-carotene, it will be 2400 µg, the conversion factor to be used in case of retinol and beta-carotene is as follows:

1 µg β-carotene = 0.25 µg retinol. If diet contains retinol and β-carotene, its vitamin A content can be expressed as follows:

- Retinol content (µg) = µg Retinol + µg beta-carotene × 0.25, if retinol and beta-carotene are expressed in µg.
- Retinol content (µg) = Vitamin A IU × 0.3 + beta-carotene IU × 0.15, if vitamin A and beta-carotene are given in international units (IU).

(b) Thiamine, Riboflavin and Nicotinic Acid The daily allowance for these vitamins is related to energy intake. The basic allowances per 1000 kcal are 0.5 mg thiamine, 0.6 µg riboflavin, and 6.6 mg nicotinic acid and niacin equivalent.

Niacin allowance takes into account the contribution of tryptophan also, assuming 60 mg dietary tryptophan yielded 1 mg of niacin in the body.

$$\text{Niacin equivalent (mg)} = \text{Niacin content} + \frac{\text{Tryptophan content}}{60}$$

(c) Folic Acid Allowance for folic acid is in terms of free foliate (*L. casei* activity) present in foods. RDA of foliate in pregnancy will be 300 µg, in addition to normal requirement of 100 µg. Since such high levels of foliate cannot be obtained, hence, therapeutic supplementation becomes necessary in pregnancy. Folic acid requirement can be expressed on the basis of body weight also, i.e. 3 µg/kg.

(d) Vitamin B₁₂ Recommended intake of vitamin B₁₂ is 1 µg/day entirely derived from animal foods. This provides justification for including some animal food in our daily diet.

(e) Vitamin C Earlier recommendations of 40 mg were retained. In case of infants, the RDA was changed from 20 to 25 mg/day.

(f) Vitamin D No dietary recommendations for vitamin D were made since adequate vitamin D can be obtained through exposure to sunlight. In case of conditions of inadequacy of vitamin D medicinal supplements can be given.

(g) Vitamin E An intake of 0.8 mg of vitamin E per g of polyunsaturated fatty acids was suggested.

(h) Vitamin B₆ Earlier (1978) recommendations were retained.

□ Unit of Calories and Joule, and their Conversions

Quantitative food requirements are usually estimated in terms of energy, i.e. calories. This unit of energy is a physiological calorie (also known as kilocalories-k cal). It is the amount of heat necessary to raise the temperature of one kilogram of water by 1° celsius from 14.5°C to 15.5°C. This is 1000 times the physical caloric unit. The reader of this book will henceforth understand that the calorie under reference is the physiological calorie or kilocalorie (kcal).

More recently kcal is slowly being replaced by the new energy unit “joule”. A Joule (J) is defined as the energy required to move 1 kilogram mass 1m by 1 Newton. One Newton is the force needed to accelerate 1 kg by 1m per second.

$$1 \text{ cal} = 4.184 \text{ joule (physical unit)}$$

$$1 \text{ kilocalorie (physiological unit)} = 4.184 \text{ kilojoule (kJ)}$$

$$1000 \text{ kilocalorie (physiological unit)} = 4.184 \text{ Megajoule (MJ)}$$

For practical purpose, the factor of 4.2 can be used for conversion of kilocalories to kilojoules.

The important points regarding the RDA for Indians are as follows:

1. The dietary allowances suggested for adults are for a reference man weighing 60 kg and for a reference woman weighing 55 kg. The allowances for calories and proteins and for B-complex vitamins should be increased or decreased depending on the body's weight.

The profiles of a *reference man* and a *reference woman* are as follows:

Reference Indian Adult Man and Woman The **Indian Reference Man** is between 18–29 years of age and weighs 60 kg with a height of 1.73m, a BMI of 20.3 and is free from disease and physically fit for active work; on each working day, he is engaged in 8 hours of occupation which usually involves moderate activity, while when not at work, he spends 8 hours in bed, 4–6 hours in sitting and moving about, 2 hours in walking and in active recreation or household duties.

The **Indian Reference Woman** is between 18–29 years of age, Non-Pregnant Non-Lactating (NPNL) and weighs 55 kg with a height of 1.61m and a BMI of 21.2, is free from disease and physically fit for active work; on each working day she is engaged in 8 hours of occupation which usually involves moderate activity, while when not at work, she spends 8 hours in bed, 4–6 hours in sitting and moving about, 2 hours in walking and in active recreation or household duties.

2. The protein allowance recommended is about 1 gram per kilogram body weight per day. Since Indians are predominantly vegetarians, this protein is assumed to be derived from a mixture of vegetable foods.

Proteins of animal origin have superior biological value as compared to vegetable proteins. However, a mixture of vegetable proteins improves the biological value. For infants and children as well as for pregnant and nursing women, it is desirable to supply about 25 percent of the total protein requirement from animal foods such as milk, meat, eggs, fish, etc.

3. The intake of fat should be limited to not more than 15 percent of the calories in the diet. Of these, at least 15 g of vegetable oils should be included in the diet to meet the requirements of the essential fatty acids. It is now recommended that the human diet contain about 4 percent of calories as linoleic acid and linolenic acid.
4. About 60–65 percent of the total calorie requirement may be met through intake of carbohydrates.
5. Allowance of phosphorus is not mentioned since most dietary ingredients are rich in phosphorus.
6. A normal well-balanced diet generally meets with the requirements for trace elements like Mg, Cu, I, etc. Hence, no RDA for these is mentioned.
7. Vitamin A is found either as retinol or β carotene in the diet. The former is preformed vitamin A while the latter is the precursor of vitamin A. Both yield vitamin A. One mg β carotene is equivalent to 0.25 mg retinol. Total vitamin A value of the diet as retinol (ug) β retinol (ug) = β carotene / 4.
8. Vitamin D is formed in the body by conversion of its precursor by the action of sunlight. Partial requirement of vitamin D may be met by this conversion but it cannot be always relied upon especially in case of children. So, RDA for vitamin D is given.
9. The requirement for thiamine, riboflavin and niacin are related to the calorie intake of the person. The RDA of each of these per 1000 calories are:

Thiamine	0.5 mg
Riboflavin	0.55 mg
Niacin	6.6 mg

The RDA for niacin includes contribution of dietary tryptophan. 60 mg tryptophan is equivalent to 1 mg niacin.

Thus, RDA are the levels of intake of essential nutrients considered to be adequate to meet the known nutritional needs of all healthy persons according to the judgement of the Nutrition Expert Group of the ICMR on Dietary Allowances, on the basis of available scientific knowledge.

RDA are also used as a guide to determine the nutritional adequacy of individual diets. One most important point to be remembered here is that RDA are recommendations for the average daily amounts of nutrients that population groups should consume over a period of time and cannot be directly applied to individual cases.

They should not be confused with requirements for a specific individual because the needs of each person may vary.

Also, the RDA do not cover abnormal problems such as premature birth, inherited metabolic disorders, infections, chronic disease and the use of medications which require special dietary and therapeutic measures.

The RDA of all nutrients are estimated to exceed the requirements of most healthy individuals. However, the total energy intake is an exception and is not overestimated.

The RDA, in all cover eleven nutrient factors.

□ Factors Affecting RDA

The nutritional requirements are affected by several factors such as the following:

- *Age*—(infant, adolescent, aged). Infants require more protein per kilogram of body weight than adolescents, since their metabolic rate is much faster than that of adolescents.
- *Sex*—(male or female) Adolescent girls require more iron than adolescent boys in order to replace the iron lost during menstruation every month.
- *Body size*—(height, weight, surface area, stature). A tall heavily built man needs more calories than a small-statured man, since his body surface area is more than that of the latter.
- *Physiological state*—(pregnancy, lactation). A pregnant woman requires more nutritious food than an ordinary adult woman, since she has to meet the additional nutritional requirements of the growing foetus.
- *Type of work*—(sedentary, moderate, heavy). A sedentary worker requires less calories than a heavy worker, since the former expends less energy than the latter during work.

The RDA may then be considered *The Nutrition Yardstick*.

□ Uses of RDA

They are mainly used:

- as a basis for all feeding programmes such as school-lunch programmes
- to interpret food consumption records
- to evaluate the adequacy of food supplies in relation to nutritional needs
- to establish guidelines for public food assistance programmes
- to develop and evaluate new food products developed by the food industry
- to establish guidelines for labelling of food from the nutritional standpoint, and most important
- to develop nutrition education programmes.

When studying RDA from Appendix III, it must be remembered that an excess for all nutrients except energy has been given. To be on the safe side, some people may consume excess of these, but it must be borne in mind that not all nutrients are well tolerated if taken in excess of RDA, e.g. vitamins A and D are stored in the body and may cause toxic effects unlike water soluble vitamins B and C, which if consumed in excess of the requirement will be excreted by the body. Also, an excess of energy intake daily, however small, can result in overweight and lead to obesity in the long run.

With regard to body requirements, the concept of bioavailability has emerged recently. Bioavailability means how much of the nutrient that is ingested actually gets digested and is absorbed across the intestines. This amount is the amount which is actually made available to the body for further use. When considering the requirement

of any nutrient, this important aspect has to be taken into account. Several studies in this regard are being carried out. This idea is being developed and soon we will become familiar with it as more data and knowledge is generated in the coming years.

2.4 ENERGY REQUIREMENTS OF THE BODY (ENERGY METABOLISM)

Combustion (a process of energy release) in living beings was first described by Lavoisier (1743–1794). This brilliant chemist discovered the true nature of oxygen and how its combination (in the body) with carbon and hydrogen results in formation of CO_2 and H_2O and the production of heat.

In 1842, Liebig announced that the substances burned in the body for energy liberation were carbohydrate, fat and protein.

Energy is needed for maintenance of body tissues and body temperature, for growth and also for physical and mental activity as well as for reproduction. In other words energy is needed for all physiological processes that go on in the body. The body expends energy for the following:

1. Voluntary actions, such as running, walking, swimming, typing and talking. The energy requirement of different activities has been tabulated in Table 2.3.
2. Involuntary actions such as expansion and contraction of the heart, respiration, and digestion. Involuntary actions include energy needed for body maintenance and is known as Resting Metabolism or the *Basal Metabolic Rate* or BMR. This energy must be supplied to the body first, because energy required by the heart for its normal functioning or for the constant supply of blood to the brain are vital functions upon which survival of a living being depends.

Basal metabolism, therefore, represents the irreducible minimum of energy required to keep up the life processes, i.e. for the basic internal functioning of the body. It is usually defined as the amount of energy required by the body when lying at rest in a comfortable environment, mentally relaxed and without food (12–15 hours after the last meal). The test measures the amount of oxygen consumed in such a condition for 6–8 minutes.

□ Factors Influencing Basal Metabolic Rate (BMR) in Humans

1. Body Size Major determinant of energy expenditure in man, since more than half the variability in BMR is due to this factor. Larger people have high BMR. A weight difference of about 10 kg may affect BMR by 123 kcal in adult men or women.

2. Body Composition Adipose tissue has lower metabolic rate than the fat-free or lean body mass. Hence, BMR is better expressed in terms of fat-free or lean body mass. However, since adipose tissue contributes to body size, the energy cost of physical activity (body movements) must be calculated considering the body size.

3. Age Energy expenditure declines rapidly as age advances. Childhood is characterized by rapid growth and high physical activity. In infants, energy required to maintain the body temperature also increases the energy cost. In adults, there is a decrease in lean body mass and increase in adipose tissue, causing lowered BMR.

Table 2.3 Gross energy costs for different activities of average young adults*
(Inclusive of basal metabolism and influences of food)

Activity	Cal/min	Activity	Cal/min
Sleep (basal)	1.0–1.2	Walking, 3.5 mph, level	
Dressing, washing, etc.	3.0–4.0	Weight, 100 lb	3.6
<i>Light indoor activities:</i>		140 lb	4.6
Lying at ease	1.4–1.5	180 lb	5.4
Standing at ease	1.7–1.6	Walking, 3.5 mph, upwards	
Sitting, writing	1.9–2.2	10 percent incline	
Sitting at ease	1.5–1.9	Weight, 155 lb	8.9
Sitting, playing cards or musical instruments [†]	2.0–2.6	Driving a car	2.8
		Canoeing, 2.5 mph	3.0
<i>Transportation:</i>		4.0 mph	7.0
Walking, 2 mph, level		Horse-riding, walk	3.0
Weight, 100 lb	2.6	trot	2.8
140 lb	2.9	Cycling, 5.5 mph	4.5
180 lb	3.5	9.4 mph	7.0
Climbing stairs		<i>Recreation involving moderate exercise:</i>	
Weight 140 lb	6.2		
180 lb	8.6	Playing with children	3.5
Walking on loose snow,		Dancing, waltz	5.7
Level, 2.5 mph, 180 lb		rhumba	7.0
man with 44 lb pack	20.2	twist	10.0
<i>Work tasks:</i>		Archery	5.2
Sweeping floors	1.7	Tennis	7.0
Machining sewing	2.8	<i>Recreation involving hard exercise:</i>	
Scrubbing, kneeling	3.4	Swimming	5.0–11.0
Ironing	4.2	Football	8.9
Typing 40 words/minute		Cross country running	10.6
manual	1.5	Climbing, light load and slope	10.7
electric typewriter	1.3	large load and slope	13.2
Gardening, weeding	4.4–5.6	Skiing hard snow	
digging	8.6	level, 3.7 mph	9.9
Ploughing with tractor	4.2	uphill, max. speed	18.6
Light industry ^{††}	2.2–3.0		
Carpentry tasks	2.4–9.1		
Coal mining tasks	5.3–8.0		

* Adapted from Passmore, R and Durin, J V G A Human energy expenditure, Physical. Rev. 35:801, 1955

† Playing Piano strenuously or instruments such as woodwinds, stringed instrument or drums—4.0–4.2.

†† Industry such as printing, radio mechanics, shoe repairing.

4. Diet It affects the BMR, both immediately as well as over a long period. Post Prandial Thermogenesis (PPT) is greater when more proteins are consumed than carbohydrates or fats. For a mixed diet which is predominantly vegetarian, the PPT may be between 5 to 15 percent.

5. Climate This factor affects energy expenditure due to its role in maintaining temperature. Temperatures below 25°C may increase energy expenditure, above 30°C may cause sweating and thereby increase energy expenditure.

6. Genetic Differences BMR varies up to 10 percent due to the ethnic, racial and genetic variations.

7. Hormonal State Endocrine disorders such as hyperthyroidism and hypothyroidism affect energy expenditure to a very great extent. In the former, BMR increases while it decreases in the latter. During pregnancy, initially there is a fall in the BMR, which rises markedly at the end of the gestation accounting for the weight gain. In lactation too the BMR falls.

8. Psychological State Acute anxiety does increase energy expenditure.

9. Active Substances Caffeine and theophylline, the alkaloids found in beverages like tea and coffee and other drugs like nicotine, amphetamines, etc., increase energy expenditure.

10. Disease Accompanied by catabolic processes, fever, tumours, burns, etc., increase the energy expenditure.

2.5 SPECIFIC DYNAMIC ACTION (SDA) OR POST-PRANDIAL THERMOGENESIS (PPT) OR THERMIC EFFECT OF FEEDING (TEF)

Dubois has compared the effect of food on metabolism to a tax deducted at source, which thus reduces the amount of income. This is the heat increment of feeding which was earlier termed as SDA. Sometimes the term DIT is used, which refers to Diet-Induced Thermogenesis. But, generally it refers to the long-term effects of food intake on energy expenditure. For example, overfeeding markedly increases the BMR.

PPT takes place due to energy expended in the digestion, absorption and transport of ingested nutrients.

TEF is of two types:

- (a) Obligatory, i.e. the energy cost of absorption, transport of nutrients and synthesis and storage of carbohydrates, proteins and fats.
- (b) Facultative, which is the excess energy expended above the obligatory thermogenesis. It is partially mediated by the activity of the sympathetic nervous system.

The rise in metabolic rate after eating carbohydrate is only about 6 percent of the total fuel value of the food, i.e. energy expenditure increases by 6 cal for each 100

cals of carbohydrate consumed. The increase in energy expenditure caused by fat is also almost the same. But this figure for protein metabolism is about 30 percent. A diet containing a lot of meat will have a PPT of around 10 percent. For an ordinary mixed diet this may be taken as 6 percent, which is a sufficient allowance. Energy expenditure increases for four to eight hours after food is eaten, and its magnitude and duration depends upon the quantity and type of macronutrient consumed, i.e. proteins, fats or carbohydrates.

2.6 CALORIFIC VALUE OF FOOD

The energy needs of the body are calculated in terms of calories (sometimes called the kilocalorie or kcal) or in the metric system, the joule.

One calorie is equal to 4.184 joules which may be rounded off to 4.2 joules.

The number of calories obtained from a food is its *calorific value*. Every food varies in its calorific value. See Table 2.4 A and B for the average calorific value of some common foods.

The variation in calorific value of foods is due to the amount of carbohydrates, fats and proteins in each of them, e.g. one *paratha* made of wheat flour and oil gives about 250 calories while a glass of coconut water gives only 45. This is because the former contains a large amount of carbohydrates, fair amount of proteins and some fat, while the latter contains negligible quantity of carbohydrates, proteins and fats.

Table 2.4(A) ICMR standard chart

Food categories	Measure	Calories	Food categories	Measure	Calories
Milk (Cow)	90 ml	50	Biscuit (Sweet)	15 g	70
Milk (Buffalo)	45 ml	50	Cake (Chocolate)	50 g	225
Cheese	15 g	50	Dosa (Plain)	1 medium	120
Butter	1 tbsp	50	Dosa (Masala)	1 medium	250
Ghee	1 tbsp	50	Pakoras	50 g	175
FRUITS			Puri	1 Large	85
Apple	1 small	50–60	Samosa	1 piece	140
Banana	1 medium	50–60	Medu Vada	1 small	70
Grapes	20 small	50–60	PROTEIN/MEAT		
Mango	1 small	50–60	Fish	50 g	55
<i>Musambi</i>	1 medium	50–60	Mutton	1 oz	75
Orange	1 small	50–60	Egg (Hen)	2 pieces	100
VEGETABLES AND DAL			MAIN DISH		
Potato	1 medium	80	Mutton Biryani	1 cup	225
<i>Dal</i>	1 large katori	80	Veg. Biryani	1 cup	200

(contd.)

(contd.).

<i>Food categories</i>	<i>Measure</i>	<i>Calories</i>	<i>Food categories</i>	<i>Measure</i>	<i>Calories</i>
Mixed Vegetables	150 gms	80	Chicken curry	100 gms	225
SWEETS			Veg. Curry	100 gms	130
Carrot Halwa	100 gms	600	Fried rice	85 gms	140
Jelebi	100 gms	500	Veg. Pulav	100 gms	130
Kheer	100 gms	180	BEVERAGES		
Rasgulla	100 gms	90	Beer	12 Fl. Oz	150
Shrikhand	100 gms	350	Cola	200 ml	90
Basundi	100 gms	500	Wine	3.5 fl.Oz	85
Puranpoli	100 gms	160			
Gulab Jamun	100 gms	300			

Table 2.4(B) Calorific value of some common foods

<i>Food</i>	<i>Average</i>	<i>Quantity</i>	<i>Calories</i>
Milk (Buffalo's)	1 cup	5 oz	200
Tea	1 cup	5 oz	60
Coffee	1 cup	5 oz	75
Bread	1 slice	30 g	75
Butter	1 tsp	5 g	35
Cheese	1 piece	28 g	110
Biscuit	1	8 g	30
Jam	1 tsp	20 g	55
Cornflakes	1 cup	25 g	100
Cake, plain	1 piece	75 g	220
Chapati	1 thin	15 g	40
Puri	1	16 g	70
Paratha	1	70 g	250
Dal	1 cup	6 oz	200
Green vegetables	1 cup	6 oz	75
Potato	1	100 g	80
Potato chips	10 pieces	20 g	100
Rice khichdi	1 cup	210 g	250
Rice (puffed)	1 cup	15 g	50
Oil, ghee	1 tsp	5 g	45
Cream	1 tsp	½ oz	50
Fruit	1	100 g	60
Coconut water	1 glass	8 oz	45
Lemon juice	1 glass	8 oz	75
Coca cola, Gold spot	1 bottle	6 oz	80
Pie (apple)	1 serving	160 g	380
Jelly (plain)	1 tsp	65 g	65
Sugar	1 tsp	5 g	20

(contd.)

(contd.).

Food	Average	Quantity	Calories
Tomato ketchup	1 tsp	15 g	15
<i>Idli</i>	1	75 g	75
<i>Dosa</i> (plain)	1	50 g	110
<i>Dosa</i> (masala)	1	100 g	210
Almonds	15	30 g	190
Cashewnuts	15	30 g	170
Groundnuts	1 tsp	15 g	90
Egg	1	50 g	75
Omelette	1	40 g	210
Chicken/mutton soup	1 serving	7 oz	35
Meat (cooked)	1 slice	30 g	80
Chicken, roast	1 serving	100 g	200
Meat	1 serving	150 g	350
Fish fry	1 serving	100 g	220
Beer	1 glass	8 oz	100
Whisky, gin/rum	1 measure	1 ½ oz	110

The contribution of calories from carbohydrates, fats, proteins and alcohol are given in Table 2.5.

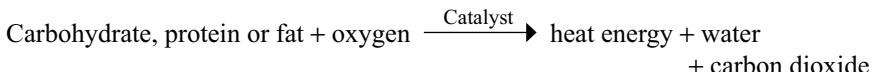
Table 2.5 Energy values of food and alcohol

Substance (1 gram):	In bomb calorimeter	In human body	
	kcal	kcal	kJ*
Protein	5.65	4	17
Carbohydrate	4.1	4	17
Fat	9.45	9	38
Alcohol (absolute ethanol)	7.1	7	29

* The values are rounded off for easy reference.

These values are derived with the help of an instrument called *bomb calorimeter*.

In this instrument, a small electric spark ignites the sample in the presence of oxygen and catalyst such as platinum. The amount of heat energy released by the complete oxidation of the sample raises the temperature of the surrounding water.



A similar process takes place in every cell of the human body but with a difference. The human body always derives less energy than the bomb calorimeter from a given amount of food. This is due to the body's efficiency for utilization of proteins, fats and carbohydrates. This is more true in the case of protein which is not

oxidized completely in the body, a fact that limits the energy released and leads to the formation of by-products such as urea and uric acid.

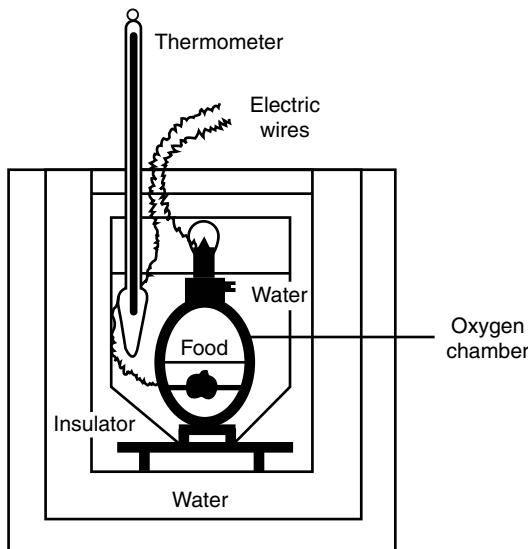


Fig. 2.2 The bomb calorimeter

From this we can understand that in the body:

- 1 g of carbohydrate yields 4.0 cal or 17 J
- 1 g of protein also yields 4.0 cal or 17 J
- 1 g of fat yields 9.0 cal or 38 J

Fats are a more concentrated source of energy than carbohydrates and proteins, and limiting fats in the diet while cutting down on calories helps weight loss and restricts weight gain.

2.7 DETERMINING YOUR OWN ENERGY NEEDS

The calorific needs of people of different ages and sex have been given by the RDI. At times it is necessary or desirable to obtain a more specific estimate of one's minimum calorific requirement. This can be obtained in the following way. (Also refer to the method described in Chapter 8.)

- STEP 1 Determine your BMR. It is generally held to be equal to about 1 calorie per kilogram per hour. Convert your body weight from pounds to kilograms by dividing the pounds of body weight by 2.2 (2.2 pounds = 1 kilogram).
- STEP 2 Multiply the number of kilograms of body weight by 24 (hours per day) to obtain calorie expenditure for BMR for 24 hours.
- STEP 3 Multiply the answer in Step 2 by 0.5 (50 percent).
- STEP 4 Add answers in Steps 2 and 3. The total sum is your minimum daily calorific requirement.

This method of calculating the minimum energy requirement is applicable to people who lead a moderately active life. It does not apply to heavy workers such as labourers and athletes, whose calorie requirement is much higher depending on their work.

The following example illustrates the method of calculating the total energy requirement. A person weighing 50 kg will need 50×24 cal, i.e. 1200 cal per day for BMR (Steps 1 and 2) 50 percent of 1200 is 600 kcal (Step 3). Therefore, his total minimum calorie requirement is $1200 + 600 = 1800$ kcal (Step 4).

Other methods of measuring the body's energy requirement are by direct and indirect calorimetry. Figure 2.3 illustrates direct calorimetry method.

□ Consumption Units

Practical nutrition work often involves the assessment of the intake of a group of persons. In such cases, it is commonly assessed by using an appropriate coefficient to the different age and sex groups. The needs of women and children are assessed in terms of those of the average man.

The energy consumption of an average male during a sedentary work is taken as one unit and the other coefficients are worked on the basis of their calorie requirements relative to that of a sedentary man.

One unit of coefficient corresponds to energy requirement of 2400 kcal/day. It is important to note that the scale of coefficients is applicable only to energy and must not be applied when assessing the needs for other nutrients.

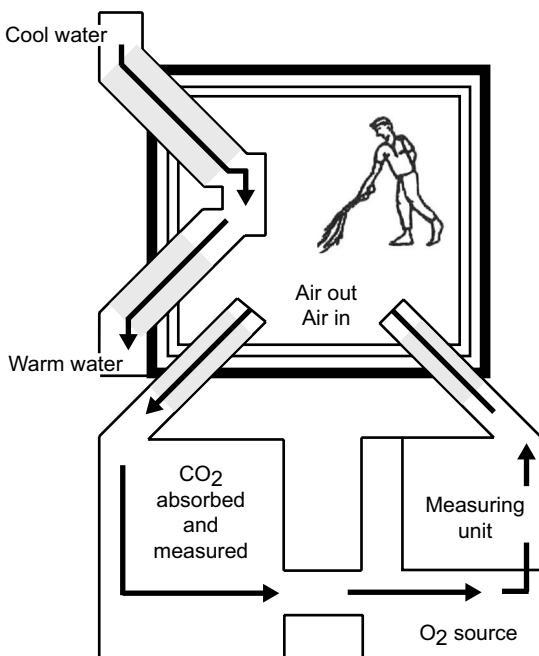


Fig. 2.3 Direct calorimetry method

Refer Table 2.6 which can be used for calculating the energy needs of a group.

With the help of this table, balanced diets yielding approximately the right amount of energy can be calculated. For this, the consumption units of a group is calculated (approximately) and the daily energy requirement for the group calculated by multiplying 2400 by the factor.

Table 2.6 Coefficient for computing calorie requirement of different groups

Group		Consumption units (CU)
Adult male	(sedentary worker)	1.0
Adult male	(moderate worker)	1.2
Adult male	(heavy worker)	1.6
Adult female	(sedentary worker)	0.8
Adult female	(moderate worker)	0.9
Adult female	(heavy worker)	1.2
Adolescents	12 to 21 years	1.0
Children	9 to 12 years	0.8
Children	7 to 9 years	0.7
Children	5 to 7 years	0.6
Children	3 to 5 years	0.5
Children	1 to 3 years	0.4

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The total energy requirement of various age groups can also be expressed in terms of basal energy requirement values. This takes care of differences in energy requirement due to age, growth, etc. Since, BMR values are available for a large number of subjects, computation of energy in any group becomes convenient. This procedure is employed by the recent FAO/WHO/UNU Committee on Energy and Protein requirements. This approach has also been adopted by the Expert Group of the ICMR of 1988 in arriving at energy needs of Indians.

2.8 TRANSLATING RDA INTO DAILY FOOD INTAKE

The system of classifying foods into various food groups is a way of translating RDA into a meaningful system that can be used for planning diets. The food group system is used to convert quantitative nutrient data into food related information that can be used both by the consumer and health professionals in planning diets in order to achieve nutritional adequacy. A wise housewife can choose from these groups and experience the difference that it makes to the health of her family. Her selection from a wide variety of foods within the family budget to get all the nutrients in the right amount can be guided by the simple principle of knowing the *basic food groups*.

The *five food group* system can be used for the following purposes:

1. *Nutritional assessment and screening* by which the inadequacies of a diet can be gauged.

2. *Nutritional counselling*: A patient can be counselled easily with the help of the *five food group* system.
3. *Therapeutic dietary counselling*: A patient can be scientifically explained about the dietary modifications when planning his therapeutic diet.
4. *Labelling of foods and surveillance system*: A consumer can be well-informed about the nutritional constituents of a commercial food product. It can also be useful in nutrition surveillance systems.

A daily food guide for India (Table 2.7) very simply provides information about the five basic food groups. If sufficient quantity of food (in terms of servings) from each of the five food groups is included in the daily diet, the nutrient needs of the body will be easily met. Such a diet is then termed as a *balanced diet*.

2.9 THE FIVE FOOD GROUPS

According to the food guide, the *five food groups* are:

1. Pulse-milk-egg-meat-fish group of body-building foods
2. Protective vegetable and fruits group
 - (a) Green and yellow vegetables and fruits group
 - (b) Amla-guava-citrus fruits group
3. Other vegetables and fruits group
4. Cereals and millets group
5. Oils, fats and sugars group

Table 2.7 Daily food guide

Food groups	Foods	Size of serving	No. of servings
1. Body Building Foods	Pulses/legumes, nuts and oil-seeds Milk and milk products Eggs Fish, poultry, meat	25 g 150 g 1 30 g	3–6 One serving equivalent to one cup medium thick <i>dal</i> (pulse) or one cup <i>usal</i> (legume) or one cup milk or one cup curd or one egg or one medium-size fish fillet or chicken or meat piece
2. Protective Foods Vegetables and Fruits	(A) Green leafy vegetables and yellow, orange fruits and vegetables	50–75 g	1 or more One serving equivalent to half-cup cooked leafy vegetable or one mango or half cup shredded carrot

(contd.)

(contd.)

<i>Food groups</i>	<i>Foods</i>	<i>Size of serving</i>	<i>No. of servings</i>
	(B) Vitamin C-rich vegetables and fruits <i>Amla*</i> , guava, drumstick orange, papaya, sweetlime, cashew, apple, tomato, etc.	50–75 g	1 or more One serving equivalent to 1–2 slices of ripe papaya or one small sweetlime or One orange or one medium-sized tomato
3. Other Vegetables and Fruits, Roots and Tubers	Lady's fingers, all gourds, brinjal, Potatoes, yam, sweet potato Banana, chiku pear, peach, etc.	50–75 g	2 or more One serving equivalent to half cup <i>brinjal</i> or bhendi curry or one banana
4. Cereals and Millets	<i>Bajra, jowar, maize, ragi</i> , rice, wheat and their preparations	30 g	6 to 12 One serving equivalent to half cup cooked rice or one medium-sized <i>chapati</i> or one slice bread or 2–3 small <i>puris</i>
5. Energy Group	Oils, fats, and sugars Oils and fats Sugar and jaggery	25 g** 25 g***	1 or more 1 or more

* Only 10 g *amla* will suffice

** One serving equivalent to: 1 teaspoon fat or oil

*** One serving equivalent to: 1 teaspoon table sugar

The role of these five food groups in the diet is comprehensively shown in Table 2.8. It must be remembered that each group supplies some nutrients and not all nutrients. A combination of items selected from each of the five groups in the right proportion is ideal and will work towards a *balanced diet*.

Let us look as to what comprises each group and what their rich contributions in terms of nutrients are the following:

Table 2.8

<i>Food groups</i>	<i>Foods included in the group</i>	<i>Principal nutrients in the group</i>
1. Body-building foods (A) Milk	Whole, skim, dry, evaporated, condensed milk, cheese, ice-cream, yoghurt, curds	The milk group is the best source of calcium and riboflavin. It also contains protein, phosphorus, carbohydrate, thiamine, and vitamin D. Whole milk contains in addition to fat, vitamin A. Do not substitute calcium tablets because they do not contain protein and riboflavin. Do not substitute cream because it is the fat content of milk. Do not substitute condensed milk because it has a very high sugar content.
(B) Meat, poultry, fish and eggs	Mutton, <i>keema</i> (minced meat), fish, shellfish, crabs, crustaceans, chicken, eggs	Meat, poultry, fish and eggs supply protein, iron, thiamine, niacin, fat, phosphorus and some riboflavin. Liver is an excellent source of vitamin A and iron. Saltwater fish contains iodine. Eggs have protein, iron, thiamine, phosphorus, riboflavin and the yolk has vitamin A and fat.
(C) <i>Dal</i> , nuts and oil-seeds	<i>Tur</i> , <i>mung</i> , <i>masur</i> and several legumes and their <i>dals</i> . Nuts include peanuts, coconuts, almonds, pistachios and walnuts. Oilseeds include sesame (<i>til</i>), garden cress seeds (<i>haliv</i>), etc.	This group supplies protein, iron and thiamine. However, the protein in legumes is of a lower quality than that found in meat, fish and eggs. The nuts supply fat, protein, iron, thiamine, riboflavin and niacin.
2. Protective vegetables and fruits group (A) Yellow and orange fruits and vegetables and leafy vegetables (B) Vitamin C-rich group	All leafy vegetables (<i>sag</i> , <i>keerai</i> , <i>palak</i>) cabbage, onion tops, carrots, orange, mango, papaya. All citrus fruits like <i>amlas</i> , lemon, guava, lime, orange, grapefruit, tomato and vegetables like drumstick, cabbage, etc.	The dark green and yellow vegetables are a rich source of vitamin A. The leafy vegetables are rich source of iron, fibre and some amounts of vitamins and minerals. Rich sources of vitamin C.

(contd.)

(contd).

<i>Food groups</i>	<i>Foods included in the group</i>	<i>Principal nutrients in the group</i>
3. Other vegetables and fruits, roots and tubers	Brinjal, French beans, <i>gavar, papdi</i> , yam, potatoes, onions, cucumber, <i>dudhi</i> , beetroot, bananas, grapes, melons, apples.	Potatoes have thiamine, iron, vitamin C, besides being rich in starch. Other vegetables supply small amount of vitamins and minerals besides supplying good amount of fibre. Vegetables and fruits from this group should not be used to substitute vegetables and fruits from group 2 (A) and (B), i.e. the vitamin A and C-supplying foods.
4. Cereals and millets	Rice, wheat, <i>jowar, bajra, ragi</i> , maize and their products such as <i>suji (rawa)</i> , rice flakes (<i>poha</i>), puffed rice (<i>kurmura</i>), vermicelli, spaghetti, bread, pizza, noodles.	All cereals contain starch and some incomplete protein. To achieve protein of high biological value, combine cereal and pulse preparation. Whole grain cereals contain thiamine and cellulose.
		Polished grains (e.g. polished rice) are of poorer nutritive value than their whole grain counterparts. Bread manufactured by the large companies which is pre-sliced contains added nutrients like lysine and is of better quality than the ordinary baked ones. <i>Poha</i> or riceflakes also supply some amount to iron.
5. Oils and fats, sugar and jaggery	All oils like groundnut, mustard, <i>til</i> , sunflower, corn, soya, etc. All fats such as <i>ghee</i> , butter, <i>vanaspati</i> . Sugar like <i>khadisakhar</i> (large crystals) table sugar, sugar cubes, powdered sugar, etc.	Supply calories (1 g = 9 cal) and essential fatty acids. Oils containing the PUFA* (Poly-unsaturated fatty acids) are advised for consumption (corn oil, safflower oil and soya oil) than the oils containing saturated fatty acids. Refined oils are enriched with vitamins A and D. <i>Ghee</i> , butter and <i>vanaspati</i> contain saturated fatty acids; hence consumption must be limited. Good source of vitamins A and D. Sugar and jaggery supply only energy (1 g = 4 cal).

Pulse-Milk-Egg-Meat-Fish Group or Body-Building Foods

The foods included in this group are important for their protein content. Proteins are required for replacing the wear and tear of the body and building of tissues. These foods also supply some amount of the B-vitamins such as thiamin, riboflavin and niacin. Eggs, milk and liver are good sources of iron and milk is a good source of calcium. One serving of this group supplies about 5–6 grams of protein.

The following points should be kept in mind while choosing items from this group:

1. Pulses include all types of *dals*, e.g. *mung dal*, *tur dal*, *masur dal*, etc. Legumes include all dry whole grams, beans, peas, etc. Nuts and oilseeds include those in common use such as sesame, which can be included in sufficient amount to contribute to the daily protein intake. Pulses and legumes offer a great deal of variety and an alteration or combination of these adds to the quality and delicacy of the diet. 25 g of each of these is taken as one serving unit. Milk includes curds and other preparations containing whole milk (5–6 percent). An average teacup or 150 ml is counted as one serving unit.
2. Egg in a diet means a hen's egg. One egg (40–50 g) is considered as one serving.
3. Meat-Fish-Poultry refer to lean parts of the animal. The protein content of the lean parts is the same but if the adhering fat is not removed, the protein content decreases in the portion of meat.

The Protective Group Including Vegetables and Fruits

This group is a rich source of beta-carotene (a precursor of vitamin A). It includes the dark green leafy vegetables such as spinach, fenugreek, radish, amaranth, coriander leaves, the light green leafy vegetables such as cabbage, and onion-tops and deep yellow vegetables and fruits such as carrots, orange, red pumpkin, mango, papaya and apricots.

Half a cup or 50–75 g of the cooked vegetable or chopped fruit can be counted as one serving unit. Whole fruits such as mango and orange may be counted as one serving.

Almost half a day's need for vitamin A is satisfied by one serving of this group.

Vitamin C-rich Vegetables and Fruits

This group includes fruits and vegetables such as *amla*, lemon, *ber*, guavas, drumsticks, cabbage, all citrus fruits such as oranges, grapes, and all other fruits such as papaya, pineapple, tomato, strawberries, etc.

Half a cup of fruit or 50–75 grams of vegetable or a portion as ordinarily served such as a slice of papaya or an orange is counted as one serving. The foods in this group are a rich source of vitamin C and fibre.

At least one serving of this group must be eaten everyday.

Other-Vegetables-and-Fruits Group

These include brinjal, cucumber, pumpkin, *bhendi*, all ash-gourds, i.e. bottle, snake, ridge gourds, etc., all immature beans and peas, beetroot, radish, potatoes,

sweet potatoes and yam. Other fruits include bananas, apples, melons, grapes, berries, etc.

Half a cup or 50–75 g of these may be considered as one serving unit. An intake of at least two or more servings of this group is recommended per day.

□ Cereals-and-Millets Group

Foods in this group provide carbohydrates, proteins and calories. The seeds of plants are richer in thiamine than all other portions of the plant. Cereals such as wheat and rice may then be considered as a good source of thiamine.

The foods in this group are edible seeds of plants belonging to the grass family. They are preparations of rice, wheat, *jowar*, *bajra*, maize, *ragi* (*nachni*) and their products such as *suji*, rice flakes, vermicelli, etc.

Any preparation containing 25 g of the cereal may be counted as one serving. In practice, it means half a cup of cooked rice or one medium *chapati*, two to three *puris*, or one small *roti*, one slice bread, 25 g riceflakes or any ready-to eat-cereal.

At least six or more servings may be selected from this group. In order to improve the quality of protein, the meal may include two or more cereals and using a cereal and pulse-legume combination, e.g. *khichdi* using rice and *tur dal*, has better protein quality than rice alone.

□ Sugar and Jaggery, Fats and Oil Group

Foods in this group mainly supply energy. This group is hence known as the *fuel group*. Sugar and jaggery release energy very easily, while fats and oils are concentrated sources of *reserve* energy.

Jaggery (*gud*) is the unrefined concentrate obtained from sugarcane juice. It is commonly used in several preparations in our country. It is a good source of minerals especially iron since it is prepared in iron vessels.

Sugar is mainly used to sweeten beverages like tea and coffee, *sherberts* and squashes. About 25 g per day is sufficient.

Oils and fats are used for seasoning our food. They improve the palatability, flavour, texture and satiety value of food. Apart from this, oils and fats are also important as they carry fat-soluble vitamins like A, D, E and K into the body and to the tissues. Hydrogenated fats are generally fortified with vitamin A. It is, therefore, advisable to use these in the daily diet.

Oils include all vegetable oils such as groundnut, sesame, coconut, sunflower, mustard, safflower, corn, soyabean, palm, etc.

Fats include *ghee*, butter, margarine as well as hydrogenated vegetable oils commonly called *vanaspati*.

Oils, besides giving energy, are invaluable for the essential fatty acids (polyunsaturated) that they supply. These fatty acids are found in all oils and fats in more or less amounts. Especially rich in these are safflower, corn, soyabean, cottonseed and sunflower oils (Table 2.9).

The Recommended Dietary Intakes (1988) suggested that fat in the diet should not exceed an amount that can provide 15–20 percent of the total recommended calorie intake. Fat intake should include at least 15 g of vegetable oils in order to meet the requirement of essential fatty acids. In young children, fat in the diet should

provide more than 25 percent of the total calories of the diet. However, for all age groups about half of this will come from invisible fat in the diet.

Table 2.9 Poly-unsaturated fatty acids in some edible oils and fats

S. No.	Fat or oil	PUFA content (g per 100 g)
1.	Coconut oil	2
2.	Cottonseed oil	50
3.	Ghee (Butter fat)	4
4.	Groundnut oil	28
5.	Maize oil (corn oil)	45
6.	Mustard oil	25
7.	Olive oil	10
8.	Rice bran oil	35
9.	Safflower oil (<i>Kusuma</i> oil)	75
10.	Sesame (Gingelly oil)	42
11.	Soybean oil	55
12.	<i>Vanaspati</i>	6

□ Miscellaneous Foods

This category is not included in the *basic five food groups*, but the items listed herein are an integral part of the Indian diet. They are spices and condiments, pickles, *papads* and *chutneys*. All these either impart taste and typical aroma to food or contribute to one or the other nutrients, e.g. the *paan* (betel leaf smeared with slaked lime or calcium hydroxide) is a rich source of calcium. Salt is the essence of our daily food and provides sodium, which is essential for our muscle control. Today, iodized salt is very commonly used in cooking, providing iodine which is a boon to people living in goitre-affected areas.

Some guidelines that may be followed in using the daily food guide for planning and evaluation are the following:

1. Choose *at least* the minimum recommended number of servings from each of the food groups.
2. Make choice within each group according to the nutritive value of the food to be replaced.
3. Try to include *at least one food* from Group 1 in *each meal*.
4. Energy derived from cereals should be not more than 75 percent of total energy requirement.
5. Ratio of cereal-protein to pulse-protein should be kept between 4 : 1 and 5 : 1.
6. A minimum milk intake of 100 ml is included.
7. Energy derived from refined carbohydrates like sugar or jaggery should be about 5 percent, and total calories from fat and sugar not to exceed 20 percent of the required calories.
8. At least, 80 g of other vegetables and minimum required quantity of leafy vegetables should be included in the diet.

Keeping in mind the basic principles of the five food groups, one can plan one's meal. Alternatively, the reader may try to evaluate his present diet to judge if he follows the simple guidelines stressed upon by the basic five food groups.

However, whether at home or in hospitals, when a housewife or a dietitian professional or a health is required to make a quick but reasonably accurate appraisal of the nutritive value of diets or if she is required to calculate diets with one or more nutrients in restricted amounts, an easier method of calculating and planning a meal comes in handy.

This method is known as using *The Exchange Lists*. It has two main purposes:

1. Rapid calculation of diets that need restrictions on carbohydrates, fat, protein and calorific value.
2. Advising patients as to which foods can be used by them and in what amounts in their diets.

NIN and ICMR have altered the five food group system which has been shown in Table 2.10

Accordingly, the Food Exchange System also has 6 lists as shown in Table 2.11.

Table 2.10 Five food group system

S. No.	Food group	Main nutrients
1.	Cereals Grains and Products Rice, Wheat, Ragi, Bajara, Maize, <i>Jowar</i> , Barley, Rice flakes, Wheat flour	Energy, Protein, Invisible fat, Vitamin B ₂ , Folic Acid, Iron, Fibre
2.	Pulses and legumes <i>Bengalgram, Blackgram, greengram, Redgram, lentil (whole as well as dals), Cowpea, Peas, Rajmah, soyabeans, Beans, etc.</i>	Energy, Protein, Invisible fat, Vitamin B ₁ , Vitamin B ₂ , Folic Acid, Calcium, Iron, Fibre
3.	Milk and Milk products Milk Milk, Curd, skimmed milk, Cheese Meat Chicken, Liver, Fish, Egg, Meat	Protein, Fat, Vitamin B ₂ , calcium Protein, Fat, Vitamin B ₂
4.	Fruits and Vegetables Fruits Mango, Guava, Tomato ripe, Papaya, Orange, Sweet lime, Water melon Vegetables (Green leafy) Amaranth, Spinach, Gogu, Drumstick leaves, coriander leaves, Mustard leaves, Fenugreek leaves Other vegetables Carrots, Brinjal, Ladies fingers, Capsicum, Beans, Onion, Drumstick	Carotenoids, Vitamin C, Fibre Invisible fat, Carotenoids, Vitamin B ₂ , Folic acid, Calcium, Iron, Fibre Carotenoids, Folic Acid, Calcium, Fibre
5.	Fats and Sugars Fats Butter, Ghee, Hydrogenated oils, Cooking oils like Groundnut, Mustard, Coconut Sugars Sugar, Jaggery	Energy, Fat, Essential Fatty Acids Energy

Table 2.11 The food exchange system

S. No.	Exchange list	Serving size or raw wt. (g)	Carbohydrate (g)	Protein (g)	Fat (g)	Energy (Kcal)
1.	Vegetables				*	30–40
	Green leafy	½ Cup	6	Nil	Nil	50–60
	Other	½ Cup	6–10	Nil		
2.	Fruit	Varies	10	Nil	Nil	40
3.	Cereal	25	19–21	2–3	*	85
4.	Legumes & Pulses	25	15	6	*	85
5.	Milk & Meat	½ Cup	4	3.5	4.0	65
		75	Nil	7.5	6.0	85
6.	Fat # sugars	10	Nil	Nil	10.0	90
		10	10	Nil		40
# Visible Fat			* Invisible Fat.			1 Cup = 200 ml.

2.10 THE EXCHANGE LIST SYSTEM

An exchange list can be defined as a list which contains a group of foods in specified amounts, which have approximately equal carbohydrate, protein and fat values. This does not mean that the values of two foods within the group are identical. There will be some differences in their values but these tend to nullify each other because of the variety of foods that are selected by the patient from within the group, day-to-day. Hence, any food from the given exchange list can be substituted or *exchanged* for any other food in that list. In the fruits list, e.g., one small mango can be substituted for one medium sweet-lime or four small tomatoes.

In all, there are eight exchange lists:

1. Milk exchange
2. Legume and pulse exchange
3. Flesh food exchange
4. Vegetable A exchange
5. Vegetable B exchange
6. Fruit exchange
7. Cereal exchange
8. Fat exchange

These are listed in Appendix V. The nutrients contributed by the eight exchanges are given in Table 2.12 which is referred to as the *Master Exchange List*.

Items such as tea, coffee, soup, spices, herbs, do not contribute significant amounts of the nutrients but make the diet more interesting. Hence, they may be included in the diet plan without any calculation except for the amount of sugar and milk added to tea and coffee.

Commercial Products The calorific value of some items such as jam, squashes, syrups, biscuits, cakes, *nankhatai* are shown in Table 2.4 and may be used as

sparingly as possible or, if included in the diet, an approximate number of calories may be substituted from the other eight exchange lists.

The minimum number of exchanges that must be included daily in the diet of a normal adult to ensure adequate intake of *nutrients* are given below. However, certain exchanges may be altered to suit the purchasing power of the person. It should be borne in mind that the alterations thus made, should fulfil the nutritional requirements satisfactorily.

Table 2.12 Composition of food exchange lists (master list)

Food	Group	Measure/Weight (ml/gram)	Carbohydrates (gram)	Fat (gram)	Protein	Energy (kcal)
1.	Milk	Refer List*	Refer List*	Refer List	5.0	100
2.	Legume and pulse	30 g	15	—	6.0	100
3.	Flesh food	Refer List*	—	Refer List**	10.0	70
4.	Vegetable A		Use Unlimited			
5.	Vegetable B	Refer List*	10	—	—	50
6.	Fruit	Refer List*	10	—	—	50
7.	Cereal	30 g	20	—	2.0	100
8.	Fat	Refer List*	—	11.0	—	100

* Details of each food group given in Appendix V.

** 13.0 g if two hen's eggs are used (i.e. one exchange).

1. *Milk exchange*—At least two exchanges.
2. *Legume and pulse exchange*—At least two exchanges.
3. *Flesh food exchange*—At least one exchange if the person is a non-vegetarian. If not, one exchange of legume and pulse may be increased.
4. *Vegetable A exchange*—At least two exchanges must be taken. They include all green leafy vegetables and some other vegetables which may be taken in unlimited quantity. They do not contain appreciable quantities of calories, protein, fat and carbohydrates, so they may be eaten liberally. However, of the two exchanges mentioned for the group, one exchange of green leafy vegetables and one exchange of the other vegetables will be the ideal distribution in the diet.
5. *Vegetable B exchange*—At least two exchanges should be included. This group includes root vegetables and some other vegetables. Similar to the previous exchange, one exchange of the two exchanges should be supplied by the root vegetables and one by the other vegetables given in the group.
6. *Fruit exchange*—At least two exchanges may be selected, one fruit from the vitamin C or vitamin A-rich group and the other from the other fruits being the ideal combination.
7. *Cereal exchange*—It includes all cereals and some cereal products. At least 6–12 exchanges may be included. One medium *chapati* or *paratha* or half a cup of rice or 2–3 medium *puris* are prepared from 30 g of the cereal.

8. *Fat exchange*—It lists some fats, oils and nuts which are generally eaten in a middle-class household. Generally, 3–4 exchanges may be served everyday.

Besides these eight exchanges, sugar is commonly used, one teaspoon or 5 g sugar contributes about 20 calories. 30–50 g sugar daily more than suffices.

□ Procedure for Calculation

When a normal diet is planned based on the Exchange List system, the calories and protein are calculated first. If the requirements of these are met satisfactorily, then it can be safely assumed that the requirements for the other nutrients of the normal diet will also be easily met.

For example, if a diet for a normal adult man is to be planned with 2400 cal and 53 g protein, refer to the master list.

1. Prepare a list of the minimum exchanges, especially of exchanges number 1, 2, 3, 4, 5 and 6, and calculate the calories and protein contributed by them.
2. Most of the balance calories and protein may be filled in by the seventh exchange list, i.e. cereals group.
3. Some of the calories may be contributed by the eighth exchange group.
4. The number of exchanges in group 1, 2 and 5 may be increased in case of pregnant and lactating women.
5. In case of toddlers, pre-schoolers, school-going children and adolescents, adjustment may have to be made in groups 1, 2, 3, 7 and 8.
6. An increase in calories and protein of the diet can be achieved by increasing the appropriate amounts of foods from lists 1, 2 and 7. An increase in calories alone can be achieved by increasing items listed in list eight or the amount of sugar in the menu plan.

Menu planning for an adult man and woman, using the exchange list, has been illustrated in Tables 2.13 and 2.14.

Table 2.13 *Menu plan for an adult man using exchange list*
(Requirement—2400 kcals; Protein—55 g)

Food Exchange List						
	Food group	No. of Exchange	Carbohydrates (gram)	Protein (gram)	Fat (gram)	Energy (kcals)
1.	Milk	3	15.0	15.0	15.0	300
2.	Legume and pulse	2	30.0	12.0	—	200
3.	Flesh food (Egg)	1	—	10.0	10.0	100
4.	Vegetable A	2	—	—	—	—
5.	Vegetable B	2	20.0	—	—	100
6.	Fruit	2	20.0	—	—	100
7.	Cereal	10	200.0	20.0	—	1000
8.	Fat	5	—	—	55.0	500
9.	Sugar	50 g	50.0	—	—	200
			335.0	57.0	80.0	2500

Menu Plan

Tea : 1 cup
Breakfast : Bread and Egg sandwich, bread slice—2 (using 5 g butter)
Boiled egg—1
Banana milkshake—1 glass
Lunch : Tomato soup—1 bowl
Chapatis—2
Rice—1 cup
Alu palak—1 cup
Dal—1 cup
Curd—1 cup
Tea : Tea—1 cup
Dinner : *Chapatis*—2
Green salad—1 small plate
Rice—1 cup
Urad-rajma dal—1 cup
Cauliflower curry—1 cup
Curd—1 cup

Table 2.14 *Menu plan for an adult woman using exchange list*
(Requirement— 2200 kcals; Protein—45 g)

Food Exchange List					
<i>Food Group</i>	<i>No. of Exchange</i>	<i>Carbohydrates (gram)</i>	<i>Protein (gram)</i>	<i>Fat (gram)</i>	<i>Energy (kcals)</i>
1. Milk	3	15.0	15.0	15.0	300
2. Legume and pulse	2	30.0	12.0	—	200
3. Flesh food	1	—	10.0	10.0	100
4. Vegetable A	2	—	—	—	—
5. Vegetable B	2	20.0	—	—	100
6. Fruit	2	20.0	—	—	100
7. Cereal	8	160.0	16.0	—	800
8. Fat	4	—	—	44.0	400
9. Sugar	40 g	40.0	—	—	160
		285.0	53.0	69.0	2160

Menu Plan

Tea : 1 cup
Breakfast : Coffee using milk and sugar
Bread butter—2 slices with butter
Egg fry—1
Banana—1 small
Lunch : *Chapatis*—2
Mung usal—1 cup
Rice—1 cup
Alu palak—1 cup
Dal—1 cup
Curd—1 cup
Orange—1 small
Tea : Tea—1 cup

Dinner	:	<i>Chapatis</i> —2
		Lady's finger curry—1 cup
		Green salad—1 small plate
		Rice—1 cup
		<i>Dal palak</i> —1 cup
		Curd—1 cup

2.11 UTILIZATION OF NUTRIENTS

Foods, when ingested in the body, release the nutrients contained in them, for the sake of giving energy, for the various body processes, maintenance of body tissue or reproduction.

The entire process that the food undergoes from the time it is eaten to its excretion is known as metabolism of food.

Metabolism of food is a combination of two important processes that take place in the body, namely:

- *Anabolism*—Process of building up of body substance.
- *Catabolism*—Process of breaking down of body substance.

Although food contains all the nutrients in various forms, i.e. complex as well as simple, the body efficiently converts the complex substances into their simpler constituents as only then they can be used for the various body functions.

The process of building new substances from the simple molecules present in the food is called *anabolism*, e.g. proteins present in the food are made up of simpler substances, i.e. amino acids and these are used for building new tissue proteins in the body.

Catabolism is the process of breakdown of various tissues to their simpler components, e.g. catabolism occurs in the breakdown of tissues during infections, burns, high fevers, routine wear and tear and various energy liberation processes.

This building up and breaking down of substances is a continuous process in the body and requires a constant supply of nutrients.

Nutrients are obtained from food by the process of metabolism that takes place in the following steps:

- Digestion
- Absorption
- Assimilation

The digestive system is specially developed for this purpose. It begins at the mouth and comprises the food pipe (oesophagus), stomach, small and large intestines, and it ends at the anus. The liver, gall bladder, salivary glands and pancreas are associated with the process of digestion. Figure 2.4 illustrates our digestive tract.

The function of each of the organs of the digestive system in brief are:

1. *Mouth.* Chewing the food (mastication) and mixing with saliva coming from salivary glands.
2. *Oesophagus.* Passage for the food from mouth to stomach.
3. *Stomach.* Storage and churning of food along with various secretions such as hydrochloric acid, pepsin, rennin.

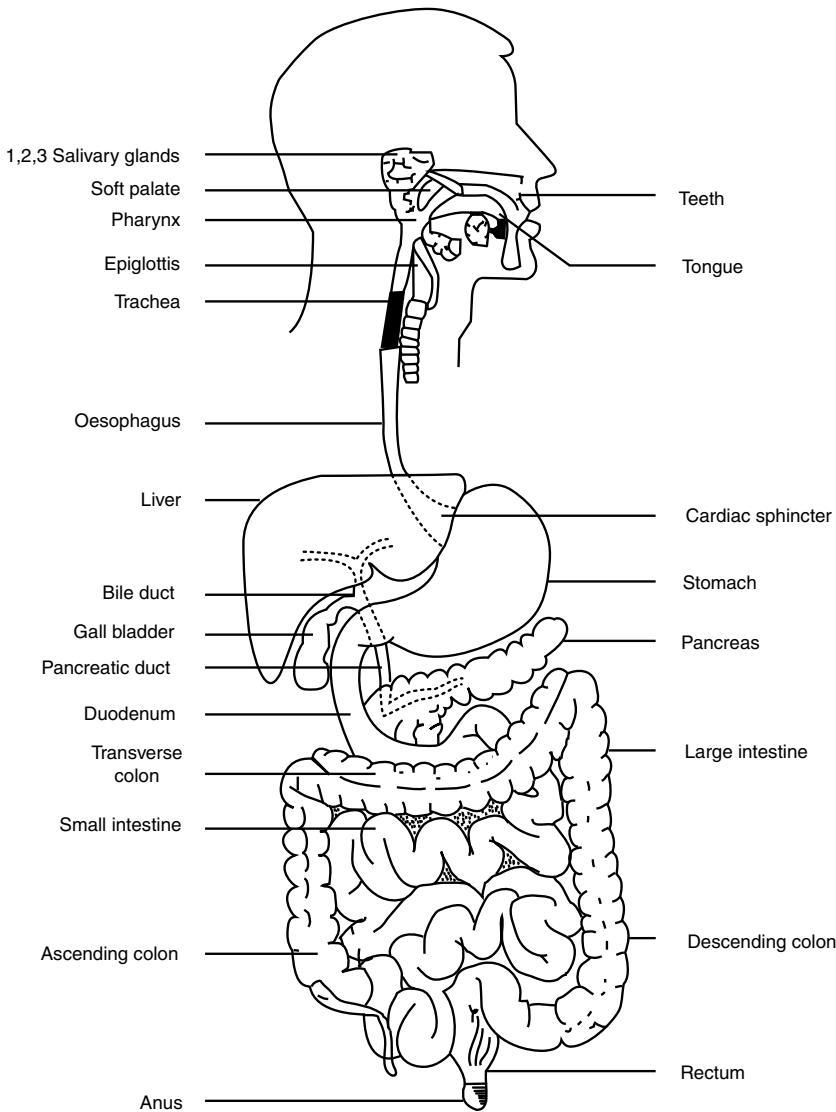


Fig. 2.4 Our digestive system

4. *Small intestine.* Made up of three parts, duodenum—a U-shaped loop of the small intestine receives pancreatic and bile juices; jejunum and ileum complete digestion and absorb the digested product through the villi (Fig. 2.5).
5. *Pancreas.* It is a diffused gland in the loop of the duodenum. It secretes digestive enzymes and also insulin which is the hormone responsible for carbohydrate metabolism.
6. *Liver.* One of the largest glands in the body as well as an important one, secretes bile which is stored in the gall bladder. The liver also stores sugar in the form of glycogen, the fat-soluble vitamins, etc.

1. Blood vessel—carry glucose, amino acids, vitamins, minerals, etc.

2. Lymph vessel—carry digested fat, i.e. fatty acid and glycerol

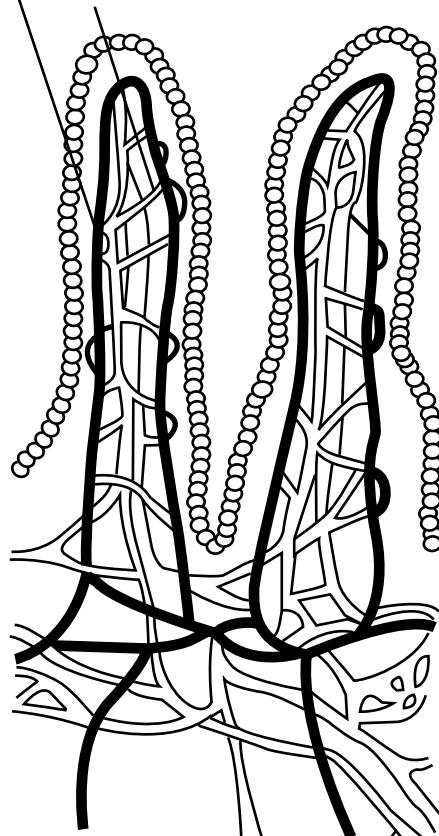


Fig. 2.5 The villi

7. *Gall bladder.* It is the storage gland for bile secreted by the liver. Bile has several functions.
 - (a) It is strongly alkaline, hence, the acidic food passing into the duodenum on mixing with bile becomes alkaline. This change from the acidic state to alkaline is essential for the action of enzymes in the small intestine.
 - (b) It prevents growth of bacteria.
 - (c) It emulsifies fat so that action of lipase is effectively brought about.
8. *Large intestine, Colon and Rectum.* The reabsorption of water and certain B vitamins take place in the large intestine. The waste products pass down into the colon and are stored in the rectum till they pass out as stools from the anus.

Let us see what happens to the food at the various levels of digestion in the digestive tract.

2.12 DIGESTION PROCESS

The enzymes present in our digestive system play a major role in the digestion process. The various enzymes are shown in Table 2.15 along with the organ in which they are secreted, the food on which they act and the products of their action.

The food moves through the gastro-intestinal tract by the regular contractions of the smooth muscles of the system. These movements are wave-like and called peristaltic movements and the process, *peristalsis*.

Digestion of carbohydrate takes the least time, protein the next and fat takes the longest. Food takes about 12 to 24 hours to travel from the mouth to rectum. A normal person digests and absorbs almost 90–95 percent of the food eaten.

Factors that affect digestion are the following:

(a) Consistency, Division and Type of Food Foods that are of liquid consistency are more readily digested than food pieces which are solid and big, and require more mechanical digestion (disintegration). Mastication or chewing of food reduces the size of the food which is then accessible to the action of enzymes present in the digestive juices. Swallowing food hastily with hardly any chewing and washing it down with water or other fluids may, therefore, cause indigestion. So, all foods containing large amounts of cellulose are digested more slowly than those which are free from fibre. Cellulose itself is not digested at all.

Table 2.15 Enzymes and their action

(Final digestion products absorbed in the body are shown in *italics*)

Secretion	Enzyme	Food acted upon	Product
Saliva	amylase (ptyalin)	starch	maltose
Gastric juice	pepsin	protein	polypeptides
	amylases	starches	maltose
	lipase	fats	<i>glycerol and fatty acids</i>
Pancreatic juice	trypsin	protein	polypeptides
	peptidases	polypeptides	<i>amino acids</i>
	sucrase	sucrose	<i>simple sugars</i> (Glucose + fructose)
Intestinal juice	maltase	maltose	<i>simple sugars</i> (Glucose)
	lactase	lactose	<i>simple sugars</i> (Glucose + galactose)
	lipase	fats	<i>glycerol and fatty acids</i>
	peptidases	polypeptides	<i>amino acids</i>

(b) Bacterial Action The normal bacterial flora in our gastrointestinal tract is either fermentative, putrefactive or bacteria of coli type. Some of these aid in the process of digestion, especially that of carbohydrates.

(c) Chemical Factors Strong acids, meat extracts, spices, caffeine and other substances stimulate the flow of gastric juices while natural fat retards it.

(d) Psychological Factors Anger, fright and worry are adverse to digestion since they depress the secretion of gastric juices. The sight, smell and aroma of food as

well as its taste enhance the process of digestion by encouraging the secretion of the saliva and gastric juices.

Let us see the process of digestion in detail:

1. Digestion in the Mouth Food is chewed in the mouth where it mixes with saliva. Digestion is initiated in the mouth though it may seem trivial. However, it is not so. Proper chewing not only breaks the food into smaller fragments but also releases more saliva. Saliva contains an enzyme *ptyalin* which has *amylase* or a starch digesting enzyme. Saliva helps to partially digest the starch present in the food. If food is not chewed properly or is swallowed hastily, sufficient amylase is not mixed with it and also big pieces of food enter the stomach. This results in incomplete and improper digestion. Saliva contains mucous secretions that wet food and make its passage easy into the stomach through the food pipe.

2. Digestion in the Stomach In the stomach, muscular contractions churn the food, break it up and mix it with the gastric juices secreted by the gastric glands in the stomach wall. The gastric juices contain a lot of water, hydrochloric acid and an enzyme, *pepsin*. The acid enhances hydrolysis and food breaks down into microfragments. Pepsin acts on proteins to form polypeptides. Another enzyme, *rennin*, predominantly found in infants, acts only on proteins of milk. While digestive action continues in the stomach, the food is prevented from moving on through the alimentary canal by a muscular valve, the *pylorus*. From time to time the pylorus relaxes, allowing some of the *chyme* (semi-digested food) to pass into the small intestines.

3. Digestion in the Small Intestine The food that now enters the small intestine is a semi-liquid mass. The first, portion of the small intestines is U-shaped, known as the duodenum. Here, the chyme is mixed with the bile juice released from the gall bladder. The gall bladder stores bile secreted by the liver. Bile, as seen earlier, contains no digestive enzymes, but is vital for digestion. It is strongly alkaline. It not only neutralises the acid that is mixed with the food in the stomach but produces an alkaline semi-digested mass on which the intestinal enzymes work best. Bile also emulsifies fat thereby increasing the surface area for the lipase, the fat-hydrolyzing enzyme, to act upon. Its bacteriostatic action prevents the growth of harmful bacteria.

Next, the alkaline mass is mixed with pancreatic juice secreted by the pancreas. This juice contains several enzymes that act upon carbohydrates, fats and proteins. They are amylases, lipase, trypsin and peptidases. Amylases act on starches and convert them to maltose. Lipase acts on the emulsified fats to form glycerol and fatty acids. Trypsin converts protein to polypeptides, which are further broken down into amino acids by peptidases.

The small intestine also secretes digestive juices. The enzymes found in the intestinal juice are lipase, peptidase, lactase, maltase and sucrase. These enzymes act on lipids, peptides and disaccharides lactose, maltose and sucrose. They convert them to glycerol and fatty acids, amino acids and simple monosaccharides (galactose, glucose and fructose) respectively. These final products of digestion are now ready for absorption.

Nearly the whole process of absorption of digested materials occurs in the lower portion of the small intestine. The intestine is lined with small fingerlike projections called the *villi*. Through these, the amino acids and simple sugars diffuse from the

intestines into the blood. In the same way, the fatty acids and glycerol are absorbed into lymph, which is another fluid of the circulatory system.

4. Digestion and Absorption in the Large Intestine Here, absorption of water is the major task. Less absorption of water results in loose stools whereas greater absorption results in dry stools (constipation). Along with water, sodium, other minerals, vitamins and amino acids are also absorbed. The colon bacteria synthesize vitamin K and some vitamins of the B-complex group (especially biotin and folic acid) which are absorbed from the colon in sufficient amounts to meet the daily requirement. The resulting mass is now made up of indigestible matter (cellulose), undigested food, bacteria, mucus, cellular debris, and metabolic waste products. The faeces (stools) are expelled from the alimentary canal through the anus.

□ Intestinal Microflora

About 35% to 50% of the contents of the human colon is composed of bacteria. Pathogenic bacteria (e.g. Haemolytic *Escherichia coli*, *Clostridium perfringens*, *Campylobacter* organisms and *Listeria* organisms) co-exist with beneficial bacteria (bifido bacteria, *Lactobacillus* organisms and non-pathogenic strain of *E.coli*). However, healthy GI microflora help the host by (1) forming a barrier against pathogens, and (2) improve gut immunity and produce certain vitamins. Healthy microflora can be developed by the use of prebiotics and probiotics.

1. Prebiotics These are nondigestible food products and their substrates that stimulate the growth of symbiotic bacterial species which are already present in the colon and improve the health of the host. These include dietary fibre and Fructooligosaccharides (FOSS). FOSS are linked together by indigestible bonds that cannot be hydrolyzed by enzymes in the small intestine, so carbohydrates from FOSS are not digested and pass into the large intestine as such. Foods containing these FOSS include honey, beer, onions, asparagus, rye, bananas, maple sugar, and oats. FOSS selectively stimulate the growth of beneficial bacteria, including bifidobacteria and lactobacillus organisms, which reduces the levels of pathogenic bacteria such as salmonella organisms and clostridia in the GI tract. Components of dietary fibre such as pectin, hemicelluloses, and inulin found in onions, asparagus, also function as prebiotics and stimulate the production of SCFA's (Short chain fatty acids).

2. Probiotics These are microbial foods or supplements that can be used to change or improve intestinal bacterial balance to improve the health of the host. They are organisms and substances that contribute to the intestinal microbial balance. The most common include *lactobacillus* organisms and *bifidobacteria*. These organisms compete with pathogenic bacteria for attachment sites and nutrients and prevent their overgrowth. *Lactobacilli* and strains of beneficial bacteria also produce organic acids that reduce intestinal pH, thus retard the growth of pathogenic acid-sensitive bacteria. At the optimal pH, the organic acids produced by beneficial bacteria exert other inhibitory influences on their growth. Fermented dairy products including live culture curds, yogurts, kefir, and commercial probiotic preparations, contain various forms of beneficial bacteria. Sauerkraut, miso, and tempeh and some other fermented foods may also be cultured with *lactobacillus* strains.

Metabolism

Once absorbed, the nutrients enter the blood stream which distributes them to all cells of the body where they undergo *metabolism*. We have seen earlier that metabolism is the chemical process consisting of the following two processes (i) anabolism, which is the process of converting absorbed food into body tissue, and (ii) catabolism, which is the breaking down of the body tissue and production of energy required for various vital processes.

Assimilation This term is synonymous with anabolism. It is the process whereby, the already digested foodstuffs are absorbed and utilized by the tissues.

The assimilation of nutrients on absorption in the body is shown in Table 2.16.

Carbohydrates are absorbed in the blood in the form of glucose. Now the body cells systematically metabolize this glucose and it undergoes the following process:

- (a) It is oxidized for liberation of energy and results in production of carbon dioxide and water as waste products. Thus, glucose is a quick source of energy.
- (b) It is changed to glycogen. If the amount of glucose is in excess, this glycogen is stored in the liver.
- (c) Another form in which it is stored in the body is as fatty tissue. The excess carbohydrates are converted to fat and deposited in the fatty tissue of the body, resulting in obesity when it exceeds the limits.

Table 2.16 Assimilation of carbohydrates, fats and protein in metabolism

Nutrient	Digestion	Assimilation in metabolism
Carbohydrates	Absorbed in the form of glucose or other monosaccharides	Oxidized for energy to CO_2 and H_2O Changed to glycogen and stored in liver Changed to fat and stored as fatty tissue
Fats	Absorbed in the small intestine in the form of fatty acids and glycerol, which are recombined into a new fat after absorption	New fat oxidized for energy to CO_2 and H_2O or stored as fatty tissue. Some fat combines with phosphorus to form phospholipids
Proteins	Absorbed in the small intestine in the form of amino acids (which builds new tissue and repairs old tissue)	Are deaminized if not needed. Nitrogen removed, changed to urea and excreted; converted to glucogenic and ketogenic amino acids, which enter Kreb's cycle to release energy and form CO_2 and H_2O

Fats, like carbohydrates, are metabolized after being absorbed in the blood. The simplest form of fats release fatty acids and glycerol. These are recombined to form new fat in the process of assimilation.

- (a) This new fat is oxidized for energy, producing carbon dioxide and water as waste products. This is a slow process and the presence of oxygen is a must for this conversion.
- (b) The excess fat is stored in the fatty tissue (adipose tissue).

- (c) Some fat combines with phosphorus to form phospholipids. Some combines with protein, forming lipoproteins, which form a major part of cell membrane.

Proteins, on digestion, are absorbed in the small intestine in the form of amino acids and are converted to new proteins of an individual's body. Each individual has his own specific proteins. The primary function of proteins is to build new muscles and other tissues and repair old worn out ones. But sometimes the person's intake of carbohydrates and fats is very low because of which his daily energy requirement is not met with. The body then turns upon proteins for its energy source. This results in the loss of body muscles and weakening of the body as a whole. The fate of protein metabolism depends upon the stores of energy in the body. If adequate supply of energy is present, the absorbed amino acids are used to

- (a) build new tissues (muscles, blood, cells), and
(b) repair old tissues (healing, replenishing).

If inadequate supply of energy is found in the body then

- (c) the amino acids are deaminated, nitrogen is removed, changed to urea and excreted from the body. The remaining is converted into keto acids which further form carbohydrate and fat intermediates, namely glucogenic acids and ketogenic amino acids which enter Kreb's cycle to release energy and form CO₂ and H₂O.

The other nutrients namely vitamins and minerals also undergo metabolism by which the functions that each has to serve is fulfilled. The details are brought out in Chapter 3.



SUMMARY

The composition of our body depends on the type of food that we eat. If the food is deficient, the body will also reflect that deficiency. We need several nutrients, the levels of which have been decided by the RDA, as given by the ICMR expert committee, 1981. The body systematically breaks down each food component to the absorbable form, and each nutrient undergoes metabolism and is assimilated into the body to be utilised for the specific function that it is meant to perform.



CASE STUDIES

Mrs A has a family of 5 members who consume a mixed diet. Her mother-in-law, husband, daughter and son are aged 70 years, 45 years, 17 years and 14 years respectively. She is 40 years old.

1. Determine the caloric needs of her family.
2. Decide the number of exchanges to make a choice of foods on a daily basis.



REVIEW QUESTIONS

1. Write short notes on chemical analysis, biological assay, and composition of our body.
 2. Define: Calorie, Joule. RDA, Reference Man, Reference Woman, Basal Metabolism, Specific Dynamic Action, anabolism, catabolism, villi.
 3. What factors affect the RDA?
 4. What factors affect the BMR?
 5. List out the five food groups, giving two examples of foods in each food group. Also briefly outline the principle nutrients in each food group.
 6. What is an exchange list? What is its main use?
 7. What is the function of bile?
 8. Which principle enzymes act on the following food components:
 - (a) Starch
 - (b) Fats
 - (c) Polypeptides
 - (d) Maltose
 - (e) Lactose
 - (f) Sucrose
 9. What are the end products of digestion of the following:
 - (a) Carbohydrates such as starch
 - (b) Fats
 - (c) Proteins
 10. How does chewing your food help digestion?

Chapter

3



Role of Nutrients

We have learnt about the various nutrients and their role in the body metabolism, and also the Recommended Dietary Allowances for each as given by ICMR. Let us now study each nutrient, including vitamins and minerals, in detail for the following:

1. Chemical composition
2. Classification
3. Digestion and absorption into the body
4. Functions
5. Deficiency symptoms
6. Sources

Although details of each nutrient can be elaborated to a very great extent, an attempt is made here to familiarize the reader with the basic knowledge about each nutrient. This will also make it clear that the functions of several nutrients are interlinked. Besides, there are several economical but rich sources of nutrients, but yet people suffer from deficiency of such nutrients either due to ignorance or due to their misuse. For example, deficiency of vitamin A is a problem which has acquired glaring proportions in the developing countries. Though large quantities of its precursor beta-carotene occurring in carrots, red pumpkin and green leafy vegetables is available in plenty, vitamin A deficiency, resulting in irreversible blindness, is found in several children in these countries.

3.1 CARBOHYDRATES

The process of obtaining energy from the solar system and converting it into assimilable forms for future use is carried out by plants. Plants synthesize carbohydrates with the help of water from the soil, carbon dioxide from the air and the green pigment chlorophyll present in them (Fig. 3.1).

□ Chemical Composition

A carbohydrate is a chemical compound made up of carbon, hydrogen and oxygen. The basic unit of a carbohydrate is a monosaccharide. It contains a series of carbon atoms linked together in a chain, attached with oxygen and hydrogen atoms. Its formula is $C_6H_{12}O_6$. Figure 3.2 gives the structural formulae of some simple carbohydrates. Glucose, a monosaccharide, is the most common sugar, which is used to store and release energy (Fig. 3.3).

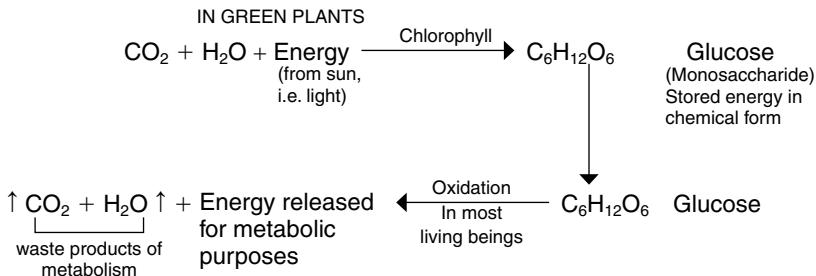


Fig. 3.1 Energy cycle of life systems on earth

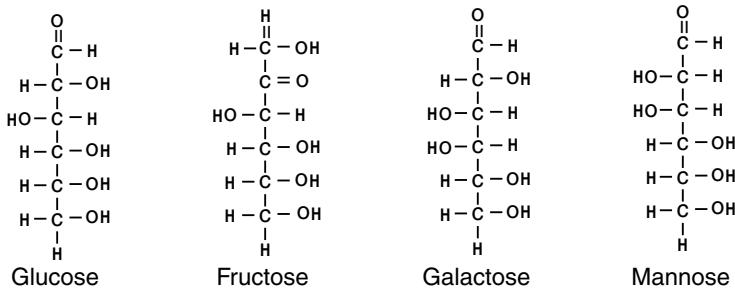


Fig. 3.2 Structural formulae of some simple carbohydrates

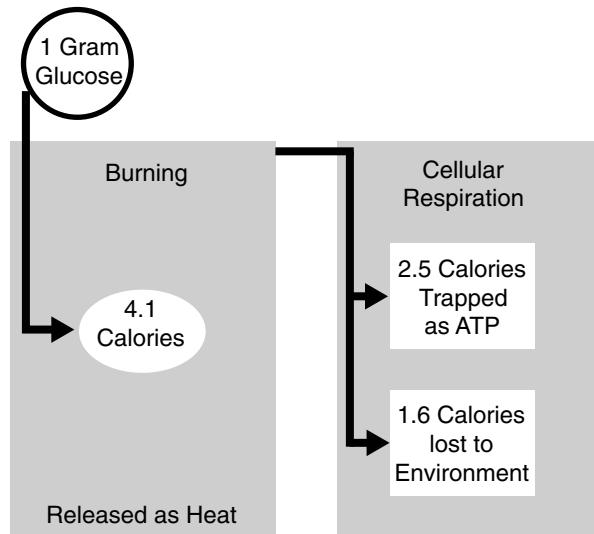


Fig. 3.3 Release of energy from glucose

Since carbohydrates in the form of glucose cannot be stored in nature on a large scale, they form chain-like complex polymeric molecules with removal of water, such as starch in plants and glycogen in animals. These, when required, are broken

down to their simple form, i.e. glucose, in the presence of water. Glycogen is the stored starch in animals and is found in liver and muscles, from where it is mobilized as soon as the glucose levels in blood dip below normal.

□ Classification of Carbohydrates

Carbohydrates (refer Table 3.1) are classified as follows:

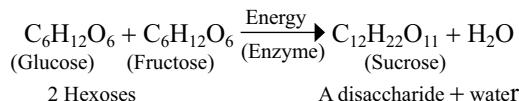
1. Monosaccharides They are the 3, 4, 5, and 6 carbon unit sugars called trioses, tetroses, pentoses and hexoses respectively. Glucose, fructose, galactose, arabinose, ribose are examples of this class.

Glucose is the sugar which is necessary for all the body systems. It is abundantly found in nature. Fructose is the fruit sugar found in honey and fruits.

Table 3.1 Classification of carbohydrates

Carbohydrates	Examples	Obtained from
1. Monosaccharides (simple sugars which contain a single unit)	(i) Glucose (dextrose) (ii) Fructose (levulose) (iii) Galactose	Corn syrup, fruits, vegetables, honey. Honey, fruits, vegetables. The digestion of lactose.
2. Disaccharides (double sugars which contain two monosaccharide units)	(i) Sucrose (1 glucose + 1 fructose) (ii) Lactose (1 galactose + 1 glucose) (iii) Maltose (2 glucose)	Cane, beet, fruits, vegetables Milk Starch in sprouting grains and digestion of starch.
<i>Digestible</i>		
3. Polysaccharides (complex compounds which contain many monosaccharide units)	(i) Starch (many units of glucose) (ii) Dextrin (iii) Glycogen (animal starch)	Grain products, legumes, root vegetables. Result of first chemical change in digestion of starch Animal body converts glucose into glycogen which can readily be converted back into glucose.
<i>Indigestible</i>		
	(i) Cellulose (ii) Hemicellulose (a) Pectin (b) Agar-agar commonly used in food as China grass	Structural parts of fruits. vegetables, whole grain. Cereals, seeds and nuts. Fruits like guava, apple, etc. A gelatinous product made from seaweed.

2. Disaccharides When two molecules of monosaccharides combine with the removal of one molecule of water, disaccharides are formed.



Sucrose or table sugar is one of the disaccharides. The others are:

- Glucose + Glucose \longrightarrow Maltose
 - Glucose + Galactose \longrightarrow Lactose

Sucrose is found in almost all plants, sugarcane and beet, being rich sources.

Lactose is found predominantly in milk. It helps to absorb the calcium present in large amounts in milk.

Maltose or malt sugar is found in all sprouted and malted products. It is produced when starch is digested by amylases. Sprouted cereals and beer contain large amounts of maltose.

3. Polysaccharides These are complex compounds with high molecular weights. They are formed by a combination of more than two molecules of a monosaccharide. Their structural formula is $(C_6H_{10}O_5)_n$ where $n < 2$. In the order of sweetness, polysaccharides are least sweet, disaccharides are medium while monosaccharides are the sweetest.

(a) Starch is the storage form of carbohydrates in plants and comprises the primary source of energy in the diet. Cereal grains, seeds, roots, tubers such as potatoes contain large quantities of starch. Starch on partial hydrolysis gives dextrin.

(b) Resistant Starch Resistant starch includes all the starch that escapes digestion in the small intestines. It is the sum of starch and the products of starch degradation not absorbed in the small intestines of healthy individuals.

There are three main forms of resistant starch:

1. Starch that is physically inaccessible to digestive enzymes owing to enclosure in food structures such as intact cells or partly milled or whole grains or seeds.
 2. Resistant B-type starch granules occurring in (uncooked) potatoes and green bananas.
 3. Retrograded amylose occurring in processed foods.

These forms are named RS 1, RS 2, and RS 3 respectively.

Although the three main forms of resistant starch probably represent the main forms of indigestible starch in most foods, a number of other reasons for resistance should be kept in mind. These include amylose-lipid complexation, retrogradation of amylopectin and the creation of new enzyme resistant glycoside bonds by dry heating at high temperatures.

Disintegration of gross and cellular structures releases physically enclosed starch and thereby, reduces the RS 1 content.

Gelatinization, which is usually more or less complete in most starchy foods as eaten, with the exception of unripe fruits, would diminish RS 2 from the resistant starch granules.

RS 3 is formed by retrogradation of amylose during processing, cooling and storage under moist conditions.

Hence, it must be noted that starch can be made resistant to digestion by altering the processing techniques, by prolonging the moist stage after cooking, by repeated cycles of heating, cooling and chilling, or even by freezing. Resistant starch content of foods can be varied within wide limits by choice of raw materials and the processing conditions.

The importance of amylose-lipid complexes, amylopectin retrogradation, chemical modification and heat treatments in dry conditions are still being assessed.

The resistant starch content of common cereal foods like bread, breakfast cereals, pasta and rice is generally below 3 percent, potato has about 4 to 5 percent, potato flakes 3 percent whereas fried, freeze dried and defatted potato chips contain up to 32 percent resistant starch due to the effect of heat treatment and processing.

Leguminous seeds generally have a comparatively high content of resistant starch after processing due to the high resistance of cells towards disintegration in cooking and the high content of amylose in these seeds, which is generally more than 30 percent. Cooking, freeze drying and milling of legumes such as peas and lentils changes the level of resistant starch and increases it to 5 to 18 percent which amounts to 12 to 40 percent of the starch content of the food.

Since resistant starch is not absorbed in the small intestines of healthy individuals hence, it is not digested to free glucose and does not provide glucose to the body. The presence of resistant starch in the gut digesta could also influence gastric emptying and digestion of other nutrients and satiety. Therapeutic use of resistant starch may also involve cholesterol-lowering effects and providing lower caloric value (approximately 2 kcal/g). It may have health promoting effects in colonic health especially lowering risk of colon cancer. However all the nutritional implications are still being reviewed.

(c) Glycogen is an animal starch stored in all animals. Fresh oysters and liver obtained immediately from a slaughtered animal are rich sources of glycogen. But since glycogen is very rapidly broken down, ordinarily the diet contains none.

(d) Cellulose and Hemicellulose are abundantly found in nature in seedcoats, skins of fruits and as a structural part of all plants. They are important for nutrition since they make up a large proportion of *dietary fibre*. Although they are indigestible by human digestive system, they help in increasing the bulk of intestinal contents and by stimulating the peristaltic movements, aid in evacuation of the bowel. In other words, they help prevent constipation.

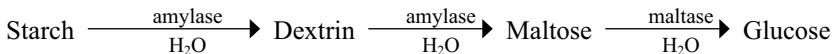
Pectins, which are also indigestible carbohydrates, are found in fruits. Their main property is to absorb water and form easy gels. They are used in preparing fruit jellies.

There are many other indigestible polysaccharides such as gums, agar, chitin, mucilages, pentosans, etc. But they form a very minor part of the human diet and, therefore, are not dealt with here.

□ Digestion and Absorption

All digestible forms of complex carbohydrates, mainly starches, are broken down by the action of the enzyme ptyalin in the mouth and further by pancreatic and intestinal

enzymes amylase and maltase to the simple sugar glucose (monosaccharide) by the process of enzyme hydrolysis.



The simple sugars are absorbed mainly in the small intestine. Details about digestion, absorption and assimilation are covered in Chapter 2.

□ Functions

The functions of carbohydrates in the body are the following:

1. They provide an economical and quick source of calories. Each gram of digestible carbohydrate supplies roughly four calories. One teaspoon sugar is about five grams and supplies about 20 calories.
2. They *spare* proteins so that proteins can be used for their more important function, i.e. to build and repair tissues. In case of deprivation of carbohydrates, protein is deaminated and used to liberate energy in place of carbohydrates.
3. Adequate supply of carbohydrates determines the amount of fat to be metabolized for energy, which in turn affects the formation and disposal rate of ketones (intermediate products of fat metabolism). In the absence of adequate supply of carbohydrates, more fat is used because of which ketones accumulate in the body and this results in a disorder called *ketosis* or *acidosis* (a condition encountered in uncontrolled diabetes). This shows that carbohydrates have an anti-ketogenic effect which prevents harmful excess of ketone accumulation in the body.
4. Lactose encourages the growth of favourable intestinal bacteria. It has laxative properties and enhances the absorption of calcium.
5. Cellulose provides faecal bulk which facilitates elimination.
6. Glucose alone can work as a source of energy for the central nervous system.
7. Adequate hepatic (liver) glycogen storage enhances normal liver detoxification ability.

□ Deficiency and Excess of Carbohydrates

A mild deficiency of carbohydrates in the diet results in utilization of fats for energy purpose. However, in case of severe deprivation of carbohydrates, fats too cannot be oxidized completely, which results in the accumulation of large amounts of ketone bodies in the body. This is a harmful condition as pointed out earlier. Excess of carbohydrates in the diet, especially the sugar sucrose, may do the following:

1. *Increase the incidence of dental caries:* Microorganisms living in the dental plaque convert the sugar into acids which attack the tooth enamel and destroy it, resulting in the formation of dental caries;
2. *Cause obesity because more calories are ingested than expended:* The excess carbohydrates are converted into fat for the purpose of storage in the body;
3. *Irritate the gastro-intestinal mucosa:* That is why large quantities of jams and jellies are not used by the gastric ulcer patient;

4. *Depress appetite:* If empty calories such as those found in synthetic soft drinks are consumed instead of the basic five food groups, malnutrition could result.
5. Increase the blood triglyceride level which in turn leads to heart diseases.

□ Sources

1. Plant Sources

(a) Cereal Grains Rice, wheat, corn, barley, *bajra*, *jowar*, *ragi* contain large amounts of starch. In addition to starch they also contain some proteins, minerals and vitamins. Whole grain and enriched sources also contain iron, B-complex vitamins and some fibre.

(b) Vegetables Roots, tubers and seeds contain large amounts of carbohydrates. Starchy legumes, beans, peas, yam, tapioca and potatoes contain a large amount of carbohydrates, whereas green leafy vegetables contain low levels. Besides starch, vegetables also supply some iron, B-vitamins and fibre. Sugars present in fresh vegetables change to starch on storage. Onions do not contain starch.

(c) Fruits These contain the simpler forms of carbohydrates namely the mono-and disaccharides. Dry fruits contain large amounts of carbohydrates. Starch is present in some raw, immature fruits. It slowly gets converted to the simpler sugar, e.g. starch in raw banana gets converted to sugar on ripening. Fruits also contain some cellulose and pectin. Nuts contain about 10–20 percent carbohydrates and are also a rich source of proteins and fats.

(d) Sweets The ordinary table sugar, ground sugar (*Pithishakar*), maple syrup, corn syrup and honey are concentrated sources of sugars but do not supply significant amounts of nutrients in addition to calories. Such sources are said to supply *empty calories*. Jaggery and molasses contain some minerals in addition to sugars.

2. Animal Sources

There are no important animal sources of carbohydrates except milk, which supplies lactose. Glycogen or *animal starch* is stored in the animal's liver but it rapidly degrades, hence, only a small amount of may be found in meat, poultry and fish.

□ Requirement of Carbohydrates

Carbohydrates in a diet should not be more than 70 percent of the daily calorie requirement of a person.

3.2 FATS

Fats are a more concentrated form of storage of energy than carbohydrates. They are found in the adipose (fatty) tissue of animals. An ingested fat undergoes emulsification, digestion and absorption. In the presence of an adequate supply of carbohydrate, fat is stored in the fatty tissue.

An excess of daily intake of carbohydrates also results in its conversion and storage as fat in the fatty tissue. Hence, overweight persons should not only avoid an intake

of fat but also an excessive daily intake of carbohydrates. The stored fat is mobilized to produce energy but this process of energy liberation is slow and, therefore, always adopted secondarily, when the supply of carbohydrates is inadequate.

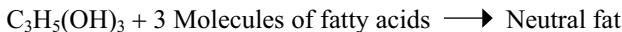
□ Chemical Composition

Fat is a complex molecule constituting a mixture of fatty acids and an alcohol, generally glycerol. Like carbohydrates, it contains carbon, hydrogen and oxygen, but it differs from a carbohydrate in that it contains more carbon and hydrogen and less oxygen. When oxidized, it gives 9.1 calories per gram fat which are approximately 2 ¼ times more than those supplied by one gram of carbohydrate.

□ Classification of Fats (Lipids)

Fats can be classified into three main groups:

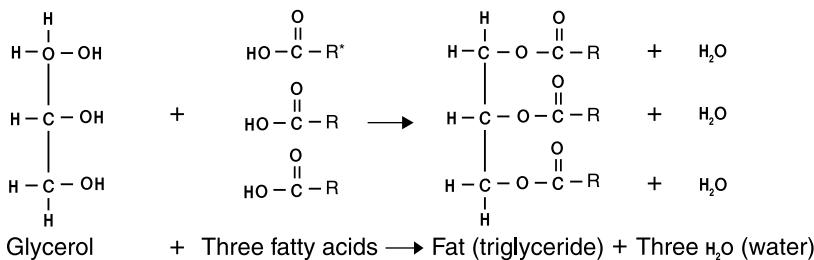
1. Simple Lipids The simple lipids are the *neutral fats*. These are chemically made up of triglycerides. Triglycerides contain a glycerol base with three fatty acids.



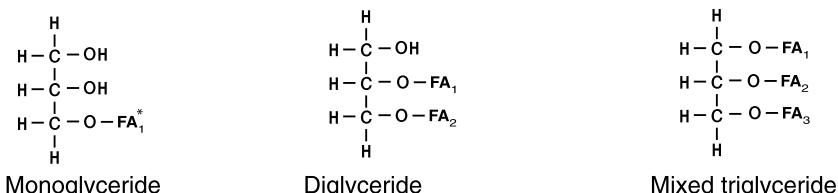
These 'neutral fats' make up 98–99 percent of food and body fats.

2. Compound Lipids These are chemically made up of simple lipids containing phosphorus, carbohydrate or protein. Such compound lipids are known as phospholipids, glycolipids and lipoproteins respectively. Lipoproteins are the most

Glycerides



*R = radical (rest of molecule)



* FA = Fatty Acid

Fig. 3.4 Structure of a lipid

important as they are the carriers of lipids in the blood and form cell membranes. Phospholipids are associated commonly with the nervous system (nerve tissue).

3. Derived Lipids They are fat-like substances produced from fats and fatty compounds. The important members of this group are glycerol and fatty acids.

(a) Glycerol It makes up about 10 percent of the fat. It is the water-soluble base of triglycerides or neutral fat. During digestion glycerol is removed and is available for formation of glucose when necessary.

(b) Fatty Acids They are the key, refined fuel form of fat that the cell burns for energy. They are part of the basic structural units of a fat and they may be saturated or unsaturated. Examples of fatty acids are oleic acid, linoleic acid, linolenic acid, arachidonic acid, palmitic acid, myristic acid and stearic acid.

4. Unsaponifiable Lipids These include steroids, terpenoids, etc.

Steroids They are fat-related substances containing sterols. The important member of this group is *cholesterol*.

The study of fatty acids, cholesterol, visible and invisible fats is important for nutrition, which we will now see in detail.

Saturated and Unsaturated Fatty Acids

Fatty acids in food are classified as saturated and unsaturated (Fig. 3.5), depending on the absence or presence of double bonds between the carbon atoms in their molecules. Food fats are generally a mixture of both types of fatty acids. The process of hydrogenation can be carried out only on fats containing unsaturated fatty acids while hydrogen cannot be added to fats containing saturated fatty acids since no unsaturation or double bonds are present in them. *Vanaspati*, a common cooking medium, is a hydrogenated fat. It is generally fortified with vitamin A and D at a level of 700 IU and 50 IU respectively.

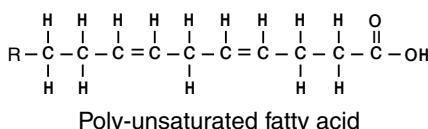
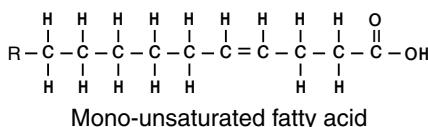
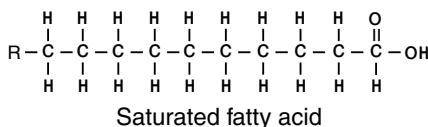


Fig. 3.5 Structures of different types of fatty acids

The predominance of saturated fatty acids in a fat makes it solid at room temperature. A fat containing more unsaturated fatty acids is liquid at room temperature. Most animal fats are saturated while most vegetable fats are unsaturated.

Table 3.2 Major types of fatty acids in fats and oils

Saturated	Monounsaturated	Polyunsaturated	
Coconut, Palm kernel, Ghee, butter, Vanaspati	Red palm oil, Palmolein, Groundnut, Ricebran, Sesame	LINOLEIC (n-6)	a-LINOLENIC (n-3)
		Low	Red palm oil Palmolein Rapeseed, Mustard Soyabean
		Moderate	Groundnut, Ricebran Sesame
		High	Safflower, Sunflower Cottonseed, Corn, Soyabean

Reference: *Dietary Guidelines for Indians*, National Institute of Nutrition, Second Edition, Hyderabad, India, 2010

There are both mono-unsaturated and poly-unsaturated fatty acids (PUFA). Oleic acid has only one double bond hence, it is a mono-unsaturated fatty acid while linoleic (18:2) and linolenic acids (18:3) with their two and three double bonds respectively make them poly-unsaturated fatty acids. Stearic acid and palmitic acid are examples of saturated fatty acids.

Foods which contain predominantly mono-unsaturated fatty acids (oleic) are avocado, olives, olive oil, peanut butter, peanut oils, lard, regular margarine, vegetable shortening, pork, poultry, eggs, cashew fruits.

Foods which contain predominantly PUFA (linoleic and linolenic) are corn, cottonseed, safflower, soybean and sunflower oil, walnuts, mayonnaise, French dressing (if made with the above oils), fish and fish oils. The relative amounts of fatty acids in foods and diets are expressed by P/S ratio (P = Poly-unsaturated, S = Saturated fatty acids), A ratio of less than 2 : 1 P/S is considered nutritionally undesirable. Hence, consumption of *vanaspati* should be controlled since it increases the proportion of saturated fatty acids in the diet.

Saturated fatty acids, especially palmitic and stearic, are found in animal products such as whole milk, cream, ice-cream, butter, cheese made from whole milk, egg-yolk, meat (except poultry), fish, pork, lard; margarine, *vanaspati*, chocolates, rich desserts, coconut and coconut oil.

Poly-unsaturated fats are found in vegetable oils including safflower, cottonseed, soybean, corn, sunflower, groundnut, *til*, fish, salad dressing, etc. The type of fatty acids present in the fat determines the nature of the fat, its flavour and other properties. Stearic acid is found in beef suet, oleic acid in almost all fats and butyric acid in butter.

The PUFA have been shown to prevent an increase in serum cholesterol on a high fat diet and are thus, considered anti atherogenic.

A nutritional classification of fatty acid is

1. Essential fatty acids, and
2. Non-essential fatty acids

Essential fatty acids are those which cannot be synthesized by the body and need to be supplied through diet. Linolenic acid, linoleic acid and arachidonic acid are the three essential fatty acids.

Non-essential fatty acids are those which can be synthesized by the body and need not be supplied through diet. Palmitic acid, oleic acid and butyric acid are examples of non-essential fatty acids.

Essential Fatty Acids

Linoleic and arachidonic acids are the principal fatty acids which are essential for the nutritional well-being of a person. These cannot be synthesized by the body and hence, must be supplied through diet. The primary source of linoleic acid in a diet is vegetable oils.

Many health disorders and especially those related to skin can be successfully managed through proper supply of the essential fatty acids.

1. Cholesterol Cholesterol is a word we come across very often in advertisements of fats and oils, in relation to heart diseases, vascular disorders and high blood pressure.

Cholesterol, one of the sterols, is found in different concentrations in all animal tissues and blood, and has several important functions in the body. It is present in animal foods. It is synthesized in the body by the liver independent of the dietary intake. The body normally synthesizes about 2 g of cholesterol daily. The normal blood level of cholesterol is 150 to 300 mg/dl (100 ml) of blood. However, this level of cholesterol is affected by the dietary intake of cholesterol-rich foods like egg-yolk, organ meats, shell-fish and dairy fat. It is necessary to restrict their intake in atherosclerotic conditions.

The intake of cholesterol should be maintained below 200 mg per day. This can be achieved by limiting the intake of high-fat animal foods like butter, ghee, meat, eggs, organ meats, and consuming foods like low fat or skimmed milk or toned milk instead of full-cream milk. Although eggs contain appreciable amounts of cholesterol, consumption of up to 3 eggs in a week is recommended since it has several nutritional advantages. Elevation of cholesterol in blood is also affected by the mode of consumption of fat. At the same level of total daily intake, frequent consumption of smaller amounts of fat has been shown to cause less elevation of blood cholesterol as compared to consumption of the same total daily fat intake at one time of the day.

Cholesterol is a precursor of the bile salts. It is closely related to sex and adrenal hormones, which are derived from it in the animal body.

2. Omega Fatty Acids Foods contain omega-3 and omega-6 fatty acids. Omega-3 (also called *n*-3) fatty acids are unsaturated fatty acids having double bond in *n*-3 position.

Important dietary omega-3 fatty acids are

- (a) Alpha Linolenic Acid (ALA),
- (b) Eicosapentaenoic Acid (EPA), and
- (c) Docosahexaenoic Acid (DHA).

Our body cannot synthesize these fatty acids but can form 20- and 22-carbon omega-3 fatty acids from 18-carbon ALA. Conversion of ALA to EPA (eicosapentanoic acid) and DHA (docosahexaenoic acid) is low (5–10% for EPA and 2–10% for DHA). Small amounts of omega-3 fatty acids are found to contribute to healthy growth and also play an important protective role in many other conditions.

Omega-6 (*n*-6) fatty acids occur in fat and oil sources. Linoleic Acid (LA) and Arachidonic Acid (AA) are common omega-6 fatty acids. Since, they are essential for normal growth in young children and animals, they are commonly known as the essential fatty acids. They are also beneficial in skin integrity, renal function, etc. Hence, both omega-3 and omega-6 fatty acids are necessary to maintain good health.

Table 3.3 Quantities of foods required to furnish 0.1 g ALA

Food	Gram
Cereal/Millet	
Wheat & Pearl millet (<i>bajra</i>)	70
Pulses	
Blackgram (<i>kala chana</i>), kidney beans (<i>rajmah</i>) & cowpea (<i>lobia</i>)	20
Other pulses	60
Vegetables	
Green leafy	60
Other Vegetables	400
Fruits	400
Spices	
Fenugreek seed (<i>methi</i>)	5
Mustard (<i>sarson</i>)	1
Unconventional	
Flaxseed (<i>alsi</i>)	0.5
Perilla seeds (<i>Bhanjira</i>)	0.3

Reference: *Dietary Guidelines for Indians*, National Institute of Nutrition, Second Edition, Hyderabad, India, 2010

(a) Omega-3 Fatty Acids and Their Role in Good Health

- (i) Omega-3 fatty acids reduce the LDL cholesterol which may thus reduce risk of coronary heart disease.
- (ii) People with problems of blood circulation such as varicose veins benefit from consumption of omega-3 fatty acids since they stimulate blood circulation and help to breakdown fibrin (clot).
- (iii) They help to reduce blood pressure and blood triglycerides. Thus, their regular intake lowers both primary and secondary heart attack risk, rheumatoid arthritis and cardiac arrhythmias. They also impart anti-inflammatory benefits.

- (iv) Omega-3 fatty acids can reduce joint tenderness and need for corticosteroids in rheumatic arthritis and oxidative stress.
- (v) Maternal intake of omega-3 fatty acids must be sufficient to maintain maternal tissue stores and to meet the needs of the growing fetus. Recommended intake for omega-3 fatty acids for pregnant women is about 0.6–1.2% of energy requirement.

Other benefits of omega-3 fatty acids are reduction of Attention Deficit Hyperactivity Disorder (ADHD)-related symptoms in children. They also reduce hyperactivity in children with autism spectrum disorders. The omega-3 fatty acids have also shown neuro-protective action in Parkinson's disease and in Alzheimer's disease.

(b) Daily Values The Acceptable Macronutrient Distribution Range (AMDR) is 0.6% to 1.2% of total calories. Ideal ratio of omega-6 to omega-3 is about 5:1.

(c) Food Sources of Omega-3 Fatty Acids **ALA:** DGLV, Nuts, Vegetable oils like Canola, Soya bean, Flax seeds.

EPA and DHA: Oily fish (Salmon, herring, mackerel, sardine, tuna), walnut.

EPA: Oil of brown algae (kelp).

EPA and DHA now are being extracted from marine sources including fish oil and algae. Flax seeds contain linseed oil which is six times richer in omega-3 fatty acids than fish oils.

A vegetarian diet contains low ALA compared with LA. Also, vegetarians consume very little of EPA and DHA as these are usually obtained from non-vegetarian sources. Vegetarians do not consume a fish diet or fish oil supplements. Consequently, tissue levels of omega-3 FA are very low in vegetarians and they are thus denied the benefits such as cardioprotective effects. Vegetarians who mostly get their omega-3 through ALA must therefore, make dietary changes to improve their omega-3 status.

Seed oils are now being developed that are rich in omega-3 fatty acids such as transgenic varieties of canola (rapeseed), soybean and safflower rich in EPA and DHA. These may prove to be a boon for vegetarians.

Omega-6 to omega-3* fatty acid ratios in some oils

Canola (Rape) oil	2:1
Soyabean oil	7:1
Olive oil	3–13:1
Flaxseed oil	1:3
Corn oil	46:1

* Oils from sunflower, peanut and cottonseed do not contain omega-3 fatty acids.

(d) Fortification of Foods with Omega-3 Fatty Acids Omega-3 supplementation in food has been a recent trend with global food companies launching products which have been fortified with omega-3 fatty acid, like bread, pizza, yogurt, orange juice, milk confections and infant formulae. Since, cardiovascular diseases are on the rise, these products may become desirable in the near future.

(e) Caution in the Dietary Use of Omega-3 and Omega-6 Fatty Acids Omega-3 and omega-6 fatty acids form eicosanoids that have important biological functions in the body and these are metabolised in a short time. If synthesis of eicosanoids exceeds their metabolism, they tend to accumulate in the body, which can have deleterious effects. Eicosanoids from omega-3 fatty acids are anti-inflammatory while those formed from omega-6 fatty acids are inflammatory as well as cause clumping of platelets, arthritis, lupus and asthma. Thus, more than the absolute quantities of the omega fatty acids, the ratio of omega-3 to omega-6 fatty acids should be balanced in the diet.

□ Choice of Cooking Oils

In view of the above, an ideal quality fat for good health is one which maintains a balance so as to give a ratio of polyunsaturated/saturated (PUFA/SFA) of 0.8–1.0, and linoleic/ α -linolenic (n -6/ n -3) of 5–10 in the total diet. For ensuring this appropriate balance of fatty acids in cereal-based diets, it is necessary to increase the α -linolenic acid intake and reduce the quantity of linoleic acid obtained from the cooking oil. Hence, the choice of cooking oil should be as follows.

Groundnut / Sesame / Rice bran + Mustard	Sunflower / Safflower + Palmolein / Olive
Groundnut / Sesame / Rice bran + Canola	Safflower / Sunflower + Groundnut / Sesame / Rice bran
Groundnut / Sesame / Rice bran + Soyabean Palmolein + Soyabean	
Safflower / Sunflower + Palmolein + Mustard	

3. Hydrogenation of Fats Hydrogenation is a process which hardens a liquid fat by converting unsaturated fatty acid components to their saturated form. Unsaturated vegetable oils such as cottonseed, corn soyabean, etc. are treated with hydrogen to produce a plastic fat for cooking purposes or to resemble and substitute a table fat like butter and ghee. Vanaspati and margarine sold in the market are examples of hydrogenated fats.

4. Visible and Invisible Fats Some fats and oils added to food or used for frying are visible fats. Many food commodities like milk, cream, egg yolk, meat, fish and even cereals and legumes contribute substantial amount of invisible fats to the diet. The foods which contain visible and invisible fats are shown in Table 3.4.

Table 3.4 *Visible and invisible fats*

<i>Visible Fats</i>	<i>Invisible Fats</i>
Pickles, salad dressings, all oils, vanaspati, margarine, butter	Egg-yolk, baked goods, whole milk, all sweetmeats, cream, cheese, ice-cream, nuts, oilseeds

□ Digestion and Absorption of Fats

Fats are not digested in the mouth and stomach. However, in the stomach the size of the particle of fat is reduced. On entering the duodenum, a hormone *cholecystokinin*

is secreted by the intestinal wall. The hormone controls the secretion of bile, produced by the liver and stored in the gall bladder. Bile emulsifies fat and provides alkaline medium for the action of pancreatic and intestinal lipase. The fat is broken down by the enzyme into fatty acids and glycerol. Free fatty acids and monoglycerides are the principal forms entering the intestinal mucosa where triglycerides are formed once again. Along with the resynthesized fats, the other products of fat digestion entering the lymph circulation are free fatty acids, mono- and diglycerides, phospholipids, cholesterol esters and possibly some fats which have not been hydrolyzed at all. Water-soluble short-chain fatty acids and glycerol are transported directly to the liver via hepatic portal circulation.

□ Functions of Fat in the Body

1. Fat supplies heat. One gram of fat gives about nine calories. Tissues, except those of the central nervous system, can utilize fat as a source of energy in the presence of oxygen.
2. Subcutaneous fat acts as an insulation and helps in retaining body heat.
3. Fat provides padding around the vital organs. It holds them in place and helps them to absorb the shock of physical blows. However, excessive fat around vital organs interferes with their functioning.
4. Fat is the carrier of the fat-soluble vitamins A, D, E and K.
5. The essential fatty acids are needed for the maintenance of body functions. Their main functions include:
 - (a) maintenance of the functioning and integrity of cellular and subcellular membranes;
 - (b) regulation of cholesterol metabolism by transporting it between the blood and body tissues;
 - (c) act as precursors of an important group of hormone-like compounds prostaglandins;
 - (d) delay blood clotting time.
6. Fats have sparing action on vitamin B₁, that is, if fat consumption is adequate, not much vitamin B₁ is needed.
7. Fat slows down the secretion of hydrochloric acid, muscle contractions and the rate of digestion. A fatty meal stays for a longer time in the stomach and prevents the feeling of hunger. This prevention of hunger is called the '*satiety value*' of fats.
8. Fats add flavour to many foods. Non-fat (skimmed) milk does not taste like whole milk.
9. The calories in fat spare proteins from being oxidized for energy.
10. Cholesterol is needed for synthesis of sex and adrenal hormones (steroid hormones).
11. Substituting fat high in PUFA for a fat high in saturated fatty acids will, in a majority of individuals, decrease the level of blood cholesterol and hence the risk of heart disorders.

□ Deficiency and Excess of Fat in Diet

Deficiency of fat in the diet causes the deficiency of essential fatty acids, mainly linoleic and arachidonic acids. Absence of these PUFA from the diet of animals has

shown failure in growth and reproduction among rats. In infants, there have been several cases where eczema of the skin was completely cured on the inclusion of these fatty acids in their diet. A skin condition known as "Phrynoderm" (toad skin) is observed in which the skin becomes rough and thick, horny papules of the size of a pin head erupt in certain areas of the body, notably thighs, buttocks, anus and trunk. This condition however, responds better to vitamin E and B-complex vitamins more effectively than to essential fatty acids treatment.

Excess Fats in the Diet

1. Cause obesity because more than required calories are consumed. In addition, the excess carbohydrates are also converted to fat for storage in the body resulting in obesity. Hence, we restrict carbohydrates like sugar and starch besides fat in a reducing diet;
2. Abnormally slow down the digestion and absorption of food product;
3. Interfere with the absorption of calcium by combining with calcium to form an insoluble calcium soap. The soap cannot be absorbed through the intestinal wall;
4. Cause ketosis unless adequate carbohydrate is present to complete the oxidation of fat. A person who is losing weight is losing his own fat deposits to produce calories needed by his body. Metabolizing either dietary or body fat necessitates the concurrent metabolism of carbohydrate to prevent ketosis, as seen in diabetes.

□ Sources of Fat

1. Plant Sources All oils obtained from edible nuts and oilseeds such as peanut, sesame (*til*), soyabean, mustard, safflower, cottonseed, sunflower, corn, coconut, palm, walnut, cashew, pistachio, almond and other nuts are rich sources of visible fats.

Hydrogenated vegetable oil, *vanaspati*, margarine and French dressing are also rich sources of visible fats.

Cereals and pulses, fruits—except avocados and olives—and vegetables are poor sources of fats. However, since cereals and legumes are consumed in large quantities they contribute to the invisible fat in the diet. A cereal-pulse based diet not containing any added (visible) fat can meet more than 50% of an individual's needs for essential fatty acids. It is now believed that a visible fat intake of 15 to 25 g per day can meet the requirements for essential fatty acids for different physiological groups.

2. Animal Sources Whole milk, pork, poultry, eggs, lard, mayonnaise, fish, dairy products (butter, *ghee*), etc. are rich sources of fats.

□ Requirement of Fat

The quantity of fat that should be included in a well balanced diet is not known with any degree of certainty. Factors which influence the requirements are:

1. The minimum amount of fat to meet the EFA requirements.
2. The amount needed to promote absorption of fat soluble vitamins.
3. The amount needed to provide palatability to food.
4. The undesirable effect of excessive intake of fat.

Table 3.5 Composition of some Common Dietary Fats

Dietary Fat	Unsaturated Fat (%)	Polyunsaturated Fat			Mono Unsaturated	Cholesterol
		LA(%)	LNA (%)	LA: LNA (%)		
Fatty acid content normalised to 100%						
Flaxseed oil	10	16	53	(0.3)	20	0
Canola oil	6	22	10	(2.2)	62	0
Walnut oil	12	58	12	(4.8)	18	0
Safflower oil	10	77	Trace	(77)	13	0
Sunflower oil	11	69	—	(69)	20	0
Corn oil	13	61	1	(61)	25	0
Olive oil	14	8	1	(8.0)	77	0
Soyabean oil	15	54	7	(7.7)	24	0
Margarine	17	32	2	(16)	49	0
Peanut oil	18	33	—	(33)	49	0
Palm oil	51	9	0.3	(30)	39	0
Coconut oil	92	2	0	(2.0)	7	0
Chicken fat	31	21	1	(21)	47	11
Lard	41	11	1	(11)	47	12
Beef fat	52	3	1	(3.0)	44	14
Butter fat	62	2	2	(1.0)	30	33

Ref: Nutrition Society of India, *Proceedings on Cardiac Health and Fat, 2008*

The requirements of essential fatty acids has been placed at 3 to 6% of the daily energy requirements. About 50% of the essential fatty acid requirements can be provided by a cereal-based diet contributing about 15 g fat.

It should be remembered that the maximum intake of fat should not exceed 30% of calories requirements, i.e. it must be less than 80 g per day.

□ Trans Fatty Acids

1. Definition Trans Fatty Acids (TFA) are unsaturated fatty acids with at least one double bond in the trans configuration. Fatty acids in foods usually have the *cis* configuration, i.e. the hydrogen atom with respect to the double bond is on the same side of the molecule. The *cis* molecule thus, has a “V” shape. In TFA the hydrogen atom is on the opposite side. The trans molecule thus, assumes a nearly linear configuration which is similar to that of saturated fatty acids. This change in configuration alters the physical property of the oils. Oleic acid which is the *cis* isomer, is liquid at room temperature where as elaidic acid, its trans isomer is solid.

2. Food Sources of TFA Partially hydrogenated vegetable oils are the major contributors of TFA in foods. Partially hydrogenated vegetable oil have a long shelf life, they are stable during frying and their semi-solidity can be customised to enhance the palatability of baked goods and sweets. Elaidic acid (C18:1 9t) is the major trans isomer (80–90%). Hence, TFA in the diet comes from deep fried fast foods, bakery products, and packaged snack foods. Besides, small amounts of TFA are also formed naturally in the stomach of ruminant animals by the action of bacteria. Hence, dairy products and meat from cattle, sheep, goats, etc. also contain TFA (~5% of total fatty acids). The major TFA present in ruminant fat is vaccinic acid (C18:1 11t).

3. Current Dietary Recommendations and Regulatory Aspects of TFA

Intake of TFA may result in considerable potential harm. Adverse effects are seen even at very low levels of intake, i.e. 1–3% of energy intake or approximately 2–6 g for a person consuming 2000 calories per day. It is recommended that avoidance of TFA is necessary to avoid risk especially due to CHD. Most of the developed countries have made stringent rules to limit the intake of TFA. The European countries have set an upper limit for the intake of TFA as 1–2% energy (2–4 g). The latest joint FAO/WHO Committee recommended that TFA intake in the diet should be below 1% of energy (2 g). From January, 2006 the FDA made it mandatory that all conventional foods and supplements must indicate the TFA content. Some countries have banned the presence of TFA in foods. Presently, in India there are no regulations specifying TFA in foods.

3.3 PROTEINS

The word *Protein* comes from a Greek word meaning *Primary*, or *holding first place*, which is an appropriate name for an essential life-forming and life-sustaining substance of all organisms.

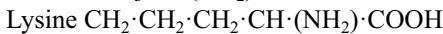
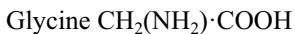
Proteins make up the major structure of all living cells and form most of the dry weight of the body cells.

Proteins may be defined as organic substances that on digestion yield their constituent, unit-building blocks—the *amino acids*. In other words, amino acids unite to form the complex molecule of a protein.

Every species of organisms has characteristic proteins shared by no other species. Even every individual organism may have proteins different from another individual.

Molecules of fat are large, those of polysaccharides are larger still, but generally protein molecules are much larger and complex.

Each amino acid contains a carboxyl (COOH) or acidic group and an amino (NH_2) or basic group. By varying the grouping which is attached to the carbon containing the amino group, many different amino acids are formed, e.g.



In all there are more than 21 amino acids important from the point of view of human nutrition.

Amino Acids Amino acids have been classified as essential and nonessential amino acids.

(a) Essential Amino Acids cannot be synthesized by the body and their requirement has to be met through dietary intake. In all there are 10 amino acids considered essential for the human infant, out of which arginine and histidine are considered non-essential for the adult.

Methionine	Threonine	Histidine
Isoleucine	Tryptophan	Arginine
Leucine	Valine	
Lysine	Phenylalanine	

(b) Non-essential Amino Acids can be synthesized by the body and they need not be supplied through diet.

Cystine*	Glycine	Aspartic acid/Hydroxyproline
Cysteine	Serine	Glutamic acid/Norleucine
Proline	Alanine	Tyrosine*

* Semi-essential

Methionine can be converted to cystine but cystine cannot be converted to methionine. Similarly, phenylalanine can be converted to tyrosine but not vice versa. Yet these spare the requirement of the corresponding essential amino acid. Hence, cystine and tyrosine are sub-classed as semi-essential amino acids.

Another way of classifying amino acids is on the basis of their reaction (Table 3.6).

□ Chemical Composition

Proteins are complex organic compounds containing carbon, hydrogen and oxygen. But unlike carbohydrates and fats, proteins contain in addition, nitrogen, usually sulphur and sometimes iron, phosphorus, iodine and copper. Amino acids are the building blocks which unite to form a protein molecule.

Protein formation (synthesis) is quite similar to that of polysaccharides which are formed from simple sugars. The amino acids are mostly linked together in forming a protein molecule through NH₂ group of one amino acid condensing with the COOH group of another amino acid with the elimination of one molecule of water, and a compound thus formed is called a peptide and the linkage is called as a *peptide linkage*. When two amino acids join, they form a dipeptide. When three amino acids join they form a tripeptide. A chain containing more than three amino acids is called a polypeptide, which ultimately forms a protein. A protein may contain hundreds or thousands of amino acid molecules. However, they are the same 21 amino acids repeated to form the huge protein molecule.

Proteins are the building blocks of the body because no tissue can be built without them, e.g. children need more proteins because growth demands more and faster tissue build up.

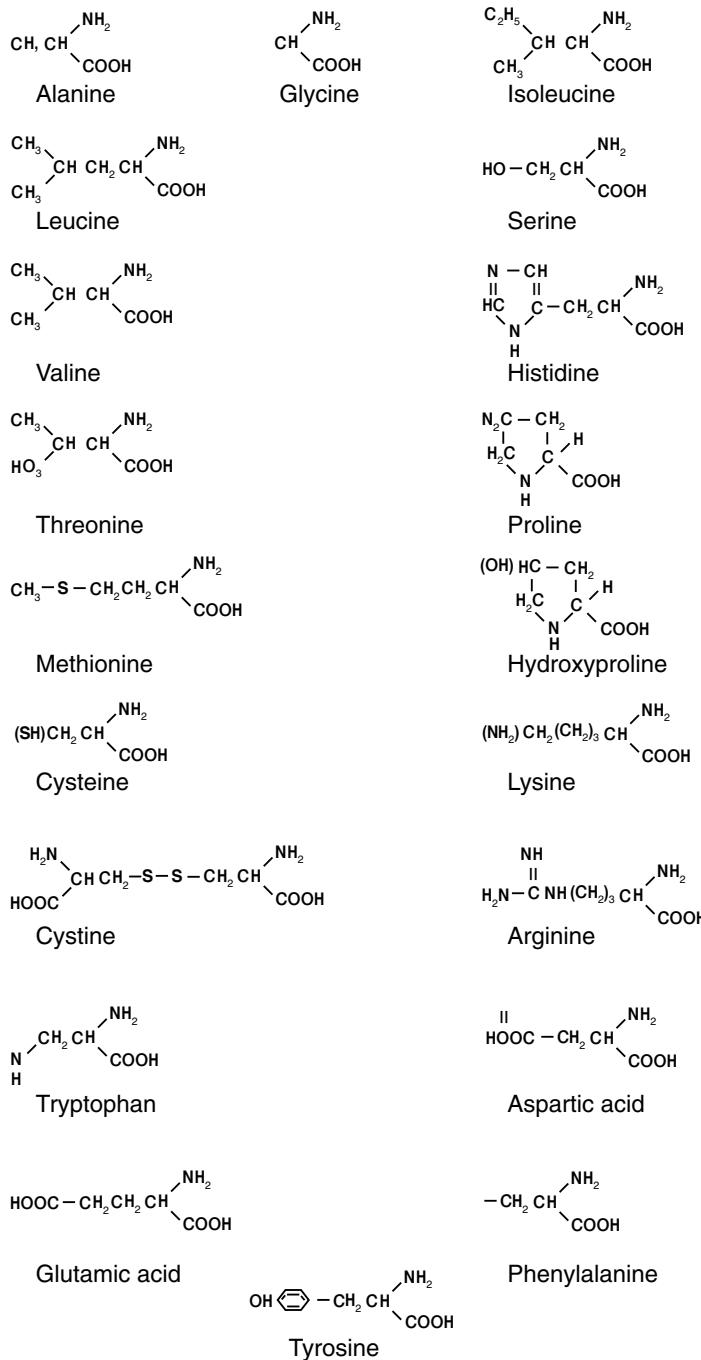


Fig. 3.6 Structure of amino acids

Table 3.6 Classification of amino acids

<i>Classification</i>	<i>Essential amino acids</i>	<i>Non-essential amino acids</i>
Aliphatic amino acids:		
Monoamino-monocarboxylic (neutral reaction)	Threonine Valine* Isoleucine* Leucine*	Glycine Alanine Serine
Sulphur containing (SH group)	Methionine	Cysteine
Diamino dicarboxylic (sulphur containing neutral reaction)	—	Cystine**
Monoamino-dicarboxylic (acid reaction)	—	Aspartic acid Glutamic acid
Diamino-monocarboxylic (basic reaction)	Lysine	Arginine Hydroxylysine
Aromatic amino acids:		
Monoamino-monocarboxylic (neutral reaction)	Phenylalanine	Tyrosine**
Heterocyclic amino acids		
Monoamino-monocarboxylic	Tryptophan Histidine (slightly basic)	Proline Hydroxyproline

* Also referred to as branched-chain amino acids.

** Semi-essential.

□ Classification of Proteins

Proteins are classified into two types from the nutrition viewpoint:

1. Complete Proteins These proteins contain all the essential amino acids in sufficient quantity and ratio to supply the body's needs. They support life even if supplied as the sole source of protein. These proteins are of animal origin, e.g. milk, meat, poultry, products and fish. The quality of these proteins is much superior to those of incomplete proteins.

2. Incomplete Proteins These proteins are deficient in one or more of the essential amino acids and therefore, they do not support life on their own. All plant sources of proteins, i.e. vegetables, fruits, cereals, pulses, nuts and oilseeds contain proteins incomplete to varying degrees. If two sources of incomplete proteins are combined in the same meal, the resulting protein may be of better quality, e.g. khichdi prepared using *tur* or *moong dal* and rice is of better protein quality than rice or *dal* cooked separately. Rice *kheer* is another example where animal and vegetable proteins—milk and rice—are cooked together.

Gelatin is the only animal protein which is an incomplete protein. It lacks three essential amino acids namely tryptophan, valine and isoleucine and has only a small amount of leucine. It is interesting to note that animals like rats too do not attempt to feed on gelatin. They also prefer complete proteins.

□ Digestion and Absorption of Proteins

No digestion of proteins takes place in the mouth since saliva does not contain any specific proteolytic enzyme.

In the stomach pepsin acts on the protein to hydrolyze it partially. In the small intestine trypsin continues to split proteins by attacking the peptide linkages. Peptidases act on the polypeptides of shorter chain-lengths liberating the end products of digestion, i.e. the amino acids. These are absorbed from the small intestine. A number of hormones, vitamin B₆ (pyridoxine) and fibre affect the digestion of proteins. Proteins require more time for digestion than carbohydrates. Hence, protein in a diet has a *satiety value* too.

Most of the ingested food proteins are almost completely digested to release amino acids in the gastro-intestinal tract and absorbed as such from the small intestine. The absorption of amino acids involves an active transport mechanism as well as specific transport proteins to be present in the intestinal mucosal cells. The pattern of amino acid absorption from the small intestine depends largely on both the qualitative as well as the quantitative composition of the mixture of the amino acids present. Hence, a mixture of proteins such as dal and rice eaten at a meal complement each other (compensates) for the limited amino acids present in each of them separately.

Certain antibiotics such as pyromycin, actinomycin-D inhibit the absorption of amino acids by blocking the synthesis of transport protein in the intestinal mucosal cell.

After absorption, the amino acids are taken up primarily by the blood capillaries of the mucosa and are transported through the plasma and erythrocytes to the liver, other organs and body tissues for metabolic utilization. A significant amount of the absorbed amino acids also appears in the lymph.

In some persons small amounts of intact proteins are absorbed through the intestinal mucosa. This leads to allergic reactions to certain food proteins.

□ Functions of Proteins

1. Growth and Maintenance Proteins are the chief constituents of muscles, organs and endocrine glands. They are the major and indispensable constituents of skin, hair, nails, bones, teeth, blood, serum, etc. All body fluids, except bile and urine, contain protein. In short, every living cell of our body contains protein and is required for growth and maintenance of every cell in our body.

2. Regulation of Body Processes Proteins are required for highly specialized functions in our body. These proteins are as follows:

- (a) *Immune proteins*—Antibodies, necessary for immunity reactions, are protein in nature. Resistance to diseases is an immunological response.
- (b) *Hormones*—Hormones such as adrenocorticotropic hormone (ACTH) and insulin, are protein in nature.

- (c) *Enzymes*—All enzymes are protein in nature and are required at every step of digestion, absorption and metabolism.
- (d) *Nucleoproteins*—These govern the synthesis of all body proteins.
- (e) *Contractile proteins*—Actin and myosin are responsible for the action of muscles.
- (f) *Blood proteins*—Haemoglobin, the most familiar constituent of blood, is a protein which carries oxygen. Other proteins found in blood are lipoproteins, transferrin, retinol-binding protein, serum albumin and immunoglobins. Serum albumin is also responsible for regulating osmotic pressure and maintaining the fluid balance of the body. *Nutritional oedema* results if the body is deficient in protein, level of blood protein falls and fluids accumulate in the tissues.
- (g) *Specific functions*—Some amino acids have specific and specialized functions in the body, e.g. *tryptophan* is a precursor of niacin and serotonin (a blood vessel constrictor); *methionine* supplies labile methyl groups for synthesizing choline, which prevents accumulation of fat in liver; *glycine* is required for the formation of the porphyrin ring of haemoglobin and is an important constituent of nucleic acids.

3. Supply of Energy Protein is the last source that the body taps for energy. Proteins, like carbohydrates, yield approximately 4.0 cal/g. However, the process of obtaining energy from proteins is not advisable since deamination of amino acids places tremendous load on the kidney, besides expending one of the costliest nutrient for a function which can be satisfied by cheaper sources such as carbohydrates. Utilization of protein for energy is a waste which weakens the body in all respects, retards growth and reduces weight.

□ Symptoms of Protein Deficiency

The deficiency symptoms include weight loss, anaemia, reduced resistance to infections, impaired healing of wounds, hepatic (liver) insufficiency, nutritional oedema, easy fatigue and muscular illness. The vulnerable group is weaning children especially those in the 3–5 years of age group. In case of lack of adequate quantity or quality of protein, especially in the growing years, children fail to grow properly, there is wasting of tissues, and they suffer from diarrhoea and oedema, which is characterized by a swollen abdomen. These symptoms are also seen during semi-starvation.

However, a particular type of complex symptom due to protein malnutrition is seen especially in Central Africa. It is a high-mortality, deficiency disease known as *kwashiorkor* meaning *red boy*. The name comes from the odd reddish orange colour of the hair, as well as from a skin rash, characteristic of the disease. Other symptoms are weakness, nervous irritability, inability to digest and absorb food normally, oedema, anaemia and fatty degeneration of the liver. Since, animal protein foods also supply minerals and B-vitamins, kwashiorkor is probably a protein deficiency, complicated with deficiency of certain minerals and vitamins.

Dry skimmed milk is one of the most effective foods for treatment and prevention of such protein malnutrition in children. Protein concentrates using locally available foods are prepared and fed to susceptible young children. The diet may be

supplemented with peanut or soyabean flour, other legumes, dried yeast or fish meal. All these can provide an adequate mixture of proteins.

□ Sources of Protein

Animal sources are complete proteins, such as meat, egg, fish and poultry, and they are good protein foods in both quantity and quality. Milk is a valuable source of protein because although, it does not contain a large quantity of protein, the quality is excellent. Gelatin, a derived protein is an exception, since it contains three limiting amino acids and hence, is a poor source.

Good sources of plant proteins are legumes, pulses, nuts and oilseeds. But their quality is poorer than that of the flesh foods listed above. However, complementing two plant sources or combining an animal and a vegetable source in one meal increases the nutritional value of the meal tremendously.

All vegetables and fruits are a poor source of protein.

□ Protein Requirement, Essential Amino Acids and Protein Quality

Two basic measures must be considered for protein requirement, i.e. quantity and quality. The higher the quality, lower the requirement and vice versa.

Protein quality varies from each type of protein. The value of a protein is dependent upon its content of essential amino acids. Since, the essential amino acid, tryptophan, is required least in the body, it is assigned the value of 1. On the basis of the provisional amino acid pattern an ideal proportionality pattern of amino acids required by an adult is constructed by the Food and Agriculture Organization (FAO), against which the amino acid ratios in different foods may be measured. According to this amino acid proportion pattern (see Table 3.7), eggs and milk rank highest as reference proteins against which the protein quality of other foods is measured.

Table 3.7 FAO's ideal amino acid proportionality pattern

Amino acid	Requirement (mg)	Proportionality pattern
Tryptophan	250	1.0
Threonine	500	2.0
Isoleucine	700	2.8
Lysine	800	3.2
Valine	900	3.6
Total sulphur amino acid	950	3.8
(Methionine minimum)	(325)	(1.3)
Leucine	1050	4.2
Total aromatic amino acid	1550	6.2
(Phenylalanine minimum)	(325)	(1.3)

□ Determination of Protein Quality

Protein *quality* is an important aspect of determining protein requirement. This concept was developed in the mid 20th century.

A number of indices have been developed for measuring protein quality, several of which are based on the nitrogen-balance principle.

Principle of Nitrogen Balance It is commonly used to determine the requirement of protein. In a normal adult living under usual conditions, the amount of amino acid ingested in a day undergoes degradation and the nitrogen from such a metabolism is excreted every day. Nitrogen balance means the amount of nitrogen lost in a 24-hour period is equal to that consumed during this period. This is so because the nitrogen consumed is mainly from protein nitrogen sources. However, in a growing child or in conditions of rapid growth, the body tries to conserve by allowing only a part of the amino acids to undergo degradation, the remaining enter the process of net synthesis of protein.

Nitrogen is lost from the body through urine, faeces, perspiration and such functions as desquamation of epidermis, growth of hair and nails, as well as secretion of nasal mucus, tears, etc. Nitrogen-balance studies, however, compute the intake of food nitrogen and output of nitrogen in urine and faeces only, since, these two constitute the major means of nitrogen loss.

In order to retain the nitrogen balance, it is necessary to ingest and absorb sufficient amount of the eight essential amino acids. If any one of these is lacking, nitrogen balance becomes proportionally negative. Addition of the missing essential amino acid to such a diet helps restore the nitrogen balance promptly.

A person is said to be in nitrogen balance (equilibrium) when his intake and output of nitrogen are equal. A person is said to be in positive nitrogen balance when more nitrogen is retained in the body than that lost, while a person is said to be in negative nitrogen balance when more nitrogen is lost than ingested. Normally, a positive nitrogen balance is seen in growing children, convalescing patients and pregnant women. A negative nitrogen balance, is observed during starvation, malnutrition, fever, after extensive burns or trauma and in post-operative conditions.

□ Indices for Determination of Protein Quality

1. Biological Value (BV) BV is an index of protein quality that reflects the percentage of absorbed nitrogen from dietary protein actually retained by the body, measured under standard conditions.

The basic formula for BV is

$$BV = \frac{N \text{ retained}}{N \text{ absorbed}} \times 100$$

For example, if rats are fed on a controlled diet using a given protein food source, the nitrogen content of the diet, urine and faeces is measured and BV is calculated as:

$$BV = \frac{\text{Dietary N} - (\text{Urinary N} + \text{Faecal N})}{\text{Dietary N} - \text{Faecal N}} \times 100$$

The greater the proportion of N retained, the higher is the BV or quality of the protein being tested, e.g. eggs have a BV of 87–97.

Whey has a BV between 106–159

Cow's milk has a BV of 85–90

Rice and Tofu (Soya-curd) have a BV of 75

With the exception of gelatin, no animal protein has a BV < 72. No plant protein has a BV > 75.

The BV of a mixed diet is higher than the average of the BV's of its individual component proteins. This complementary effect is due to the fact that particular amino acid deficiencies in one protein are often compensated by the other source. Timing of ingestion of proteins is crucial to this synergistic effect of mixed proteins. A combination of cereal and pulse in the ratio of 5:1 has been found to give an optimum combination. Thus, the habitual diets of vegetarians in India based on cereal and pulse has a rational basis.

2. Net Protein Utilization (NPU) NPU is an index that takes into account the relative digestibility of proteins. Since, even the best mixture of amino acids will be less available for use in the body if it is packaged in a protein that is only partially digested.

Therefore, $NPU = BV \times \text{digestibility}$

$$\begin{aligned} NPU &= \frac{\text{N retained}}{\text{Dietary N}} \times 100 \\ &= \frac{\text{Dietary N} - (\text{Urinary N} + \text{Faecal N})}{\text{Dietary N}} \times 100 \end{aligned}$$

Proteins are generally easy to digest. Most proteins are 90 percent or more digestible. Thus, in most cases, NPU approximates the BV.

3. Protein Efficiency Ratio (PER) This indice is not based on nitrogen-balance studies. It is, therefore, less precise than BV and NPU, but it is technically easier to derive and use.

PER is defined as the change in body weight relative to the amount of protein eaten. It is usually measured in laboratory rats kept under standardized diet conditions.

$$PER = \frac{\text{Weight gain in grams}}{\text{Dietary protein in grams}}$$

For example, if a rat is given a standard diet nutritionally adequate in all respects, containing 2 g of casein per day as the only source of protein and his weight gain is found to be 5 g per day, then the PER of casein would be

$$\frac{5}{2} = 2.5$$

Whole egg has a PER of 3.8, while gelatin has 0 PER.

4. Protein Digestibility Corrected Amino Acid Score (PDCAAS) This protein quality measurement was instituted by the FAO and WHO in 1985 and since then it has been accepted internationally as the official assay for evaluating protein quality.

It is based on the amino-acid requirements of children aged 2 to 5 years. It represents the amino acid score after correcting for digestibility. The PDCAAS of 1.0 is assigned to those proteins that after correcting for digestibility provide aminoacids equal to or in excess of the requirements, e.g. soyprotein has a PDCAAS of 1.0 since it meets the protein needs of adult humans when consumed at a level of 0.6 g/kg body weight as the only source of protein.

The PDCAAS of some foods are shown in Table 3.8:

Table 3.8 PDCAAS of some foods

Food	PDCAAS
Soybean	1.0
Milk	1.0
Egg	1.0
Beef	0.82
Peas	0.73
Oats	0.57
Groundnuts	0.52
Rice	0.47
Maize	0.42
Wheat	0.25

5. Amino Acid Score It is a chemical score based on chemical analysis of the protein and not on a biological test. It compares the content of essential amino acids in a protein or protein mixture with that found in a standard reference protein, defined by FAO/WHO (1973) (see Table 3.9).

Table 3.9 Provisional amino acid scoring pattern

Amino acid	Suggested level mg/g of protein
Isoleucine	40
Leucine	70
Lysine	55
Methionine + Cystine	35
Phenylalanine + Tyrosine	60
Threonine	40
Tryptophan	10
Valine	50
Total	360

The amino acid score is determined by the following formula:

$$\text{Amino acid score} = \frac{\text{mg of amino acid per gram of test protein}}{\text{mg of amino acid per gram of reference protein}} \times 100$$

The score of the test protein is determined by the amino acid that is lowest in proportion to its amount in the reference protein.

Soybeans have sulphur-containing amino acids, methionine and cystine, in the smallest proportion to their level in the reference protein. Since, soybean protein has only 74 percent as much of these amino acids as the reference protein, the amino acid score of soybean protein is 74. Thus, the sulphur containing amino acids are said to be *limiting amino acids* (Table 3.10).

Table 3.10 Limiting amino acids in categories of vegetable protein foods

Category	Limiting Amino Acid(s)
Most grain products	Lysine, threonine (sometimes tryptophan)
Most legumes or pulses	Methionine, tryptophan
Nuts and oil seeds	Lysine
Green leafy vegetables	Methionine
Leaves and grasses	Methionine

Lysine, threonine, tryptophan and the sulphur-containing amino acids, cystine and methionine, are the limiting amino acids in most foods, e.g. in wheat the limiting amino acid is lysine.

The chemical scores, limiting amino acids and NPU of some foods is given in Table 3.11 and 3.12.

Importance The concept of limiting amino acids has a number of practical applications as in the following cases:

- (a) In dietary planning of informed vegetarians. Vegetarian must include foods providing complementary proteins at every meal, e.g. cereals + legumes in one meal.
- (b) In trying to develop a new product by nutritionists, using two plant proteins, e.g. *Incaparina* developed for child feeding programmes in Guatemala.
- (c) In agricultural research by which newer strains of wheat are being developed, containing increased levels of lysine and tryptophan.
- (d) In fortification of wheat flour with lysine in some developing countries, e.g. bread.
- (e) In protein-enriched products which are being developed, e.g. nutrela nutrinuggets, meal maker, etc.

□ Vegetarian Diets

A vegetarian diet consists of only foods of plant origin, and no meat, fish, eggs or other animal products are allowed.

There are four types of vegetarians:

1. *Ovolactovegetarians*: This diet consists of plant foods, along with eggs, milk and milk products.
2. *Lactovegetarians*: This diet is of plant origin, supplemented with milk and milk products.
3. *Pure vegetarians or vegans*: Eat all foods of plant origin.

Table 3.11 The protein quality of some common foods

<i>Food</i>	<i>Protein</i>	<i>Digestibility</i>	<i>Biological value (BV)</i>	<i>Net Protein utilization (NPU)</i>	<i>Net Dietary calories (ND Cals)</i>	<i>PER</i>	<i>Chemical score (CS)</i>	<i>Limiting amino acid</i>
<i>Unit</i>	<i>g/100g</i>	<i>percent</i>	<i>percent</i>	<i>percent</i>	<i>percent</i>		<i>percent</i>	
Eggs	13	99	94	94	30	3.92	100	None
Cow's milk, whole	4	97	85	82	20	3.09	61	Methionine and cystine
Fish	19	98	83	81	49	3.55	75	Tryptophan
Beef	18	99	74	74	21	2.3	69	Valine
Chicken	21	95	74	70	49		67	Valine
Pork	12	—	74	—	—	—	68	Methionine and cystine
Gelatin	86	—	—	3	3	-1.25	0	Tryptophan
Soybeans	34	90	73	66	22	2.32	46	Methionine and cystine
Common dry beans	22	73	58	42	11	1.48	34	Methionine and cystine
Peanuts	26	87	55	48	9	1.65	43	Methionine and cystine
Brewer's yeast	39	84	67	56	31	2.24	45	Methionine and cystine
Wheat whole grain	12	91	66	60	9	1.5	48	Lysine
Corn whole grain	9	90	60	54	5	1.12	40	Lysine
Brown rice	8	96	73	70	6	—	56	Lysine
White rice	7	98	64	63	5	2.18	53	Lysine
Potato	2	89	73	5	7	—	48	Methionine and cystine

4. *Fruitarians:* These vegetarians consume raw or dried fruit, nuts, honey and olive oil. They may supplement their diet with grains and legumes.

□ Problems of Vegetarianism

(a) Energy Obtaining calories is not a problem for adults but for children, since, foods contribute to bulk and are high in fibre.

(b) Protein The requirement for essential amino acids has to be met with foods having lower digestibility. The essential amino acid in vegetarian food pattern is not well balanced as in the foods of animal origin. Hence it is necessary to complement foods in such a manner that the limiting amino acid of one food will be supplied by another food eaten at the same meal. Combining a cereal and a pulse as in *khichdi*,

Table 3.12 *The chemical scores, limiting amino acids and net protein utilization (NPU) of some foods*

<i>Food</i>	<i>Chemical score based on the egg essential amino acid pattern</i>	<i>Limiting amino acid</i>	<i>NPU</i>
Egg	100	—	100
Egg albumin	90	Tryptophan	83
Spinach	90	Methionine and cystine	—
Beef	80	Methionine and cystine	80
Cotton seed meal	80	Methionine and cystine	66
Sweet potato	75	Methionine and cystine	72
Fish	75	Tryptophan	83
Rice	75	Lysine	57
Oats	70	Lysine	—
Peanut flour	70	Methionine and cystine	48
Soybean flour	70	Methionine and cystine	56
Sunflower seed	70	Lysine	65
Wheat germ	65	Methionine and cystine	67
Casein	60	Methionine and cystine	72
Milk (cow's)	60	Methionine and cystine	75
Millet	60	Lysine	56
Peas	60	Methionine and cystine	44
Sesame seed	50	Lysine	56
White flour	50	Lysine	52
Potato	48	Methionine and cystine	71
Cornmeal	45	Tryptophan	55
Navy bean	42	Methionine and cystine	47
Cassava	40	Methionine and cystine	—
Wheat gluten	40	Lysine	37

idli, dosa, are some common examples of complementing foods. A mixed diet based only on plant proteins can meet the protein requirements of adult and older children, provided that they consume enough diet to meet their energy needs. The protein content of the diet must contribute about 10% of the total calorie requirement. For growing children and pregnant and lactating women, the requirements are relatively greater and it is desirable that some animal foods which have a high protein quality should be included in their diets (especially if the protein quantity and quality in the diet is low). Milk is the preferred choice for children since it is a good source of calcium which is normally lacking in a vegetarian diet. Skim milk is a richer source of protein than whole milk. Eggs, another source of good quality protein, can be used in various forms such as boiled or fried. It is also a good source of a wide range of nutrients especially B_{12} which is absent in vegetarian foods.

Curds and buttermilk which are probiotics normally used in the Indian dietaries are also a good source of protein. Fish is also a good source of protein whenever available and acceptable. It must be included in the diet especially that of the older children and adults. In the Indian dietaries economic considerations often preclude the inclusion of animal foods.

(c) Calcium If milk is omitted then the calcium in the diet may be marginal. However, dark green leafy vegetables like colocasia, fenugreek (*methi*) are rich in calcium. Fortified soybean milk, malted *ragi* may be consumed since they are a rich source of calcium.

(d) Iron Plant sources of iron are absorbed less than animal iron. The concentration of iron is also lower. Therefore, vegetarians must choose good sources of iron as well as ascorbic acid for enhancing the absorption of iron.

(e) Zinc Grains are a good source of zinc but its absorption may be affected due to the presence of phytic acid. Yeast fermentation lowers phytic acid and increases the availability of zinc and other trace minerals.

(f) Vitamin D Rich sources of vitamin D are animal sources. Exposure to sunlight may fulfil the requirement of vegetarians but supplementation may be necessary.

(g) Riboflavin Major sources are meats, milk and dairy products. However, legumes and whole grains may provide significant amounts.

(h) Vitamin B₁₂: There are no known plant sources of this vitamin. Once a deficiency occurs, effects on the nerves are not always reversible. Vitamin B₁₂ should be provided by a supplement, by fortified foods such as soybean milk, meat analog, or by yeast grown on a B₁₂ enriched media.

□ Healthful Vegetarian Diets

This requires care in planning and knowledge of the strengths and weaknesses of the various foods. For this purpose, the following steps should be taken:

1. Reduce substantially all high-calorie, low-nutrient density foods like soft drinks (carbonated beverages). Such foodstuffs have empty calories. Instead use unrefined foods as far as practical, which on a caloric basis supply their share of nutrients.
2. Replace meat with legumes, seeds and nuts.
3. Increase the intake of whole grain breads and cereals, legumes, nuts and seeds to maintain energy intake.
4. Use a variety of legumes and whole grains in order to complement the diet.
5. Use a variety of fruits and vegetables.
6. Eat dry fruits since they contain substantial quantities of several nutrients. In order to meet the requirement of vitamin D, regularly expose the body to the sun's rays, and supplement the diet with vitamin B₁₂.
7. Obtain additional food energy from sweeteners such as sugar, and jaggery, margarine, oils and shortenings.
8. Eat sufficiently to maintain ideal weight for height.
9. Ensure selection of nutritious foods.
10. Use vegetarian cookbooks and recipes for preparing tasty and nutritious dishes.

□ Advantages of Vegetarianism

Vegetarians on low total fat and high saturated fatty acid diets show decreased LDL levels and elevated HDL cholesterol levels. HDL:LDL cholesterol ratios are also found to be increased. Addition of eggs (which contain high amounts of cholesterol) to the diet of lacto-vegetarians increases LDL-lipoprotein levels in three weeks.

An improvement in HDL:LDL cholesterol ratio is found in non-vegetarians who are fed lacto-vegetarian diet for six weeks.

Lacto-vegetarian have altered platelet linoleic and arachidonic acid levels in comparison with non-vegetarians. Vegans and vegetarians do not differ in serum thromboxane or prostacyclin levels or platelet aggregation.

Non-vegetarians show changes in platelet function when saturated fatty acids are decreased and P:S ratios are increased. Platelet aggregation to thromboxane and clotting activity of platelets is decreased and Saturated fatty acids increase thrombin aggregation. Platelet function can be decreased by altering diets.

Hepatic encephalopathy may be precipitated if a high protein diet is consumed, particularly one that is derived from animal proteins.

Choline present in foods like wheat germ, soybean, peanuts and skimmed milk may prevent the formation of a fatty liver.

Overall, there are more advantages in a vegetarian diet than a non-vegetarian one.

3.4 WATER

Water is second only to oxygen in its vital importance to the body. One can live without food for a longer time than one does without water.

Our body contains about 65 percent water. An infant's body contains more water than that of an adult. A thin person has a higher percentage of water than a fat person. Men have more body water than women. All body tissues have water but there is a wide variation, e.g. a striated muscle contains 75–88 percent, blood contains 85–90 percent, whereas teeth contain only about 5 percent and bone contains 20–25 percent.

Dehydration is nothing but depletion of water in the body. A 10 percent loss of body water causes very serious symptoms while a 20 percent loss often results in death.

□ Functions of Water

1. Water is more important than food. In the human body it is found as intracellular fluid and also around organs as extracellular fluid, and between the cells as intercellular fluid. All the constituents of protoplasm are suspended in water. It is a structural component; it cushions all cells. 0.4 g water is found per g of protein, while 0.2 g water is found per gram of fat. In some tissues such as bone it is tightly bound, but in most cells there is a constant interchange of ICF and ECF in order to maintain osmotic pressure. Turgidity of tissues and cells is due to the water content.
2. It acts as a solvent in all stages of digestion. We feel more thirsty after a meal.
3. It keeps nutrients in solution form so that they may be absorbed through the intestinal walls.
4. It transports nutrients through blood to all the tissues.

5. It acts as a vehicle for the waste products which are excreted either through the bowels or through the kidneys.
6. It is a lubricant and prevents friction between the moving parts. Saliva in the mouth helps us in swallowing food. The fluids around joints, mucous secretions of the gastro-intestinal tract, the genito-urinary and respiratory tracts are some other examples.
7. Water regulates body temperature through evaporation from the lungs and skin. Its cooling effect is necessary to get rid of metabolic heat generated in the body. Each litre of water lost through perspiration represents a heat exchange of about 600 kcal.

□ Sources of Water

The body has three sources of water. Besides drinking water, the following are the sources of water:

1. The water contained in food, e.g. fruits and vegetables contain 80–90 percent water. Milk contains 80–88 percent. Flour, crackers and bread contain 5–35 percent. Meats contain 40–75 percent water.
2. In addition to water, ingested fluids such as *kheer* (milk-based preparation), soups and beverages, also supply essential minerals and vitamins.
3. Metabolic water is formed by the metabolism of food in the body. It may amount to about 450 ml per day.



Oxidation of 100 g fat → 107 ml water

100 g protein → 41 ml water

100 g carbohydrates → 56 ml water

To ensure adequate fluid intake, at least five to six glasses and preferably six to eight glasses of water or other beverages should be taken daily.

Water is lost through faeces, urine, lungs (expiration), skin—(invisible perspiration and visible perspiration) amounting to about 2–3 litres per day. During infections and fever, the liquid intake should be increased as losses are higher. A moderate amount of water taken with or preceding a meal is an aid to digestion, since, it promotes the secretion of gastric juice in the stomach. Hence, a moderate amount of water may be taken during meals but should not be used to wash down the food. Large quantities of an iced beverage before or during meals slows down digestion.

□ Deficiency of Water

Dehydration results in extreme deficiency of water and fluids. Symptoms of dehydration are fatigue, headache, sullenness and, in extreme cases, collapse.

The steps in the progression of dehydration are as follows:

1. Thirst
2. Stronger thirst, vague discomfort, loss of appetite

3. Decreasing blood volume, impaired physical performance
4. Increased effort for physical work, nausea
5. Difficulty in concentrating
6. Failure to regulate excess temperature
7. Dizziness, laboured breathing with exercise, increased weakness
8. Muscle spasms, delirium, and wakefulness
9. Inability of decreased blood volume to circulate normally
10. Failing renal function, less or no urine formed

Excessive loss of water takes place due to vomiting, diarrhoea, haemorrhage, excessive perspiration, exudating burns, uncontrolled diabetes mellitus, fever, strenuous exercise and hot weather.

It can be fatal and causes death in several children which could be easily avoided by proper fluid intake or *oral rehydration therapy*.

ORT Oral Rehydration Therapy is a method of treating dehydration by making the patient drink readily available preparations, such as Electral, Electrose, Pedialyte, etc. dissolved in water as per the manufacturer's instructions. In case these are not available, a similar solution can be prepared by dissolving salt and sugar in boiled and cooled water.

A typical ORT formula as recommended by WHO is given in Chapter 12.

□ Water Intoxication

Water intoxication results due to excess intake of water. This results in an increase in the volume of intracellular fluid. This condition can lead to headache, nausea, vomiting, muscle twitching, and convulsions. It can even be fatal.

3.5 DIETARY FIBRE (DF)

Vegetable fibre or cellulose is not a true nutrient since it is not digested by the human digestive system nor is it assimilated in the body, but it has a regulatory function in the diet.

□ Chemical Composition

This vegetable fibre, which is a polysaccharide, should not be confused with *animal fibre* as found in meats. It is the term collectively given to indigestible carbohydrates in plant foods. They comprise polysaccharides and lignins not digested by the endogenous secretions of the human GI tract.

DF is further subclassified into:

IDF (Insoluble Dietary Fibre): which are non viscous slowly fermentable, e.g., Cellulose, lignin and some portions of hemicellulose.

SDF (Soluble Dietary Fibre): which are viscous and fermentable, e.g., Pectins, gums, Beta-glucans, mucilages and major portions of hemicellulose.

DF is found to have hypoglycemic and hypolipidemic effects. IDF is effective in reducing constipation and diverticulosis. SDF is effective in reducing the incidence of CHD, Type II diabetes (NIDDM) and obesity.

Foods such as fenugreek seeds which have a high level of IDF (48.6%) and SDF (20.0%) have been shown to be effective in reducing blood glucose and cholesterol levels. Some supplements such as psyllium, gum karaya and gum acacia, which have a high SDF, have shown to reduce body weight.

Also, TDF contributes to the bulk in the diet thereby reducing energy intake and helping to reduce body weight.

Dietary fibre is supplied through fruits, vegetables and the coats of grains (Fig. 3.7). Dietary fibre is mostly made up of cellulose besides pentosans, hemicellulose, lignins, pectins and other indigestible plant matter in small quantities. Cellulose is a fibrous material found only in plants.

Fibre is defined as the component of dietary plant materials that cannot be digested by human enzymes and consist of a heterogenous mixture of complex polysaccharides and non-polysaccharide polymers.

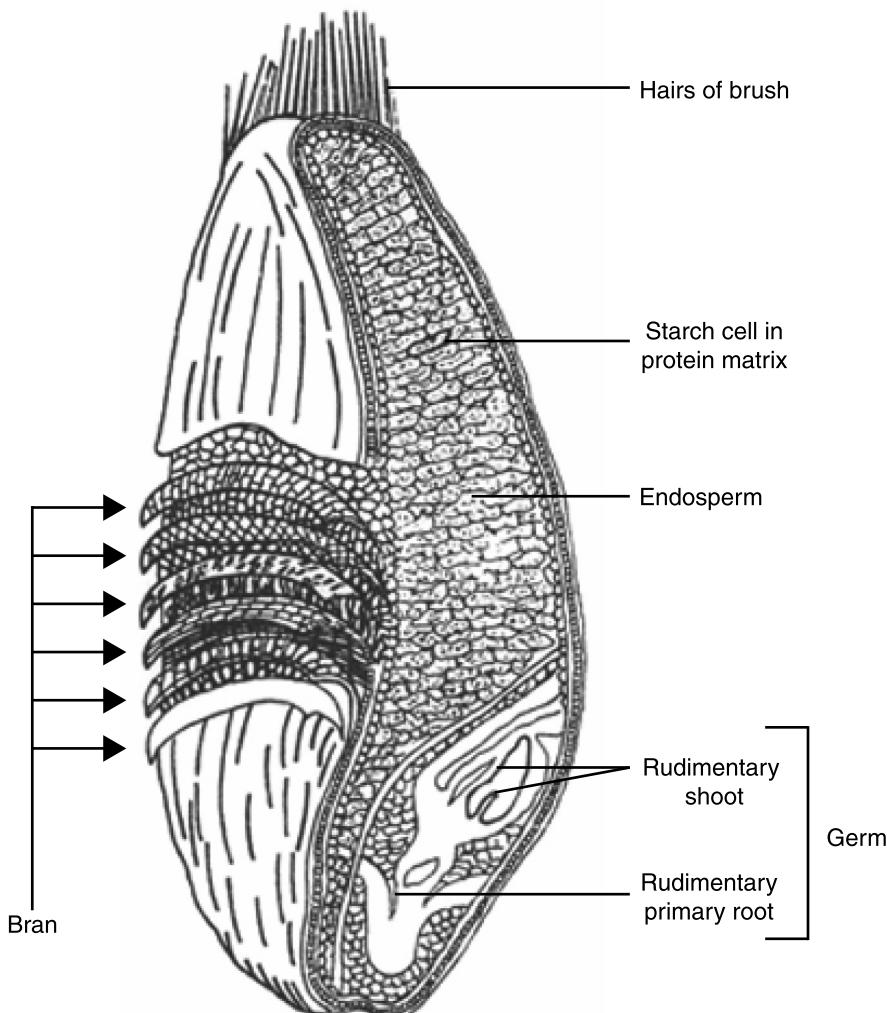


Fig. 3.7 Parts of a grain

Table 3.13 Classification of food polysaccharides

<i>Role in the plant/food</i>	<i>Types of polysaccharides</i>	<i>Products of digestion</i>
Storage polysaccharides (available carbohydrates)	Starch: Amylose Amylopectin Fructans Galactomannans	Mono- and di-saccharides
Structural components of the plant cell walls (non-available carbohydrates)	Non-cellulosic: Pectins Hemicellulose Cellulose	Short chain fatty acids: Acetate Propionate Butyrate
Isolated polysaccharides Naturally occurring	Gums Mucilages Pectin	Carbon dioxide, hydrogen, methane
Polysaccharide food additives	Gums Algal Polysaccharides Modified celluloses Modified starches	

Major fibre types are celluloses, hemicelluloses, pectins, gums, mucilages, algal polysaccharides and lignins. All except lignins are polysaccharides.

Fibres can also be classified according to their water solubility. Those, which are insoluble in water and non-fermentable, are the structural fibres like cellulose, lignin and some hemicelluloses. The non-fermentable, insoluble fibre fractions affect the intestinal function by retaining the water in the stools, thereby increasing the faecal bulk and decreasing the transit time.

Natural gel forming fibres, which are water soluble and fermentable, are pectins, gums, mucilages and the remaining hemicelluloses. The fermentable, soluble fibre fractions also contribute to the decrease in the transit time by stimulating microbial

Table 3.14 Benefits and examples of good sources of soluble and insoluble fibre

	<i>Soluble Fibre</i>	<i>Insoluble Fibre</i>
Natural Fibre Components	Gums, mucilages, pectins	Cellulose, lignins, some hemicelluloses, some hemicelluloses
Benefits	May help in reducing blood cholesterol and reducing blood glucose levels. Decreases faecal bulking. Slows gastric emptying. Prolongs small bowel transit.	May help prevent colon cancer. Helps prevent constipation. Increases resistance to digestion. Increases resistance to fermentation. Reduces carbohydrate availability. Increases faecal bulking. Induces propulsion in small intestine. Alters hormone profiles. Increases faecal bile acid secretion. Reduces post prandial glycemia.
Good Sources	Oat bran, beans (navy kidney, pinto or lima) barley, vegetables and fruits.	Whole-wheat bread, beans (navy, kidney, pinto or lima), cereals and the skins of vegetables and fruits.

growth in the intestine, which increases the faecal bacterial mass. Additionally, soluble fibre slows glucose absorption and lowers serum cholesterol.

The major food sources of fibre are fruits, vegetables and whole grain cereals. Although, food sources of fibre are complex, they may be rich in specific types of fibre, e.g. oat bran is rich in water-soluble gums and is a good source of viscous fibre while wheat bran contains more insoluble fibre.

Vegetables and grain products contain large amounts of cellulose; bran cereals and other whole grain products are the most concentrated sources of hemicellulose; and apples and citrus fruits contain a large amount of pectin.

Fibre is estimated by different methods. Earlier, Weende's method was used to estimate the crude fibre content of foods. Today, it is still being used to estimate fibre in animal feeds, etc. Later, it was proposed that dietary fibre should be measured as the non-starch polysaccharide in plant foods, which gives the best index of plant

Table 3.15 Comparison of crude fibre and total dietary fibre content of various foods

	Crude fibre ^a	Total dietary fibre ^b	Non-cellulose polysaccharides (soluble fibre)	Cellulose (insoluble fibre)	Lignin (insoluble fibre)
Food	g/100 g edible portion				
Cereals					
Flour, white	0.3	3.2	2.5	0.6	0.03
Flour, whole	2.3	9.5	6.3	2.5	0.8
Wheat bread, white	0.2	2.7	2.0	0.7	Tr
bread, whole wheat	1.6	8.5	6.0	1.3	1.2
Fruits					
Apples	0.6	1.4°	0.9 ^c	0.5 ^c	0.1 ^c
Oranges (peeled)	0.5	0.29	0.22	0.04	0.03
Pears	1.8	11.0°	5.04 ^c	2.9 ^c	3.0 ^c
Banana	0.5	1.8	1.1	0.4	0.3
Peaches	0.6	2.3	1.5	0.2	0.6
Legumes and nuts					
Kidney beans	1.8	7.3	5.7	1.4	0.2
White beans	1.7	7.3	5.7	1.4	0.2
Peanuts (roasted)	2.0	9.3	6.4	1.7	1.2
Peas	2.0	7.1	4.5	2.4	0.2
Vegetable					
Beans, green	1.0	3.4	1.9	1.3	0.2
Carrots	1.0	3.7	2.2	1.5	Tr
Cabbage, white	0.8	2.8	1.8	0.7	Tr
Cauliflower	1.0	1.8	0.7	1.1	Tr
Lettuce, romaine	0.6	1.5	0.5	1.0	Tr
Pepper, green	1.4	0.9	0.6	0.3	Tr
Potato, with skin	0.05	3.5	2.5	1.0	Tr
Corn, cooked	0.8	4.7	4.3	0.3	0.1
Tomatoes, fresh	0.5	1.4	0.7	0.4	0.3
Turnips, raw	0.9	2.2	1.5	0.7	Tr

Tr = Traces

a = Crude fibre, g/100 g edible portion, method of Weende, in Composition of Foods (Agricultural Handbook No. 456), Washington D.C.: U.S. Department of Agriculture, 1975.

b = Total dietary fibre, Southgate method, D.A.T. Southgate et al., *J. Human Nutr.* 30:303–313, 1976.

c = Flesh only.

cell wall polysaccharides. By the method of Southgate, from which the Englyst's procedure evolved, it is possible to differentiate between the soluble and non-soluble dietary fibre of foods.

□ Functions

It is not digestible by the human digestive system. It performs two very important functions: (i) providing the faecal bulk, and (ii) stimulating the large intestine for easy movements. There are a few others but the mechanism of its action is not yet understood.

1. Providing Faecal Bulk The chief function of fibre is to provide bulk. Starch, proteins and fats are usually 90–98 percent digestible. Absorption of minerals and vitamins is also fairly complete under favourable conditions. Faecal bulk is therefore, made up of cellulose besides indigestible substances, bacterial cells and water, which are also present. Cellulose binds the undigested and excretory matter. It absorbs water and thus increases intestinal bulk. This prevents hardening of stools and promotes laxation.

Constipation, which is a very common disorder of daily life, can easily be prevented if adequate quantity of fibre is included in the daily diet. Agar from seaweed and pectin from fruits are commonly used as therapeutic aids to overcome constipation. These have several advantages over chemical laxatives like castor oil or mineral oils such as paraffin as well as laxatives available in tablet form. Mineral oils interfere in the absorption of fat-soluble vitamins.

This is more important for older persons who prefer food which is soft and smooth. Such a diet combined, with an inadequate fluid intake leads to persistent constipation. Although, rough fibres such as those found in drumsticks, fruit skins, lettuce, cabbage and nuts are not advised for older persons, the fibre of tender vegetables, peeled fruits and whole-grain cereals help in the normal evacuation of the bowels.

2. Stimulating Peristalsis Fibre is essential for the movement of the bowel as it stimulates the large intestines. When the large intestines contract, the faecal matter is pushed and the undigested food and other excretory matter is then eliminated.

Fibre, which is also called roughage, plays this important role of bowel motility. Due to its coarse surface it mechanically stimulates (irritates) the intestinal mucosa. This helps peristaltic movements which are vital for the perfect functioning of the digestive system. This process is important for the passage of food in the gastrointestinal tract.

A few years ago fibre in the diet was considered unnecessary. White bread was preferred to brown bread, refined and highly processed foods were considered superior to their unrefined and unprocessed counterparts. These and similar trends of excluding fibre from the diet because of the ignorance of its, *nutritive value* did great harm. More and more people suffered from constipation, colon cancer, cardiovascular diseases, etc. When these disorders were proved to be related to the lack of fibre in the diet, the trend reversed. Now it is a proven fact that *fibre* is nutritionally important though it has no nutritive value. Today, it is considered very important to include a good amount of fibre in the diet to promote good

health. Fibre content of food items is advertised regularly and many such foods are available in the market.

□ Deficiency of Fibre

There are many diseases for which epidemiological data is being collected to see if dietary fibre plays any part. These are:

1. Alimentary tract diseases such as diverticulosis, hiatus hernia, gall bladder disease, appendicitis, polyps and colon cancer.
2. Cardiovascular conditions such as ischemic heart disease, occlusive vascular disease, varicose veins, hemorrhoids and deep vein thrombosis.
3. Other metabolic conditions such as obesity and diabetes.

□ Sources of Fibre

Fruits and vegetables (except peeled potatoes) provide about 1 gram of cellulose per serving.

Whole grain cereals and nuts supply 1/2–1 1/2 gram of cellulose per serving.

In a normal adult diet, an intake of about 40 g of fibre per day is recommended, which can be easily supplied through whole grain cereals, fruits and vegetables commonly included in an Indian diet.

The fibre content of various food groups is listed in Table 3.16 and details of each group given in Appendix VI.

Table 3.16 Average fibre content of foods

<i>Food group</i>	<i>Percentage of fibre</i>
1. Cereals and pulses	2.3
2. Leafy vegetables	1.2
3. Roots and tubers	0.8
4. Other vegetables	1.9
5. Nuts and oil seeds	3.2
6. Fruits	2.2

3.6 VITAMINS

Vitamin is a word which is commonly heard. Advertisers claim that their products contain some vitamin or the other which is good for health, etc. But, what is a vitamin? Does it really play an important role in our health?

A vitamin is a vital substance. It is needed in a very small quantity for growth and good health. Vitamins are vital body regulators. They may be defined as a name given to a group of potent organic compounds which are not carbohydrates, proteins or fats in nature, but are present in foods and are essential in minute quantities for specific body functions of growth, maintenance and reproduction. Most of them are not synthesized by the body and must be supplied through diet, except a few whose requirement may be partially met by synthesis in the body, such as folic acid and vitamin D.

Discovery and Nomenclature of Vitamins Numerous scientists have contributed to the discovery of vitamins. The word vitamin was coined by Casimir Funk who discovered a water-soluble substance in rice polishings which prevented beri-beri. He described this vitamin as a *vital amine*. Hence, he named the substance *vitamine*. The *e* was dropped later when it was discovered that other similar vital substances were a variety of organic compounds and not just *amines*.

□ Characteristics of Vitamins

The two essential characteristics of a compound in order to be classified as a vitamin are:

1. It is a vital organic dietary substance which is not a carbohydrate, protein, fat or mineral. It is required in a very small quantity to perform a particular metabolic function or to prevent an associated deficiency disease.
2. It cannot be synthesized by the body and must, therefore, be supplied through food, though there are some exceptions to this rule.

When the vitamins were discovered, they were named for convenience in an alphabetical order. Vitamin A was discovered before vitamin C hence, the corresponding alphabet assigned to it. But as new vitamins were discovered rapidly and some substances which were thought to be single units turned out to be a group of substances, numbers were assigned to them along with alphabets, e.g. vitamins B₁, B₂, B₃, B₆, B₁₂, etc. Sometime later, meaningful names were given to the vitamins to describe their chemical nature or functions, such as vitamin C was given the name *antiscorbutic vitamin* or *ascorbic acid*. However, many vitamins are still referred to by their alphabetical names. Table 3.17 shows a list of vitamins along with their synonyms or descriptive terms.

Some of the vitamins are quite unstable. So food must be carefully prepared, processed and stored to retain these vitamins. Refining of food, improper storage, or thermal processing of food may cause heavy loss of certain vitamins. Hence, addition of synthetic vitamins as supplements is recommended for several processed foods.

□ Classification of Vitamins

Vitamins are classified according to their solubility in fat and water.

1. *Fat-soluble* vitamins are A, D, E and K
2. *Water-soluble* vitamins are B group vitamins and vitamin C

It is necessary to explain the term *provitamin* (or precursor) here. A provitamin is a substance which the human body can convert into the vitamin, e.g. beta carotene, a precursor of vitamin A is called provitamin A since our body can convert it into vitamin A.

Dehydrocholesterol and Ergosterol are precursors (provitamins) of vitamin D.

□ Chemical Characteristics of Fat-soluble Vitamins—A, D, E and K

Following are the general properties of these vitamins:

1. They are not easily destroyed by ordinary cooking methods.
2. They are stored in the body and, at times, cause toxicity when supplied in excess. This phenomenon is called hypervitaminosis. It is dealt with individually under each fat soluble vitamin.
3. They are destroyed by rancidity as they are always associated with fats.
4. They are not absorbed if mineral oil is present in the intestine.

Detailed chemical characteristics of the fat-soluble vitamins, A, D, E and K, can be seen from Tables 3.18 and 3.19.

Table 3.17 Nomenclature of vitamins

Vitamin	Synonym/descriptive term
<i>A group</i>	
A ₁	Antixerophthalmic vitamin
A ₂	Retinol
A acid	Dehydroretinol
Provitamin A	Retinoic acid (Tretinoin)
	Carotene (alpha and beta) cryptoxanthin (hydroxy betacarotene)
<i>B group</i>	
Thiamine	Formerly vitamin B complex
Riboflavin	Vitamin B ₁ , aneurin, anti-beriberi vitamin
Niacin	Vitamin B ₂ , lactoflavin
	Nicotinic acid and nicotinamide, pellagra-preventive factor
Pantothenic acid	Formerly vitamin B ₃
B ₆	Pyridoxine, pyridoxal, pyridoxamine
Biotin	Co-enzyme R
Folacin	Folic acid (pteroylmonoglutamic acid, PGA) and polyglutamates, tetrahydrofolic acid (formerly citroverum factor, folinic acid)
B ₁₂	Antipernicious anaemia vitamin, cyanocobalamin, hydroxocobalamin (Formerly vitamin B ₁₂ b) (natriocobalamin) (formerly vitamin B ₁₂ c)
C	L-ascorbic acid, antiscorbutic vitamin
<i>D group</i>	
D ₂	Antirachitic vitamin
D ₃	Ergocalciferol (formerly calciferol) activated ergosterol
	Cholecalciferol, activated 7-dehydrocholesterol.
<i>E group</i>	
Alpha (a) tocopherols	Possess vitamin E activity in varying degrees.
Beta (b) and tocotrienols	They occur as fatty acid esters.
Gamma (g)	
Delta (d)	
<i>K group</i>	
K ₁	Antihaemorrhagic vitamin
K ₂	Phylloquinone
K ₃	Farnoquinone
K ₄ -K ₇	Naturally occurring Menadione, menaquinone Biologically active analogues of menadione (synthetic)

Table 3.18 Chemical characteristics of fat-soluble vitamins

Name of the vitamin	Forms of the vitamin	Characteristics	Unit of measurement of the vitamin
Vitamin A	Retinol- Vitamin A, Vitamin A alcohol <i>Retinyl esters</i> Vitamin A esters <i>Retinaldehyde</i> Vitamin A aldehyde, retinene, retinol <i>Retinoic acid</i> Vitamin A acid	<ul style="list-style-type: none"> Mineral oil interferes with absorption Stable to acid and alkali Destroyed by wilting Destroyed by rancidity Stable to heat by the usual cooking methods but slowly destroyed by exposure to air, heat, drying Stored in the liver Bile is necessary for absorption 	(a) Measured in international units 1 IU = 0.3 mg retinol 1 IU = 0.3 mg beta carotene 1 IU = 1.2 mg other carotenoids (b) Measured in terms of retinol equivalent 1 RE = 1 mg retinol (3.33IU) 1 RE = 6 mg betacarotene (10 IU) 1 RE = 12 mg other carotenoids (10 IU)
Vitamin D	Vitamin D ₂ (Ergocalciferol, Calciferol or viosterol) Vitamin D ₃ (Activated 7-dehydrocholesterol, cholecalciferol)	<ul style="list-style-type: none"> Stable to heat and oxidation Destroyed by rancidity Skin synthesis by activity of ultraviolet light on cholesterol Stored in the liver Enhance absorption of calcium and phosphorus 	(a) Measured in international units (IU) 1 IU = 0.025 mg pure crystalline vitamin D3 (b) Measured in micrograms (mg) of cholecalciferol (c) Line test Amount of vitamin D that must be fed for 7–10 days to young rats on a rachitogenic diet to produce a good calcium line
Vitamin E	<i>Tocopherols</i> — most potent is a-tocopherol <i>Tocotrienols</i>	<ul style="list-style-type: none"> Stable to light and heat except fat frying Fat-soluble Destroyed by rancidity Destroyed by ultraviolet radiation Is a strong antioxidant, prevents oxidation of PUFA and phospholipids Synthesis in the intestine 	(a) a-tocopherol equivalents (TE) 1 mg d-a-tocopherol = 1 aTE (b) Total vitamin E activity (mg a TE) in a mixed diet = mg a tocopherol = b. tocopherol = 0.5 = (mg g tocopherol 0.1) = (mg a tocotrienol = 0.3)

(Contd.)

(Contd.)

Name of the vitamin	Forms of the vitamin	Characteristics	Unit of measurement of the vitamin
		<ul style="list-style-type: none"> Vitamin E spares vitamin A and C by preventing these from oxidation 	
Vitamin K	<i>Quinones</i> Vitamin K ₁ — Phylloquinone Vitamin K ₂ — Menaquinone <i>Menadione</i> — Synthetic Compound	<ul style="list-style-type: none"> Fat-soluble vitamin Easily destroyed by light, alkali Fairly stable to heat, oxygen Synthesis in the intestine Mineral oil interferes with absorption 	mg of test material required to prevent haemorrhage in young chicks. Menadione is used as the standard for measuring vitamin K potency.

Table 3.19 Deficiency, toxicity and sources of fat-soluble vitamins

Vitamin	Deficiency symptoms	Hypervitaminosis or toxicity symptoms	Important sources
Vitamin A (Retinol) (Precursor—Carotene)	<ul style="list-style-type: none"> Rough, scaly skin, dry mucous membranes, causing a general low resistance to microbe invasion Poor tooth formation Xerosis of conjunctiva of eye. Bitot's spots on conjunctiva of eye Corneal Xerosis of eye, perforation, Keratomalacia and loss of sight 	<ul style="list-style-type: none"> Anorexia Fatigue Weight loss Irritability Skin lesions Joint and bone pains Spleen and liver enlargements Loss of hair Increased intracranial pressure 	<ul style="list-style-type: none"> Liver and liver sausages, butter, cream, whole milk, egg-yolks Green and yellow vegetables, yellow fruits, ripe pains tomatoes, fortified margarine Fish liver oils
Vitamin D (Calciferol)	<ul style="list-style-type: none"> <i>Rickets</i> Soft bones, bowed legs, poor teeth, lowered amount of calcium and phosphorus in the blood, poor posture, enlargement of junctions between the ribs and breastbone forming a series of knobby protuberances called <i>rachitic rosary</i>. 	<ul style="list-style-type: none"> Anorexia, fatigue weight loss, nausea and vomiting, diarrhoea and polyuria, weakness, headache, renal damage, calcification in the soft tissues of the heart, blood vessels, lungs, stomach and renal tubules 	<ul style="list-style-type: none"> Milk, in small amounts in butter, egg-yolk, liver, salt-water fish. Fish oils, organ meats.
	<ul style="list-style-type: none"> Projection of breastbone (pigeon breast) Narrow pelvis, spinal curvature, knock knees, skull deformation, various muscle 		

(Contd.)

(Contd.)

Vitamin	Deficiency Symptoms	Hypervitaminosis or Toxicity Symptoms	Important Sources
	<ul style="list-style-type: none"> Malformation of the teeth, Osteomalacia (in adults), weakening of bones increased porosity decreased density in bones resulting in various deformities, pain in the bones of the legs and lower back, general physical weakness, difficulty in walking and susceptibility to bone fractures 		
Vitamin E	In severe deficiency— Increased haemolysis of RBC, Creatinuria, deposition of brownish ceroid pigment in smooth muscle, development of muscular dystrophy	Relatively non-toxic, elevation of serum lipids, impaired blood coagulation, reduction of serum thyroid hormones	Vegetable oils, green leafy vegetables margarine, egg-yolk milk fat, nuts, wheat germ oil
Vitamin K	Delay in clotting of the blood. Haemorrhage in the new-born.	Hyper-bilirubinaemia in infants, jaundice, kernicterus, mild haemolytic anaemia	Green leafy vegetables, liver cauliflower, cabbage

□ Chemical Characteristics of Water-Soluble Vitamins—B Group and Vitamin C

- Compared to the fat-soluble vitamins they are unstable since they are easily affected by factors such as heat, light, oxidation, radiation, contamination by metals, etc.
- They are affected by preparation practices, e.g. if the water in which the food is cooked (some vitamins are mixed with the water) is thrown away.
- Excess intake of these vitamins results in urinary excretion of the surplus that the body cannot retain.

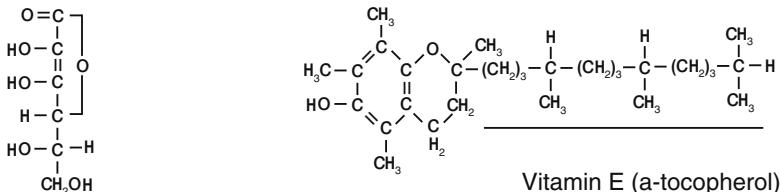
Detailed chemical characteristics of B group of vitamins and vitamin C can be seen from Table 3.20.

3.7 VITAMIN A AND CAROTENE

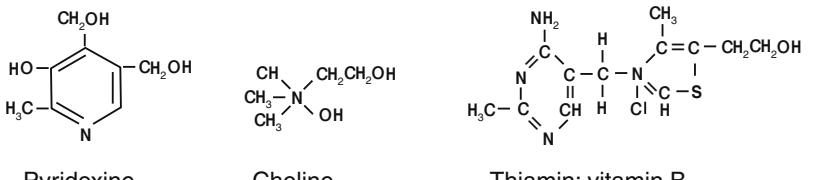
Vitamin A was the first fat-soluble vitamin discovered. Animal nutritionists observed growth failure in calves born of cows maintained on wheat or oats alone, whereas whole corn plant supported growth and development of the animals. The vitamin was found to occur in green or pigmented plants. Further study revealed that the vitamin

Table 3.20 Deficiency, sources and characteristics of water-soluble vitamins

Vitamin	Deficiency Symptoms	Important Sources	Characteristics
Vitamin C (Ascorbic acid)	Sore mouth, stiff, aching joints, weak-walled capillaries (haemorrhages in joint muscles, subcutaneous tissue, gums) lassitude, impaired wound-healing, improper bone and cartilage development	Fresh fruits (especially citrus), such as <i>mosambi</i> , orange, lemon, strawberries, canned fruit-juices, tomatoes—fresh or canned, raw vegetables—especially green cabbages, peppers, potatoes and <i>amla</i> —the richest source.	Highly soluble in water, most easily destroyed vitamin. Destroyed by heat, alkali, aging, drying, oxidation. Acid inhibits, while copper accelerates destruction. Very little lost in commercial canning and quick freezing. Very little is stored in the body.
Vitamin B ₁ (Thiamine)	Anorexia, fatigue, constipation, depression, irritability, tenderness of the leg calf with some loss of muscular coordination, abnormal carbohydrate metabolism	Meat (especially pork), whole grain and enriched cereals, organs (especially liver), nuts and peanut butter, legumes, especially soybeans, milk, dairy foods, eggs, brewer's yeast and wheat germ.	Stable in the dry form. Quickly destroyed by heat in neutral and alkaline solutions. Destroyed by sulphites and alkali. Limited amount stored in body.
Vitamin B ₂ (Riboflavin)	Burning and itching eyes, blurred and dim vision, eyes sensitive to light, inflammation of the lips and the tongue, lesions in the angles of the mouth, digestive disturbances, greasy, scaly skin	Milk, dairy foods, organ (especially liver), meat, legumes, eggs, enriched and whole grain cereals, green leafy vegetables, brewers yeast, liver concentrates.	Destroyed by alkali stable to heat, acid. Very limited body storage.
Niacin (tryptophan precursor)	Fatigue, dermatitis, sore mouth, especially the tongue, gastro intestinal disturbances (diarrhoea and vomiting), nervous disturbances, mental depression, weakness, anorexia	Meat (especially liver), fish, poultry, whole grain and enriched cereals, nuts, legumes, peanuts, brewer's yeast, liver concentrates	Stable to heat, light, acids, alkali. Very limited body storage. Body synthesis: 60 mg tryptophan equivalent to 1 mg niacin.



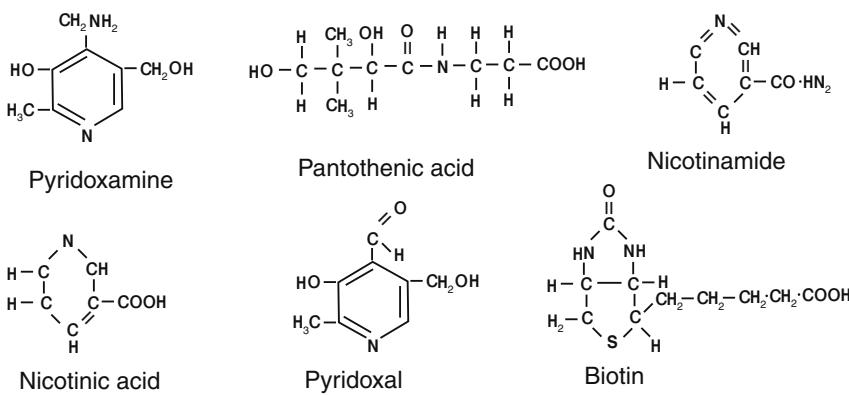
Ascorbic acid: vitamin C



Pyridoxine

Choline

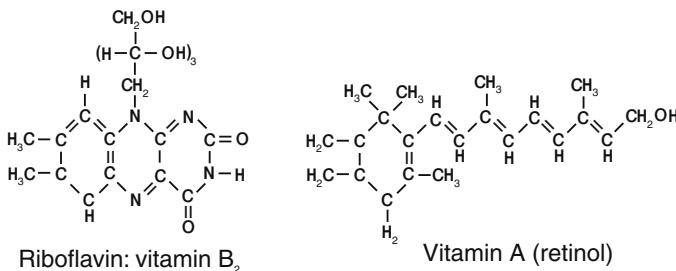
Thiamin: vitamin B



Nicotinic acid

Pyridoxal

Biotin

Riboflavin: vitamin B₂

Vitamin A (retinol)

Fig. 3.8 Structural formulae of fat soluble and water soluble vitamins

is essential for the maintenance of normal tissue structure and for other important physiological functions such as vision and reproduction.

□ Chemistry and Chemical Characteristics of Vitamin A

Vitamin A is represented primarily by the cyclic polyene alcohol vitamin A₁ (retinol) with an empirical formula of C₂₀H₃₀O and its four conjugated double bonds in the side chain are in the *trans* arrangement.

The other two forms are vitamin A₂ and neovitamin A-a. Both have low biological activity.

Vitamin A₁ is a pale yellow crystalline compound, soluble in fat-solvents and has an ultraviolet absorption maximum at 328 nm wavelength. It is not readily destroyed by heat but is easily oxidized and is less stable in acid than in alkaline solution. The esters of vitamin A₁ with the fatty acids, acetic and palmitic, are commercially important since, they are considerably more stable than alcohol.

Beta carotene, a precursor of vitamin A is found in all yellow, chlorophyll-containing compounds. Alpha carotene and cryptoxanthin also exhibit provitamin A activity but less than that of beta carotene. The utilization efficiency of beta carotene is generally considered to be 1/6th for humans. In other words, one gram of beta carotene would have the same biological activity as 0.167 g of retinol. This conservatively takes into account the decremental effects on carotene utilization of absorption, transport and tissue conversion to the active vitamin.

Like vitamin A₁ the carotenes are soluble in fat-solvents, in crystalline form appear deep orange or copper-coloured and have characteristic absorption spectra.

□ Digestion and Absorption of Vitamin A

Retinyl esters in food are hydrolyzed by pancreatic and intestinal enzymes to form free retinol. After absorption, the retinol, is *reesterified* and transported to blood.

Carotenes are split in the intestines to form retinaldehyde which is then reduced to retinol. Some carotene may be absorbed intact and later converted to vitamin A in the liver or kidney. Bile is necessary for the absorption of vitamin A and carotene. Vitamin E in the intestinal tract prevents oxidation of the vitamin. Mineral oil hinders absorption since it dissolves the vitamin but is not absorbed.

□ Functions of Vitamin A

Vitamin A is mainly associated with vision and tissue growth.

1. Vision The retina of the human eye contains two distinct photoreceptor systems. The rods, which are the structural components of one system, are especially sensitive to light of low intensity. A specific vitamin A-aldehyde is essential for the formation of rhodopsin (the high-molecular-weight glycoprotein part of the visual pigment within the rods) and for the normal functioning of the retina. By virtue of this relation to the visual process, vitamin A alcohol has been named retinol and the aldehyde form, retinal. A person with vitamin A deficiency has an impaired adaptation to darkness.

Wald's Visual Cycle Retinol is transported to the retina via the circulation, where it moves into the retinal pigment's epithelial cells. There, retinol is esterified to form a retinyl ester that can be stored. When needed, retinyl esters are hydrolyzed and isomerized to form 11-cis-retinal, which can be oxidized to form 11-cis-retinal. 11-cis-retinal can be shuttled to the rod cell where it binds to a protein called opsin to form the visual pigment *rhodopsin* (visual purple).

Absorption of the photon of light catalyzes the isomerization of 11-cis-retinal to all trans-retinal cells and results in its release. This isomerization triggers a cascade

of events, leading to the generation of an electrical signal to the optic nerve. The nerve impulse generated by the optic nerve is conveyed to the brain where it can be interpreted as vision.

Once released, all-trans-retinal is converted to all-trans-retinol, which can be transported across the inter-photoreceptor matrix to the retinal epithelial cell to complete the visual cycle.

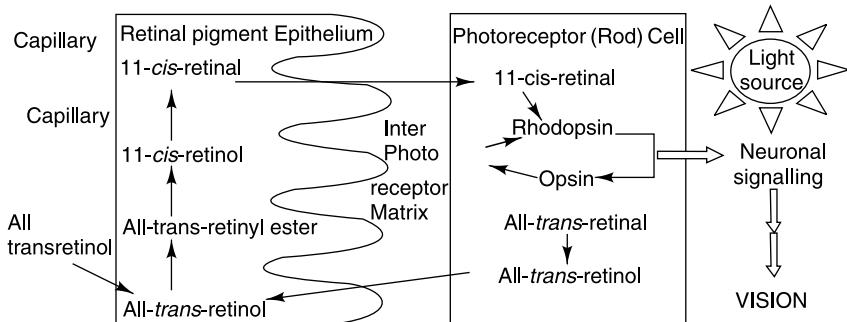


Fig. 3.9 The visual cycle

2. Tissue Growth Vitamin A also helps maintain the integrity of the epithelial membranes that normal structures may be substituted by stratified keratinizing epithelium in the eyes and para-ocular glands, respiratory, alimentary and genito-urinary tracts, under the stress of a deficiency. The basal cells do not lose their function under such conditions, however, and are able to restore themselves to normal function when sufficient vitamin A is absorbed.

□ Deficiency Symptoms of Vitamin A

The deficiency symptoms of Vitamin A progress gradually, giving some early warning signs which, if heeded, may help to save blindness, especially in children.

Some of the important symptoms of vitamin A deficiency are the following:

1. Changes in the Eye The early symptoms start with itching, burning and inflammation of eyelids followed by various eye conditions.

Prolonged Vitamin A deficiency results in nyctalopia, or nocturnal amblyopia, or *night blindness*. Night blindness, or impaired vision in dim light and in the dark, is due to impaired functioning of certain specialized vision cells.

One is unable to see well in dim light, particularly after exposure to a bright light. 'Blindness' is explained by the fact that Vitamin A is combined with a protein in the retina of the eye to form a pigment called *visual purple* or *rhodopsin*. Rhodopsin is formed by the combination of Vitamin A-aldehyde (retinone) and protein (opsin). This is bleached in strong light. During the photochemical reaction, some amount of Vitamin A is lost. If Vitamin A stores in the body are adequate then the eyes adapt quickly in subdued light and one can see almost at once.

Night blindness is more common in poor people. Males suffer more than females. A pregnant woman frequently suffers from night blindness partly due to underlying diseases and partly due to increased demand of Vitamin A. This Vitamin A deficiency condition is referred as *functional night blindness*.

Xerophthalmia occurs when deficiency of Vitamin A is severe and prolonged. Xerophthalmia occurs due to changes in the epithelial tissues of the eye. The cornea becomes dry, wrinkled, lustreless, hazy and pigmented. The tear glands stop secreting tears which keep the eyes moist, and wash away bacteria and other foreign matter. Hence, it results in dry, inflamed eyelids and loss of the glistening transparent appearance of the eye. The inflammation results in ulceration. The final stage is *keratomalacia*—softening and destruction of eyeball leading to blindness which is incurable.

Xerophthalmia is sometimes associated with *Bitot's spots* which are well-demarcated foamy white or greyish irregular areas found on the temporal side of the cornea. These spots do not interfere in vision. Keratomalacia more commonly affects children between 1–5 years due to absence of Vitamin A in their diet.

2. Changes in the Epithelial Tissue Deficiency of Vitamin A leads to atrophy (degeneration) and keratinisation (hardening) of the epithelium. These cells get flattened and collect one upon the other in a heap. There is increased susceptibility to severe infection of the eye, nasal passages, sinuses, middle ear (incus), pharynx, mouth, respiratory tract, lungs and the urinogenital tract. The epithelium of the eye gets so severely damaged that the condition is incurable.

3. Changes in the Skin Deficiency of Vitamin A may lead to *xeroderma* (dry and scaly skin with itching) and follicular *hyperkeratosis* (dry, rough, scaly skin). Thickening of the keratin layers of the skin on the palms and soles occurs. Follicles like goose pimples appear first on the upper arms and thighs, then along the shoulders, back, abdomen and buttocks. The sweat glands of the skin become blocked with horny plugs of keratin so that their secretion diminishes. This condition is known as *phrynodermia* or *toad skin*.

4. Changes in the Respiratory Tract The linings of the respiratory organs like nose, throat, trachea and bronchi become dry and rough. Thus, the respiratory tract becomes prone to bacterial infections.

5. Changes in the Alimentary Tract Due to Vitamin A deficiency, the alimentary tract dries up resulting in diminished secretion of digestive juices, lack of absorption and increased susceptibility to intestinal infection and diarrhoea.

6. Changes in the Reproductive Tract Keratinizing metaplasia occurs in the renal pelvis, bladder, uterus, oviduct and accessory sex glands. Vaginitis in females can occur.

7. Urolithiasis This is a condition in which urinary *calculi* (stones) are present. The stones are composed of calcium phosphate. Keratinization of the urinogenital-tract epithelium takes place due to Vitamin A deficiency which is later followed by bacterial invasion.

8. Changes in the Skeletal System Irregular development of the skeleton, including the skull and vertebral column, are seen. This leads to distortion and injury of the brain and the spinal cord. Growth of bone and teeth are markedly impaired.

9. Lowered Resistance to Infection Vitamin A is needed for the maintenance and functioning of the mucous membranes of the body. Due to its deficiency, the membranes become thin, dry, porous and flaky. They are unable to perform their protective functions and bacteria have ready access. It lowers barriers to certain infections and the person becomes susceptible to infections.

□ Measurement of Vitamin A

This vitamin is commonly measured in international units (IU) but now the measure of retinol equivalents (RE) is being adopted by most countries. In general carotene, the precursor of vitamin A, has 1/6 the value of vitamin A₁ in the diet because of the differences in intestinal absorption and the necessity for conversion of carotene to vitamin A₁ by the liver.

One IU is equivalent to 0.6 mg of pure beta carotene or 0.3 mg of retinol. One RE is equivalent to one mg retinol (3.33 IU) or six mg beta carotene (10 IU).

□ Sources of Vitamin A

Richest sources of carotene are yellow and green leafy vegetables and yellow fruits. Preformed vitamin A₁ is supplied primarily from the fat of dairy products and egg-yolk, but other important sources are liver, kidney and fish. *Vanaspati* in our country is fortified with vitamins A and D.

□ Toxicity of Vitamin A

Prolonged ingestion of excessive vitamin A can lead to the development of toxicity. It includes pathogenic changes in bones, periosteal tissues, skin, mucous membrane and liver. It was observed that vitamin A toxicity had occurred in infants who were given liver in their diet daily for a period of three months.

For other toxicity symptoms refer to Table 3.19.

3.8 VITAMIN D

It is the anti-rachitic vitamin effective in promoting calcification of body structures. It is formed by the action of ultraviolet rays from the sun on the precursor sterols in the skin. Therefore, exposure to sunlight has powerful anti-rachitic effect. The term *rachitic* denotes the condition of a person affected with vitamin D deficiency disease, rickets.

□ Chemical Characteristics of Vitamin D

The two biological precursors (provitamins of vitamin D) are 7-dehydrocholesterol and ergosterol. Under the influence of UV-rays each undergoes a chemical change yielding vitamin D₃ (cholecalciferol) and vitamin D₂ (ergocalciferol).

Pure vitamins are white, odourless crystals that are soluble in fat and fat-solvents but insoluble in water. Both these forms are stable to oxidation by air, moderate heat, in neutral and alkaline solutions. Vitamin D is stable over long periods in oil solutions but quite unstable in the presence of mineral salts.

□ Digestion and Absorption of Vitamin D

Dietary vitamin D is absorbed along with dietary fats in the small intestines and transported to the lymph system. Bile is essential for the absorption of this vitamin. Excess vitamin is stored in the body.

□ Functions of Vitamin D (Dihydrocholecalciferol—DHCC)

The major part of the vitamin circulating in the blood is neither D₂ or D₃ but the metabolite 25, hydroxy cholecalciferol (25-HCC) to which the ingested vitamin is converted in the liver. A more potent metabolite 1, 25-dihydroxycholecalciferol (1, 25-DHCC) or calcitriol is synthesized in the kidney. It appears in the intestinal mucosal cells, bones and skeletal muscles for regulating calcium absorption and metabolism. Vitamin D is, therefore, a precursor of true hormone 1, 25-DHCC which performs a vital function. Vitamin D through the action of these active metabolites performs the following functions:

1. Absorption of calcium from digested food.
2. Reabsorption of phosphate in the renal tubule.
3. Calcification of osteoblast cells of growing skeletal structures.

□ Deficiency Symptoms of Vitamin D

Deficiency of vitamin D causes impairment of all these functions, resulting in rickets in children and a form of rickets called *osteomalacia* in adults. Both these represent the failure of the process of calcification.

Skeletal malformations occur because of the inability of soft bones to withstand the stress of body weight.

Delayed closure of fontanelles and softening of skull in infants, soft fragile bones with bowing of legs, spinal curvature, swelling of wrists, knee and ankle joints, poorly developed muscles, restlessness and nervous irritability are some of the other symptoms.

Rickets is difficult to diagnose in the early stages.

□ Measurement of Vitamin D

Vitamin D is measured in terms of international units (IU) of cholecalciferol (vitamin D₃). One IU is equivalent to 0.025 mg of pure crystalline vitamin D₃.

□ Sources of Vitamin D

Vitamin D is supplied very little by conventional foods. Egg-yolks, which are the best source, vary in content depending mostly upon the content of the vitamin in the hen's diet. Dairy products contain some vitamin D, the potency varying with the season. Fish supply appreciable quantities of the vitamin. Liver of fish and oils extracted from the livers are extremely rich sources. Vitamin D is added to fortify *vanaspati*.

□ Toxicity of Vitamin D

Vitamin D has a serious toxic potential. An intake of about 1000 to 3000 IU/ kg body weight per day, which is only about 80 to 100 times the RDA, may lead to hypercalcemia and other complications such as metastatic calcification and renal calculi in adults while as little as 2000 IU can inhibit linear growth in normal children. In advanced stages, demineralization of bones occurs and multiple fractures may result from very slight trauma. For other toxicity symptoms see Table 3.19.

3.9 VITAMIN E

Vitamin E was named *tocopherol* from a Greek word meaning *childbirth* or *to bring forth*. Chemically, Vitamin E designates the group of compounds (tocol and tocotrienol derivatives) which exhibit qualitatively the biological activity of alpha tocopherol. It was shown to be necessary for reproduction in rats. It is erroneously termed the anti-sterility vitamin, since, it is not known to specifically function in this capacity in humans.

□ Chemical Characteristics of Vitamin E

As with several other vitamins, there is a series of closely related compounds, *tocopherols*, known to occur in nature. Biological activity associated with vitamin E is exhibited by four compounds designated as alpha, beta, gamma and delta tocopherols. All of these exist in various stereo-isomeric forms. Of these, alpha tocopherol is the most important because of its biological activity and occurrence.

Tocopherols are oily liquids at room temperature. High temperature and acidic pH do not affect its stability but its oxidation occurs in the presence of iron or rancid fat. Tocopherols themselves act as anti-oxidants. Delta tocopherol shows the highest anti-oxidant power.

□ Digestion and Absorption of Vitamin E

Fat and bile salts facilitate absorption of vitamin E in the intestinal wall. The vitamin is then carried to the liver. However, very little vitamin E is transferred to the infant across the placenta. Hence, a newborn infant has very low tissue level of vitamin E.

□ Functions of Vitamin E

1. Exact biochemical mechanism of its function in human body is still unknown, but it is certain that its most critical function is in the membranous part of the cell. Here, it integrates with phospholipids, cholesterol, triglycerides—the three main structural elements of membranes.
2. Vitamin E converts the free radicals into less reactive and non-toxic form.
3. It works as protector against oxidation. The nutritional interaction is seen with a wide variety of nutrients such as vitamin A, selenium, sulphur, amino acids, polyunsaturated fatty acids and to some extent with vitamin C.

In general, vitamin E plays an important role in maintaining stability and integrity of cell membrane.

□ Deficiency Symptoms of Vitamin E

A clearly defined, uncomplicated vitamin E deficiency disease has not been recognized as a public health problem.

It appears that in severe deficiency there is increased haemolysis of the red blood cells, creatinuria, deposition of brownish ceroid pigment in smooth muscle and development of muscular dystrophy.

□ Measurement of Vitamin E

It is measured in terms of mg (milligram) of DL-alpha-tocopherol acetate, or as tocopherol equivalent (TE).

□ Sources of Vitamin E

Vitamin E is ubiquitous in its distribution and is found particularly in vegetable fats, oils, dairy products, meat, eggs, cereals, nuts, leafy green vegetables and yellow vegetables. It is difficult to prepare a diet deficient in vitamin E and see how vitamin E deficiency in humans may occur.

□ Toxicity of Vitamin E

Vitamin E is relatively non-toxic. Toxicity symptoms include elevation of serum lipids, impaired blood coagulation and reduction of serum thyroid hormones. For other toxicity symptoms refer to Table 3.19.

3.10 VITAMIN K

Vitamin K is also a group of substances having similar biological activity. It is widespread in nature.

The first compound of this group was isolated from alfalfa and the other from putrefied fish meal. It is essential in diet due to its involvement in synthesis of prothrombin and other blood clotting factors.

□ Chemical Characteristics of Vitamin K

The parent structure of the K family of vitamins is 2-methyl, 1, 4-naphtho-quinone or menadione which is manufactured synthetically.

Vitamin K₁ (isolated from alfalfa) is 2-methyl, 1, 4-naphthoquinone called phylloquinone. Vitamin K₂ obtained from putrefied fish meal exists as a chemical series.

The naturally occurring substances in pure form are light yellow solids or oils, insoluble in water but soluble in fat-solvents. Vitamin K compounds have characteristic absorption spectra in the ultraviolet and are sensitive to alkali, light and ionizing radiation.

□ Digestion and Absorption of Vitamin K

More than half the human requirement of vitamin K is met by the synthesis by symbiotic bacteria in the lower intestinal tract of the human body. Extended treatment with anti-bacterial drugs that alter the enteric flora increases the dietary vitamin K

requirement in man since the useful symbiotic bacteria are destroyed. Since, it is a fat-soluble dietary factor, it requires bile for its absorption. This takes place in the upper part of the small intestine. Menadione, however, can be absorbed even in the absence of bile.

□ Functions of Vitamin K

Prothrombinogen and other blood clotting factors are formed in the liver with the help of vitamin K. These factors are necessary for the clotting of blood. For new born infants and especially those born premature, a single dose of 1 mg of vitamin K₁ immediately after birth is often a routine measure to prevent haemorrhagic disease.

□ Deficiency of Vitamin K

Its deficiency interferes with the formation of prothrombinogen and thus, reduces the clotting tendency of blood. In other words, the blood clotting time is prolonged. Clinically this condition is called *hypoprothrombinemia*. Internal or external haemorrhages may ensue either spontaneously or following injury or surgery.

A premature infant is sensitive to lack of this vitamin.

□ Measurement of Vitamin K

It is measured in terms of biological equivalency to milligrams or micrograms of menadione in a chick-feeding test.

□ Sources of Vitamin K

It is widely distributed in nature. The green leafy vegetables, tomatoes, cauliflower, egg-yolk, soybean oil and liver are good sources.

We also utilize vitamin K synthesized by certain enteric bacteria and probably obtain a large part of our requirement from this source.

□ Toxicity of Vitamin K

Its toxicity may be exhibited in the form of hyperbilirubinemia. In infants jaundice, kernicterus and mild haemolytic anaemia may be seen. For other toxicity symptoms refer to Table 3.16.

3.11 ASCORBIC ACID OR VITAMIN C

This vitamin derived its name because of its antiscorbutic or antiscurvy properties. Scurvy has been recognized since the middle ages and was found to be widespread in northern Europe, and among the crews of sailing ships. During the 18th century it was learned that when fresh fruit was made available on board the sailing vessels, scurvy was avoided. In 1907, Holst and Frolich observed a scurvy-like syndrome in guinea pigs that was similar to human scurvy and cured it by feeding citrus juices. This gave an experimental means for the rapid development of our knowledge of vitamin C.

□ Chemical Composition and Characteristics of Vitamin C

Chemically the structure of ascorbic acid is almost identical to that of glucose. All animals except humans, monkeys and guinea pigs can synthesize ascorbic acid from glucose.

Ascorbic acid is a white, crystalline compound structurally related to the monosaccharides. It exists in nature both as reduced and oxidized form called dehydroascorbic acid. These substances are in a state of reversible equilibrium in biological systems, and both have the same biological activity. (Figures 3.2 and 3.8 show the structural formulae of glucose and ascorbic acid, respectively.)

Ascorbic acid is an unstable, highly reducing, easily oxidizable acid. It can be destroyed by oxygen, alkalies and high temperature. Oxidation is accelerated by heat, light, alkalies, oxidative enzymes, and traces of copper and iron. Hence, food should be cooked for as short a period of time as possible and kept covered even after cooking. Soda, an alkali commonly used in cooking by Indian housewives, should not be added to cook the food faster or to preserve the colour. To avoid loss of vitamin C vegetables should not be cut into small pieces, since larger chunks have less area of exposure, resulting in less destruction of vitamin C. Fruit juices should not be left uncovered. Vegetables should be cooked in minimum quantity of water which should not be thrown away, since ascorbic acid is readily lost due to its solubility in water. They should be covered tightly and cooked until just tender to retain maximum ascorbic acid. Pressure cooking maintains a good amount of the vitamin as cooking time is short and exposure to oxygen is minimum.

□ Digestion and Absorption of Vitamin C

Being soluble in water, it is rapidly absorbed from the gastro-intestinal tract and distributed to the various tissues.

□ Functions of Vitamin C

(a) Intercellular Cement Substance Vitamin C is required to build and maintain bone matrix, cartilage, dentine (tooth), collagen, capillaries and connective and general body tissue. In scorbutic tissues the amorphous ground substance and the fibroblasts in the area between the cells appear normal but without the matrix of collagen fibres. These bundles of collagenous material appear within a few hours after the administration of ascorbic acid.

(b) General Body Metabolism Tissues which are metabolically, more active, such as the adrenal gland, brain, kidney, liver and pancreas, contain more vitamin C. It is closely associated with protein in tissue growth, tissue building and rebuilding and in cell metabolic processes. Hence, requirement of vitamin C is higher in periods of stress.

(c) Building Haemoglobin Vitamin C helps in formation of haemoglobin and development of red blood cells by influencing the absorption of iron for haemoglobin formation.

(d) Healing of Wounds Including Internal Fractures of Bones Vitamin C is needed in large amounts for extensive tissue building such as in severe burns. It is also essential for healing bone fractures.

(e) Fevers and Infections Resistance to infections is helped by optimum tissue stores of vitamin C. There is much controversy regarding the effectiveness of massive doses of vitamin C in the prevention of common cold.

(f) Stress Large amounts of ascorbic acid are required by adrenal tissue during any body stress. Even emotional stress increases the need for ascorbic acid.

(g) Growth Periods such as pregnancy, infancy and childhood demand more ascorbic acid. This may be due to demand for foetal growth and maternal tissues.

(h) Metabolism of Tyrosine Vitamin C is necessary for the metabolism of tyrosine. Its action is on the enzyme p-hydroxyphenyl pyruvic oxidase which catalyzes the conversion of p-Hydroxy-pyruvic acid to Homogentisic acid which later enters the tri-carboxylic acid cycle.

□ Deficiency Symptoms of Vitamin C

Deficiency of vitamin C results in defective formation of the intercellular cementing substance. Shooting joint pains, irritability, retardation of growth in an infant or child, anaemia, shortness of breath, poor wound-healing, increased susceptibility to infections are some of the symptoms of vitamin C deficiency.

During the deficiency of ascorbic acid, the blood vessels and capillaries are particularly affected and the latter become fragile, rupture easily and bleed. The tendency to bruise easily gives the first indication of deficiency of vitamin C. The occurrence of petechiae—pin-point haemorrhages that occur in the skin under reduced pressure—is a symptom for the diagnosis of scurvy.

The deficiency syndrome of vitamin C is scurvy. When this antiscorbutic vitamin is not supplied in the diet for long, especially in case of infants above six months, a gross deficiency may precipitate. There is pain, tenderness and swelling of the thighs and legs. The baby does not move and cries when handled. There is pallor and constant irritability. This may be accompanied by fever, infections and vomiting. The gums are likely to have swelling, tenderness (sponginess) and bleeding. Bones become brittle and cease to grow, and normal structures are replaced by connective tissue that contains calcified cartilage. Anaemia is a common symptom in scurvy caused by an impairment of haematopoiesis.

In adults, scurvy is manifested as black and blue spots on the skin, swelling, infection and bleeding of gums, and anaemia. Even a slight injury causes bleeding.

□ Measurement of Vitamin C

Ascorbic acid is measured in terms of milligrams by chemical methods that depend on its reducing property.

□ Sources of Vitamin C

Ascorbic acid is found in all fresh fruits, vegetables and their juices. Citrus fruits such as sweet lime, lemon, oranges, pineapple, etc. contain large amounts of vitamin C. In our country, *amla* or *avla* is the richest sources of vitamin C. As compared to other fruits it is the cheapest and consuming a small quantity of it (eight to ten g) may meet our daily requirement of vitamin C. (100 g of *amla* contains 600 mg of ascorbic acid.)

Tomatoes, lettuce, cabbage, sweet potatoes, potatoes, green and yellow vegetables, green peppers and guavas are good sources of vitamin C.

Vitamin C can be easily oxidized, hence, the handling, preparation, cooking and processing of any food source should be considered in evaluating the nutritional contribution of this unstable vitamin.

3.12 B VITAMINS

The *water-soluble B* of McCollum, or the *anti-beriberi vitamine* of Funk, has now been differentiated into at least eleven separate and distinct chemical entities. It has been established that eight of these are required by the human body. These are thiamin, riboflavin, niacin, folacin, pyridoxine, biotin, pantothenic acid and cyanocobalamin. Paraamino-benzoic acid (PABA), choline and inositol have an essential part in cellular metabolism in plants and animals, but this alone does not constitute presumptive evidence of their importance in human nutrition.

When the dietary intake of methionine is adequate, choline can be synthesized endogenously. Hence, the requirement of choline is related to the methionine intake just like niacin is related to tryptophan.

Similarly, it is found that human beings do not require an exogenous source of PABA. Inositol is required more in infants and milk is a good source of it.

These eight vitamins are grouped together since their functions are closely related. These vitamins are vital in several metabolic functions. They serve as vital control agents in many reactions as coenzymes in energy metabolism and tissue-building and rebuilding. They can be considered under three groups as given in Table 3.21.

Table 3.21 Classification of B-Vitamins

<i>Group I</i> — Classic disease factors	:	Thiamin — B ₁
		Riboflavin — B ₂
		Niacin — B ₃
<i>Group II</i> — More recently discovered coenzyme factors	:	Pyridoxine — B ₆
	:	Pantothenic acid
<i>Group III</i> — Blood-forming factors	:	Folic acid
		Cyanocobalamin — B ₁₂

□ Group I—Classic Disease Factors

1. Thiamine (B₁) Thiamine or B₁ is the beriberi preventing factor. It was isolated first from rice polishings.

(a) Chemical Characteristics of Thiamine It is a water-soluble, fairly stable vitamin. It is destroyed by alkalies. It has a faint yeast-like odour and a salty nut-like taste. It is stable in the dry form. It is stable in acidic medium, but is easily destroyed by cooking foods in neutral or alkaline medium. It is insoluble in fat-solvents.

(b) Digestion and Absorption of Thiamine Thiamine that is consumed through food is available in the free form or bound as thiamine pyrophosphate or in a protein

phosphate. The bound forms of thiamine are split before being absorbed in the duodenum. The vitamin is then distributed to various body tissues. Metabolically active tissues such as heart, brain, liver, kidney and muscles contain large amounts of thiamine.

(c) Functions of Thiamine Thiamine functions mainly as thiamine pyrophosphate (TPP), also known as cocarboxylase. TPP is formed by the action of ATP. The TPP acts as a coenzyme in a number of enzyme systems. Its functions are:

- (i) *Control of energy metabolism* The main function of B₁ is to act as a controlling agent in energy metabolism. It does so by acting as a coenzyme TPP in key reactions that produce energy from glucose or that convert glucose to fat for tissue storage. Thus the symptoms of beriberi such as muscle weakness, disturbances and neuritis are manifestations of impairment of these basic functions of B₁.
- (ii) *Production of keto acids* Thiamine pyrophosphate is also a coenzyme in Transketolase which is an enzyme that is required to produce keto acids.

(d) Deficiency of Thiamine *Polyneuritis* (malfunctioning of the nervous system) or beriberi is a deficiency disease of B₁. Since B₁ is the key energizing control agent in the cells, clinical effects are seen in the gastro-intestinal, nervous and cardiovascular systems.

The symptoms include loss of appetite, indigestion, loss of muscle tone, general apathy, emotional instability, irritability, depression and fatigue. As deficiency persists, heart muscles weaken and cardiac failure may result. Oedema in the lower extremities may also be observed.

Peripheral neuritis is a pathological condition of the nerves of the extremities. Usually both legs are affected and sometimes the arms as well. Peripheral neuritis is characterized by a feeling of heaviness and weakness of the legs followed by tenderness and cramping of calf muscles and burning and numbness of the feet.

Dry beriberi is characterized primarily by emaciation and multiple neurotic symptoms which proceed from foot, then to calf muscles and then to the thighs.

Wet beriberi is characterized by severe oedema which masks the emaciation. Enlargement of the heart, tachycardia (increase in the rate of heart-beat), dyspnoea and palpitations of the heart even on the slightest exertion are some other symptoms of beriberi.

As thiamine acts on the nerves, its deficiency can become complicated leading even to paralysis. In laboratory animals this paralysis can be reversed, but not in human beings. Table 3.22 summarizes deficiency of Thiamine.

(e) Requirement and Measurement Our requirement of thiamine is closely related to the calorific needs, and increase in intake of calories also increases the thiamine requirement. The average adult requires from 0.23 to 0.5 mg per 1000 calories. The RDA states that 0.5 mg thiamine should be taken for every 1000 calories.

(f) Sources of Thiamine Good sources of thiamine include most foods rich in protein, i.e. lean pork, beef, liver, nuts, whole or enriched grains, legumes, eggs and fish. Some vegetables are also good sources. Cooking losses of thiamine vary

Table 3.22 Clinical features of thiamine deficiency

Type of Deficiency	Symptoms
Early stage of deficiency	Anorexia Indigestion Constipation Heaviness and weakness of legs Tender calf muscles Numbness of Legs Increased pulse rate and palpitations
Wet beriberi	Oedema of legs, face, and trunk Tense calf muscles Fast pulse Distended neck veins High blood pressure Decreased urine volume
Dry beriberi	Worsening of early-stage polyneuritis symptoms Difficulty in walking Wernicke-Korsakoff syndrome: Possible Encephalopathy Loss of immediate memory Disorientation Nystagmus (jerky movements of eyes) Ataxia (Staggering gait)
Infantile beriberi (2–5 months of age)	Acute stage symptoms: 1. Decreased urine output 2. Excessive crying, thin and plaintive whining 3. Cardiac failure Chronic stage symptoms: 1. Constipation and vomiting 2. Fretfulness 3. Soft toneless muscles 4. Pallor of skin with cyanosis

widely but are increased with high temperature, prolonged cooking or overcooking, discarding of water in which the food was cooked. Addition of an alkali like soda during cooking destroys thiamine. Sophistication and processing of foods generally tend to reduce the thiamine supply, e.g. in preparation of wheat flour, separation of the bran coat and germ removes three-fourth or more of the thiamine present in the whole wheat. Hence enrichment of flours with thiamine is essential.

2. Riboflavin (B_2) Riboflavin was formerly known as vitamin B_2 or C_1 and lactoflavin. Its discovery as one of the components of the B group of vitamins was based on its characteristic fluorescence and pigmenting quality in such common foods as milk and egg-yolk. Isolation and characterization of the yellow protein enzyme originally from yeast led to studies on the essential nature of the flavin pigment part of the enzyme in human metabolism, growth and health.

(a) Chemical Characteristics of Riboflavin Riboflavin or B₂ is a yellow-green fluorescent pigment that forms yellowish-brown, needle-like crystals. It is water-soluble and relatively stable to heat but is easily destroyed by visible light and irradiation. Like B₁, it is sensitive to alkalies, stable in acidic media and is not easily oxidized.

(b) Digestion and Absorption of Riboflavin Riboflavin in food is present either in free state or in combination with a phosphate or with protein and phosphate. This vitamin is absorbed in the upper part of the small intestine and is then phosphorylated in the intestinal wall. In the body it is present as the coenzyme or flavoproteins.

(c) Functions of Riboflavin The main function of B₂ is to act as a control agent in both energy production and tissue-building. It does so by acting as a coenzyme.

- (i) *Coenzyme in protein metabolism* Riboflavin is a vital factor in protein metabolism just like B₁ is in carbohydrate metabolism. It controls removal of amino nitrogen from certain D and L amino acids.
- (ii) *Coenzyme in carbohydrate metabolism* B₂ is a part of key enzyme production reactions taking place in the cell. The two coenzymes of which riboflavin is a constituent are riboflavin monophosphate or Flavin Monucleotide (FMN) and Flavin Adenine Dinucleotide (FAD). Functionally, these enzymes are closely associated with niacin nucleotides—NAD, NADP. Some of the flavin enzymes contain metallic constituents. These metalloflavoproteins may contain iron, copper or molybdenum, e.g. succinic dehydrogenase contains iron and xanthine oxidase contains molybdenum as well as iron.

(d) Deficiency of Riboflavin Ariboflavinosis is manifested as tissue inflammation and tissue breakdown. The symptoms include delayed wound-healing, swelling of lips with characteristic cheilosis (cracks at the corner of lips), photo-cracks and irritation at nasal angles. The tongue becomes red and swells (glossitis); eyes become sensitive to light (Photophobia) and are easily tired, with itching and burning. Corneal vascularization—development of proliferating capillaries is seen. These are some of the early signs of riboflavin deficiency. Growth failure in children has also been noticed as a symptom.

(e) Requirement of Riboflavin Unlike B₁ the requirement of B₂ is not related to the calorie intake but to the protein intake. The protein intake of a person is related to the rate of metabolism and growth. The parameter used to express these most closely is the metabolic body size, represented as kilogram of body weight taken to power three-fourth. It is necessary to supply B₂ daily to the body through dietary sources. Hence, 0.55 mg of B₂ for 1000 calories intake is found to be sufficient.

(f) Sources of Riboflavin The most important source of this vitamin is milk. Milk contains lactoflavin which is the mild form of B₂. Other good sources are organ meats such as liver, kidney and eggs. While some vegetables and fruits furnish a small but constant supply. Polished cereals and their flours are a poor source of riboflavin.

Since, B₂ is a light sensitive vitamin, protection of food sources, especially milk from exposure to light is necessary to prevent its destruction. If milk is bottled in clear glass, almost three-fourth of the vitamin is lost in a short time. So also, considerable loss can occur if food is cooked using open containers and excess water. Hence, cooking in covered containers with minimum water is advisable.

3. Niacin (B_3) Nicotinic acid (niacin) and nicotinamide (niacinamide) have same properties as vitamins. Both compounds have been known for sometime before their biological significance was realized. In 1867, nicotinic acid was synthesized by oxidation of nicotine with nitric acid. But it was not until 1937 that it was isolated from biological sources and found to be effective in the cure of black tongue in dogs and later, pellagra in humans. It should be remembered that niacin has none of the pharmacological properties of nicotine.

Niacin or nicotinic acid is the P-P vitamin or pellagra-preventing vitamin. The vitamin is related to an essential amino acid, tryptophan. Tryptophan is a precursor of niacin. It can be used by the body to be converted to niacin. Due to this inter-relationship between niacin and tryptophan the term *niacin equivalent* is used. 60 mg of tryptophan produces 1 mg niacin. This amount of tryptophan is designated as a niacin equivalent.

(a) Chemical Characteristics of Niacin Niacin exists in two forms—nicotinic acid and nicotinamide. The latter is the easily converted amide form of nicotinic acid. Niacin is the generic term which includes both these forms. It is water-soluble, fairly stable to acid and heat, alkali, light and oxidation. Boiling and autoclaving do not decrease the niacin value of food. Of all the B vitamins, niacin is the most stable.

(b) Digestion and Absorption of Niacin Niacin is easily absorbed from the small intestine. Tryptophan, the precursor of niacin, is converted to the vitamin in the body in the presence of pyridoxine. This amino acid present in large amounts in milk and eggs, prevents niacin deficiency even if the diet does not contain niacin.

(c) Functions of Niacin

- (i) It functions as coenzymes in tissue oxidation. Two coenzymes, nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP), are present in the body. Niacin is needed with riboflavin in the process whereby protein is deaminated and converted to glucose.
- (ii) These coenzymes are also needed in the system that oxidizes glucose to release controlled energy.

(d) Deficiency of Niacin Generally, deficiencies of niacin and riboflavin are observed simultaneously since, both are closely interrelated as control agents in cell metabolism. Pellagra, which means rough skin, is primarily the deficiency disease due to lack of sufficient niacin in the diet and it appears only after months of dietary deprivation. The condition involves the gastrointestinal tract, the skin and the nervous system. Deficiency of niacin leads to weakness, headaches, lassitude, loss of weight, loss of appetite, indigestion and various skin eruptions. The skin and the central nervous system are the most affected. In the more advanced state, there is severe diarrhoea. Dermatitis has a characteristic appearance and occurs at those sites which are subject to exposure or irritation. In such cases the skin lesions are usually bilaterally symmetrical; Glossitis is common and mental symptoms vary. A confused mental state with hallucinations, mania, and delirium is seen in advanced stages of the disease. Neurologic symptoms include confusion, dizziness, poor memory, and irritability, and these lead to hallucinations and dementia. Pellagra is characterized by dermatitis, diarrhoea, dementia and death.

(e) Requirement of Niacin 6.6 mg of nicotinic acid is the ideal intake for every 1000 calories. This requirement is inclusive of the niacin obtained from conversion of tryptophan.

(f) Sources of Niacin Protein-rich foods such as poultry, fish, meat, peanuts, beans and peas are all good sources of niacin. All grains are also fair sources. However, corn and rice are poor sources since they are low in tryptophan. Some green leafy vegetables, potatoes, legumes, milk, eggs and cheese are poor sources of preformed niacin but rich sources of tryptophan.

□ Group II

1. Pyridoxine (B_6) Vitamin B_6 does not denote a single substance but is rather a collective term for a group of naturally occurring pyridines that are metabolically and functionally interrelated.

(a) Chemical Characteristics of Pyridoxine Three basic forms in the body namely pyridoxal, pyridoxamine and pyridoxine undergo conversion to the phosphate form ($B_6\text{-PO}_4$) which is the most potent and active form of pyridoxine. Pyridoxine is water-soluble, stable to heat and acids. It is sensitive to light and alkalies. Of the three forms mentioned here, pyridoxine is more resistant to food processing and storage conditions.

(b) Digestion and Absorption of Pyridoxine Pyridoxine, which is water-soluble, is easily absorbed in the body. The active form of Vitamin B_6 is pyridoxal phosphate which can be formed from any of the three compounds.

(c) Functions of Pyridoxine

(i) Coenzyme in Protein Metabolism In our body several reactions governing the use of amino acids take place. Pyridoxine in its active phosphate form, either as pyridoxal phosphate or pyridoxamine phosphate, is the active coenzyme controlling agent for these reactions. These are:

- Deamination and transamination of amino acids to form new amino acids. This is important in the formation of nonessential amino acids in the body.
- Decarboxylation of amino acids, the resultant amines being active metabolic control agents. Thus, serotonin, a potent constrictor of blood vessels, which stimulates cerebral activity and brain metabolism, is formed from tryptophan.
- Formation of niacin from tryptophan.
- Trans-sulphuration or sulphur transfer reactions which help to form sulphur-containing amino acids from precursors, e.g. cystine is formed from methionine.
- Incorporation of two amino acids into *haeme* part of the core of haemoglobin.

(ii) Coenzyme in Carbohydrate and Fat Metabolism Pyridoxine helps to control reactions to produce energy from carbohydrates and fats. It also participates in the conversion of linoleic acid to arachidonic acid, both being essential fatty acids.

(d) Deficiency of Pyridoxine Notable deficiency of pyridoxine does not exist, probably because it is widely distributed in nature and the requirement is so small that a deficiency is unlikely. Severe deficiency of pyridoxine may lead to anaemia since, haeme is not formed. Central nervous system disturbances such as hyperirritability,

and convulsive seizures are seen. Anaemia, weakness, vomiting and abdominal pain are some of the other symptoms.

(e) Requirement of Pyridoxine It is between 2.0 to 2.5 mg for adults. During pregnancy, requirement of pyridoxine is increased. Women taking oral contraceptives need more pyridoxine since the state of tryptophan to niacin metabolism is altered.

(f) Sources of Pyridoxine The amount of pyridoxine available in foods is very small. Good sources include yeast, wheat, corn, liver, kidney, other meats, poultry and fish. Milk, eggs, potatoes, sweet potatoes and vegetables are fair sources. Whole grains are a good source of pyridoxine but most of it is lost due to milling.

2. Pantothenic Acid *Pantothenic* is a word derived from the Greek word *pantothēn* which means *in every corner* or *from all sides*. This implies that it is widespread in nature. It is also synthesized by intestinal bacteria. These two things together make deficiency of pantothenic acid unlikely.

(a) Chemical Characteristics of Pantothenic Acid Pantothenic acid is a free acid, unstable, viscous yellow oil, soluble in water. It is sensitive to acids, bases and heat.

(b) Functions of Pantothenic Acid Pantothenic acid is of the highest biological importance because of its incorporation into coenzyme A. Coenzyme A is the functional, active form of pantothenic acid in the body. It is involved in several vital enzymatic reactions.

- (i) The most important of these reactions is the formation of active acetate which is an important common molecule in the process of energy production in the cell from carbohydrates and fats.
- (ii) This active form of acetate is also a precursor of cholesterol and as such of steroid hormones. Active acetate is also required for the production of haeme in the synthesis of haemoglobin.
- (iii) It is involved in the degradation and synthesis of fatty acids.

(c) Requirement and Deficiency of Pantothenic Acid Since it is widespread in nature, deficiency is unlikely. Hence, no RDA is prescribed for it.

(d) Sources of Pantothenic Acid Yeast and metabolically active tissues such as liver and kidney are rich sources. Good sources include egg-yolk and skimmed milk powder. Fair sources are lean meat, beef, cheese, legumes, sweet potatoes and yellow corn.

□ Group III

1. Folic Acid The name folic acid is derived from the Latin word *folium* which means the leaf because the sources of its isolation were dark green vegetables like spinach. A reduced form of folic acid, folinic acid, has also been discovered.

(a) Chemical Characteristics of Folic Acid Folacin is the generic term for folic acid or pteroylglutamic acid and other compounds having the activity of folic acid. Folic acid is a substance made up of three linked components, a pteridine group, para-amino benzoic acid and glutamic acid.

It is slightly water-soluble and some small amount of folic acid is also synthesized by intestinal bacteria. It is not stable at acidic pH and is readily destroyed by boiling in acidic medium. It is also easily oxidized in an acid medium and is sensitive to light.

(b) Digestion and Absorption of Folic Acid In foods, about 25 percent of folacin is in free form and is completely absorbed. But the polyglutamate forms of folacin having two to eight glutamic acid groups can only be absorbed after they are acted upon by conjugase, an enzyme that is present in the intestinal mucosal cells. Conjugase removes the extra glutamate groups, thereby releasing the absorbable folic acid.

In the body the active form of folic acid is tetrahydrofolic acid. Ascorbic acid is present in the body along with this potent form and prevents its oxidation.

(c) Functions of Folic Acid Coenzymes of folacin known as tetrahydrofolates are necessary for the following functions:

- (i) Formation of purines, pyrimidines and amino acids** Folic acid is essential for the interconversions of various amino acids and in purine and pyrimidine synthesis. The biosynthesis of purines and pyrimidines is ultimately linked with that of nucleotides and ribo- and deoxyribonucleic acids, which are the functional and genetic elements of all cells. It is also required for the interconversion of the amino acids glycine and serine.
- (ii) Formation of haemoglobin** Folic acid helps to form haeme, the iron containing part of haemoglobin. Folic acid is one of the important haemopoietic agents necessary for proper blood formation.

(d) Deficiency of Folic Acid Deficiency of folic acid results in megaloblastic anaemia. It is characterized by a reduction in the number of red blood cells in blood and release of large nucleated cells into the blood circulation. The haemoglobin level as well as leukocyte (WBC) and platelet level fall especially during pregnancy and infancy. Glossitis, diarrhoea and weight loss are the other symptoms of megaloblastic anaemia. Folic acid has been found to be effective in the treatment of sprue, a kind of intestinal malabsorption disease.

(e) Requirement of Folic Acid The actual requirement has been recommended to be 100 mg per day for a normal healthy adult. This requirement increases during pregnancy and lactation.

(f) Sources of Folic Acid Fresh green leafy vegetables like spinach and lettuce. Liver, kidney, dry beans and pulses are good sources of the vitamin. Fruit, milk, poultry and eggs are relatively poor sources.

2. Cyanocobalamin (B_{12}) Vitamin B_{12} , recently discovered as one of the B group, was isolated from liver fractions in crystalline form in 1948 and was soon shown to be specific for the treatment of Addisonian pernicious anaemia.

It is the extrinsic factor in the prevention of pernicious anaemia.

(a) Chemical Characteristics of Cyanocobalamin Vitamin B_{12} or cyanocobalamin molecule contains in its core a single atom of cobalt. It occurs as a protein complex in foods. Its food sources are almost entirely of animal

origin. It is synthesised in small measure in the intestines of humans, although the amount supplied from this source is not known. It occurs in several forms known as cobalamins.

(b) Digestion and Absorption of Cyanocobalamin Vitamin B₁₂ is a very large molecule, requiring a special mechanism for absorption. It is broken down from its complex form and bound to the intrinsic factor secreted by the stomach. This forms a complex with calcium which is then transferred across the intestinal mucosa and finally bound to a protein *transcobalamin II* in order to be transported by the circulating blood.

(c) Functions of Cyanocobalamin The vitamin is essential for the normal functioning of all cells, but particularly for cells of the bone marrow, the nervous system and the gastro-intestinal tract.

- (i) *As Coenzyme* Vitamin B₁₂ acts as an important coenzyme control agent along with folic acid in the synthesis of deoxyribonucleic acid and vital proteins in the cell.
- (ii) *Formation of RBC* Vitamin B₁₂ is necessary for the formation of red blood cells.
- (iii) It is also required for the activation of folic acid coenzymes.

(d) Deficiency of Cyanocobalamin A deficiency of vitamin B₁₂ results in pernicious anaemia characterized by large nucleated red blood cells. It has been found to be effective in the treatment of the intestinal disease, sprue.

(e) Requirement of Cyanocobalamin The requirement of vitamin B₁₂ by man has not been defined accurately and appears to be very small; estimated to be under 1 mg per day.

(f) Sources of Cyanocobalamin Vitamin B₁₂ is supplied almost entirely by animal foods. The richest sources are liver, kidney and lean meat. Milk, eggs and cheese supply a fair amount of it whereas vegetables and fruits do not contain any.

3.13 MINERAL ELEMENTS

Minerals constitute three to four percent of the total body weight. A *mineral* is an inorganic element occurring in the form of its salt, e.g. calcium, phosphorus, potassium, sodium, iodine, iron, copper, molybdenum, sulphur, chlorine, magnesium, manganese, etc. Minerals help to build tissues, regulate body fluids or assist in various body functions. They too, like the vitamins, are required in small quantities and are vital to the body. They should be supplied daily as they are excreted through the kidney, the bowel, and the skin.

They may be present in the body as organic compounds such as phospho-proteins, phospholipids, haemoglobin, thyroxine, or as inorganic compounds such as sodium chloride, calcium phosphate, and as free ions. Minerals may be classified into three groups.

1. *Major minerals or macrominerals* These are required in large amounts, at least 100 mg/day, e.g. calcium, phosphorus, sodium, chlorine, potassium.

2. *Minor minerals* These are required in small quantities, less than a few mg a day, e.g. iron, sulphur, magnesium.
3. *Trace elements (micro)* Their requirement is of the order of a few micrograms, e.g. iodine, fluorine, molybdenum, zinc.

The ICMR, 2010, has recommended daily dietary allowance only for two minerals (see Appendix III). The requirement of the other mineral is very small and is easily met in a normal diet: hence, the RDA, for them is not given.

Functions of minerals vary widely but may be generalized as follows:

1. They are structural components of bones, teeth, soft tissues, muscles, blood and nerve cells.
2. They help in regulating the activity of nerves with regard to stimuli and contraction of muscles.
3. They help maintain the acid-base balance of the body fluids.
4. They control the water balance in the body by means of osmotic pressure and by regulating the permeability of cell membranes.
5. They help to utilize food by helping in the process of digestion.
6. They are part of the molecules of hormones and enzymes. Many elements are part of metallo-enzymes.
7. They act as enzyme activators.
8. They regulate cellular oxidation.

Table 3.23 Mineral requirement of various tissues

Tissue	Elements especially needed	Deficiency symptoms
Bones and teeth	Calcium and Phosphorus	Stunted growth, weakened or soft bones. Malformed or decaying teeth, and rickets.
Hair, nails and skin, soft tissues	Potassium Phosphorus Sulphur Chlorine	
Nervous tissue	Phosphorus	
Blood	Iron Calcium Sodium Phosphorus Copper	Lack of iron or copper results in less than normal amount of haemoglobin in blood, a condition called nutritional anaemia.
Glandular secretions:		
Gastric Intestinal Thyroid Pancreas (Insulin)	Chlorine Sodium Iodine Zinc	Lack of iodine results in enlargement of thyroid gland-simple goitre.

□ Minerals as Body Regulators

To maintain normal exchange of body fluids (osmosis)	Sodium, potassium, chlorine, bicarbonate, magnesium
Contractility of muscles	Balance of calcium with sodium and Potassium
Irritability of nerves	Calcium
Clotting of blood	Iron, iodine, selenium and manganese, Balance between: Basic elements—sodium, potassium, calcium, magnesium and iron. Acid elements—phosphorus, sulphur, chlorine.
Oxidation processes	
pH of body fluids	

□ Digestion and Absorption of Minerals

Most of the minerals are best absorbed by the body in their soluble form. Organic form is better absorbed by the body, than inorganic form, e.g. iron in the inorganic form in *poha* (rice flakes) and jaggery, is not absorbed as much as that in meat.

For a normal adult a balance exists between the intake of an element and its excretion. *Homeostasis* is a mechanism by which the continuous flow of nutrients into the cell and out of it takes place, e.g. bone. This tissue of the body is thought to be inert, but it is not so. It is an active tissue in its uptake and release of nutrients, especially minerals. In spite of this there is always a state of balance so that at any given time there is an adequate supply of nutrients. Figure 3.10 illustrates this point to show the different mechanisms which control the amount of calcium that is absorbed.

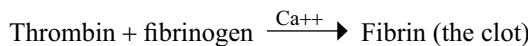
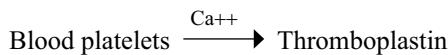
Indian diets are generally deficient in calcium, iron and iodine. If these three minerals are supplied by a diet in adequate amounts the requirement for the rest will be easily met.

□ Calcium

Of all minerals, this is the most abundant mineral found in the skeletal and bone tissues. Approximately 1200 g of calcium is found in our body, of which 99 percent is combined as salts—mainly as calcium phosphate—which gives hardness to the bones and enable them to hold the weight of a body.

The remaining one percent performs the following function:

1. It catalyzes the clotting of blood. Injury to a cell is taken care of as follows:



2. It activates several enzymes such as pancreatic lipase, adenosine triphosphatase and some proteolytic enzymes.

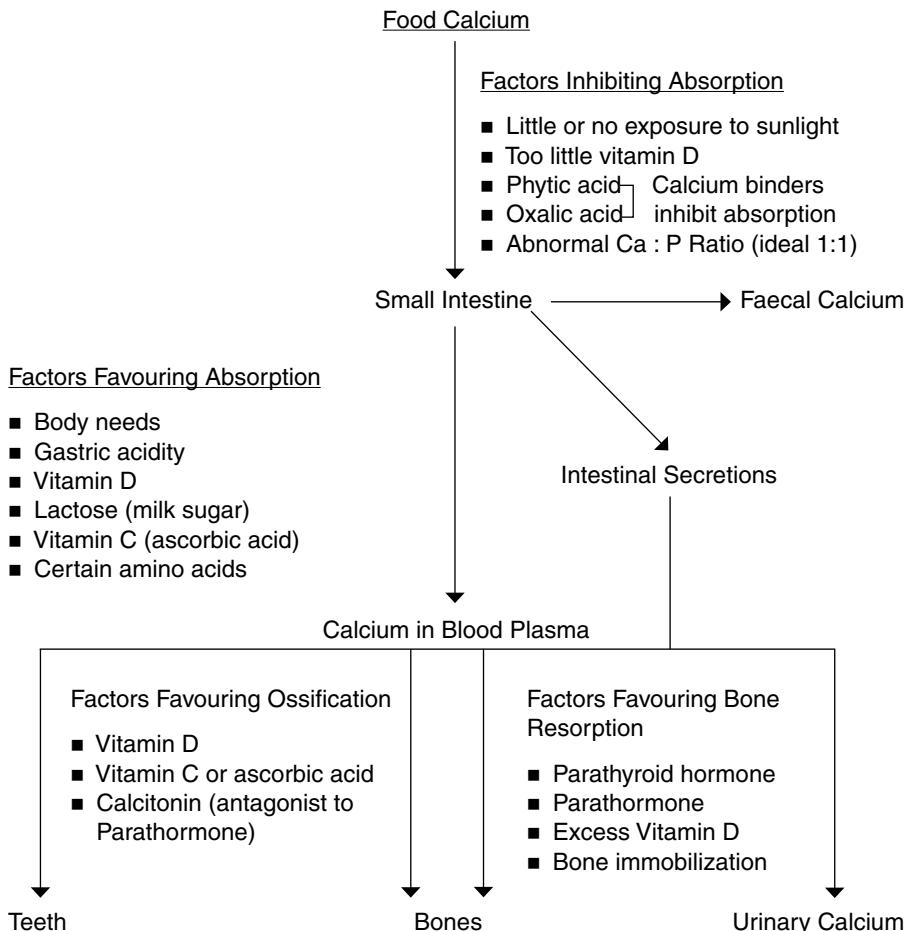


Fig. 3.10 Utilization of calcium

3. It is necessary for synthesis of *acetylcholine*, a substance that is necessary for transmitting nerve impulses.
4. It helps to absorb vitamin B₁₂ in the ileum.
5. Its vital function is to regulate contraction and relaxation of muscles, including the beating of heart.
6. It helps the absorption process by increasing the permeability of cell membranes.

1. Deficiency of Calcium A severe deficiency of calcium leads to rickets in children and osteomalacia in adults.

(a) Rickets It is seen more often in premature infants than full-term infants as their growth and calcification rate demand more calcium and vitamin D. The characteristics of rickets are delayed closure of the fontanelles, bulging or bossing of the forehead and soft and fragile bones. There may be bowing of the legs or knock-

knees if there is enlargement of wrist, knee and ankle joints. Muscle development is poor and walking may be delayed. There may be restlessness and nervous irritability.

Rachitic rosary is seen in the breast region as enlargement of the costochondrial junction. Projection of the sternum causes *pigeon breast*.

(b) Osteomalacia or Adult Rickets Calcium requirements are also increased during pregnancy to meet the needs of a growing foetus and during lactation to compensate for calcium secreted in the breast milk. A healthy breast fed baby of 3 months draws its supply of calcium from mother's milk. If the mother's diet is deficient in calcium content, the calcium from her bones will be depleted predisposing her to fractures of the bones. Hence, adequate supply of calcium is essential during pregnancy and lactation periods. This explains softening of the bones which may be seen in women due to repeated pregnancies and low intake of vitamin D and calcium. It can also be seen in patients suffering from diseases with interference in fat absorption and in patients with renal disease.

Osteomalacia is characterised by softening which usually takes place in the bones of the legs, spine, thorax and pelvis, which may bend and show deformities. Other symptoms of the disease are rheumatic-type pain in bones of the legs and lower part of the back, general weakness, especially while walking and climbing stairs, and spontaneous multiple fractures.

(c) Hypercalcemia Excessive intake of calcium can result in raising the blood calcium, thereby causing an increased deposition of calcium in the soft tissues and increased excretion of calcium in urine.

This has been observed in patients with peptic ulcers who consume excessive alkalies along with a large amount of milk for a long period of time. It may be accompanied by symptoms such as vomiting, gastro-intestinal bleeding and an increase in blood pressure.

Infants who are given excessive doses of vitamin D exhibit gastro-intestinal upsets and retarded growth. It can be corrected by removal of the vitamin from their diet.

2. Sources of Calcium Rich sources include milk in any form and cheese. Good sources are green leafy vegetables such as amaranth, drumstick leaves, mustard greens, spinach, colocasia, fenugreek (*methi*), etc. Root vegetables, such as tapioca, are a good source. Millet ragi (*nachni*) is a particularly rich source of calcium. Some of the pseudocereals such as *rajkeera* (grain amaranth) are also good sources. Small fish such as mandeli, when eaten with the bone, is also a good source of calcium. In India, *paan* is very commonly eaten after meals. Since, it is smeared with calcium (*chuna*) it provides a fair amount of calcium, besides aiding the process of digestion.

Meat and cereal grains, especially rice, are poor sources of calcium.

Chlorine

Chlorine is found in the body as chloride ion. Large amounts of chloride are found in the extracellular fluid but some amount is also found in the red blood cells and to a lesser degree in other cells.

1. Functions of Chlorine Our body contains approximately 50 mEq of chloride per kilogram of our body weight and it performs the following functions:

- (a) In the extracellular fluid, chloride is necessary for the regulation of osmotic pressure, water balance, and acid-base balance.
- (b) In the gastric juice it is the chief anion along with hydrogen ion because of which hydrochloric acid is formed. It provides an acid medium for activating digestion enzymes as well as enabling digestion in the stomach.
- (c) Chloride activates amylases.

2. Deficiency of Chlorine Severe deficiency of chloride occurs in cases of excessive vomiting, and diarrhoea when large amounts of chloride is lost resulting in alkalosis due to replacement of chloride with bicarbonate.

3. Sources of Chlorine Table salt is the main source of chloride in diet. Generally as much chloride is ingested as is sodium.

Table 3.29 gives a list of 14 mineral elements, with their sources, functions and deficiency symptoms.

□ Copper

Along with iron, copper too is involved in haemoglobin synthesis. Liver, brain, heart and kidney contain high concentrations of copper. It performs the following functions in the human body:

1. Functions of Copper

- (a) Copper-protein complex known as ceruloplasmin is the major complex of copper. Some amount is bound to albumin. The ceruloplasmin plays an important role in the transport of iron in transferrin for haemoglobin synthesis.
- (b) Other functions include taste, sensitivity, formation of melanin pigment, maturation of collagen and elastin formation, integrity of the myelin sheath, synthesis of phospholipids and bone development.
- (c) It is a part of several enzymes like cytochrome oxidase, dehydrogenase, tyrosinase, etc.

2. Deficiency of Copper Deficiency of copper is uncommon in human beings. It may be observed in kwashiorkor, nephrotic syndrome, sprue and sometimes in anaemia, or in patients being given total parenteral nutrition.

A daily intake of 2–3 mg can satisfy its requirement. Excessive dosage of copper is toxic. It leads to hepatitis, lenticular degeneration, renal malfunction and neurologic disorders. Workers in copper mines often suffer from such toxic conditions.

3. Sources of Copper Organ meats, shell-fish, whole-grain cereals, legumes and nuts are good sources of copper, while milk is a poor source.

□ Fluorine or Fluoride

Fluoride is the term for the ionized form of the element fluorine, as it occurs in drinking water. The two terms, fluorine and fluoride, are used interchangeably.

Fluorine is present in small but widely varying concentrations in practically all soils, water supplies, plants and animals. It is therefore, a constituent of all normal diets. Also, fluorine is one of the atmospheric contaminants of industries which use coal, ore or earthy phosphates.

The adult human contains less than 1.4 mg of fluorine most of which is in the bones and teeth. In small amount, fluorides help develop strong bones and teeth, but in excessive amounts, bones become porous and soft and teeth become mottled and easily worn down.

A proper intake of fluorine is essential for maximum resistance to dental caries (tooth decay), a beneficial effect that is particularly evident during infancy and early childhood, and which is persistent through adult life.

1. Functions of Fluorine Although fluorine is found in various parts of the body, it is particularly abundant in bones and teeth; it normally constitutes 0.02% percent to 0.05% percent of these tissues. Fluorine is necessary for sound bones and teeth.

The fluoride ions, at proper levels of intake, assist in the prevention of dental caries. When children under five years of age consume drinking water containing one ppm of fluorine, the teeth have fewer dental caries in childhood, adolescence and throughout life. This has led to fluoridation of water supplies in many countries.

The mechanism by which fluorine increases caries resistance of the teeth is not fully understood. However, it appears that crystals of fluoroapatite can replace some of the calcium phosphate crystals of hydroapatite that are normally deposited during tooth formation, and that it may also replace some of the carbonate normally found in the tooth. Apparently these fluoride substances are more resistant to mouth acids. Fluorine may also inactivate oral bacterial enzymes which create acids from carbohydrates.

Increased retention of calcium, accompanied by a reduction in bone demineralization, has been observed in patients receiving fluoride salts. This indicates the possibility that dietary fluorine is essential for optimal bone structure and for the prevention of osteoporosis in humans. This has prompted some medical doctors to use fluorine therapeutically in the treatment of osteoporosis in the aged.

2. Deficiency Symptoms Deficiency of fluorine results in excess dental caries. Also, there is indication that its deficiency results in osteoporosis in the aged. However, excess of fluorine is of more concern than its deficiency.

Fluorine is a cumulative poison; hence, chronic fluorine toxicity, known as fluorosis, may not be noticed for some time. The enamel of the teeth is likely to lose lustre and become chalky and mottled when one of the following conditions prevail:

- (a) When the fluoride content of the drinking water exceeds 2.5 ppm.
- (b) When the amount of fluorine ingested exceeds 30 to 40 ppm of the dry matter of the diet.
- (c) When a person consumes (in food and water) fluorine in excess of 20 mg/day over an extended period of time. The degree of mottling depends on the level of fluorine intake and individual susceptibility. Mottling of teeth in children has been observed if fluoride concentrations in the diet and drinking water are two to eight ppm.

In India fluorosis occurs as an endemic disease in Andhra Pradesh (AP) (Nalgonda District) and in Punjab (Patiala district). In AP, another clinical manifestation of fluoride toxicity called "Genu valgum" has been identified recently. However, besides high intakes of fluorine other factors associated are high levels of molybdenum and low levels of copper.

Fluorosis also affects the bones. They lose their normal colour and lustre, become thickened and softened, and break more easily.

3. Recommended Daily Allowances of Fluorine The ranges suggested are obtained without difficulty in areas with a water supply containing at least 1 mg/litre of fluoride, either naturally or through fluoridation.

Fluoridation of water supply is the simplest and most effective method of providing such added protection, although it is possible to add fluorine to milk, cereals and salt or to take it in tablet form as sodium fluoride. The range of safety in fluoride intake is wide enough to accommodate normal fluctuations in the fluoride content of foods without the risk of inducing mottling.

4. Sources of Fluorine Fluorine is widely, but unevenly, distributed in nature. It is found in many foods, but seafood and tea are the richest dietary sources. Food alone can supply 0.3–0.8 mg fluorine.

The fluorine content of foods varies widely and is affected by the fluorine content of the environment (air, soil and water) in areas in which they are produced. Nevertheless, some foods do accumulate and contain more fluorine than others. One must bear in mind that it is the total fluorine ingested over an extended period of time that is important.

An average daily diet provides 0.25 to 0.35 mg of fluorine. In addition, the average adult may ingest 1.0 to 1.5 mg daily from drinking and cooking water that contains 1 ppm of fluorine. For children in the age group of one to 12 years, water may contribute anywhere from 0.4 to 1.1 mg of fluorine per day.

Fluorine tablets and fluorine toothpaste can serve as reliable, though expensive, sources of this element.

5. Fluoridation of Water Supplies Fluoridation of water supply to bring the concentration of fluoride to 1 ppm (one part of fluorine to a million parts of water) has proved to be a safe, economical and efficient way to reduce tooth decay. It is a highly important public health measure in areas where natural water supplies do not contain this amount. Extensive medical and public health studies have clearly demonstrated the safety and nutritional advantages that result from fluoridization of water supplies. In communities in which fluoridation has been introduced, the incidence of tooth decay in children has been decreased by 50 percent or more.

The concentration of fluoride in public water supplies should be adjusted slightly to allow for differences in water consumption with seasonal temperature changes.

6. Fluorosis Fluorosis is a chronic disease resulting from the accumulation of toxic levels of the mineral fluorine in the teeth and bones. It is a crippling disease characterized by bone overgrowth, brittle bones, stiff joints, weakness, weight loss and anaemia. Mottling of the teeth may occur if the exposure was during the

formation of enamel. Contaminated water and food are the principal sources of excessive fluoride.

□ Iodine

This is a trace element required in minute quantities by our body. But this minuscule amount has a far-reaching effect on the growth and metabolism of our body.

1. Functions of Iodine The only known function of iodine is as a constituent of the thyroid hormones, thyroxine and triiodothyronine. In these hormones, tyrosine along with iodine, regulates the rate of oxidation within the cells and in doing so determines the rate of metabolism.

2. Deficiency of Iodine

(a) Goitre People of the hilly regions and those who are far from the sea suffer from iodine deficiency syndrome, namely *simple* or *endemic goitre*. The soil in these regions lacks iodine, therefore, consumption of vegetables, cereals and pulses grown here does not contribute iodine in appreciable amounts. The entire population in such areas suffers from goitre, hence, the name endemic goitre.

Goitre is an enlargement of the thyroid gland since the size (hypertrophy) and the number of (hyperplasia) epithelial cells in the gland increase. The BMR is normal. Women are more affected than men, especially in adolescent and pregnant women it is more pronounced.

Endemic goitre is a matter of serious concern since, infants of women suffering from goitre and who are unable to meet the foetus demand for iodine, suffer from *cretinism*.

Cretinism is characterized by low basal metabolic rate, muscular flabbiness and weakness, dry skin, rough hair, enlarged tongue, thick lips, retardation of skeletal development and severe mental retardation. Administration of desiccated thyroid brings relief to a certain extent in that physical growth is improved and mental retardation is less severe, but damage to the central nervous system cannot be reversed and is a permanent feature of the cretin.

(b) Myxoedema Hypothyroidism, which is seen more commonly today, is a clinical syndrome in which the bodily metabolic processes slow down due to a deficiency or absence of thyroid hormone. The symptoms of hypothyroidism can manifest in all organ systems and the severity differs according to the degree of hormone deficiency. The disease typically progresses over months to years but can recur rapidly if the thyroid replacement medicines are discontinued or even if the thyroid gland is surgically removed.

The term *myxoedema* refers to the thickened, non-pitting, oedematous changes to the soft tissues of patients in a markedly hypothyroid state. A rare, life-threatening condition called *Myxoedema coma* can occur late in the progression of hypothyroidism. The condition is seen typically in elderly women and is often precipitated by infection, medication, environmental exposure, or other metabolic-related stresses. The diagnosis may be made on clinical grounds and treatment should be started promptly.

(c) Goitrogens Substances known to interfere with the activity of thyroxine to produce goitre in spite of a normal intake of iodine are known as *goitrogens*.

Goitrogens, generally thio-cyanates, are found in cabbage, turnips, rutabagas, cauliflower, brussel sprouts, peanuts and mustard. However, the goitrogens in these foods are inactivated by cooking that involves high temperature.

3. Sources of Iodine The daily requirement for adults is 100–150 mg. Saltwater fish, shellfish, seaweed contain large amounts of iodine. The iodine content of eggs, dairy products, meat and poultry depends upon the iodine content of the animal's diet. Vegetables and fruits that are grown in soil that is rich in iodine are good sources of iodine. Hence, the iodine content of the food obtained from animals or plants depends upon the iodine in the animals' diet or the soil in which the plant is grown.

Fortification of common salt with potassium iodate is a recommended method of making iodine easily available. Iodised salt must be used after cooking is over to prevent heat losses. Special government subsidies are available for preparing iodized salt. Even legislative measures making it compulsory to make iodine available through common salt are under way. This will go a long way in preventing iodine deficiency in our country.

□ Iron

Besides calcium and iodine, iron is an essential nutrient, but it is generally deficient in the Indian diet. Anaemia is commonly seen in all age groups in India, especially in women in their reproductive years. Iron performs the following functions in our body:

1. Functions of Iron

- (a) Iron is present principally as haemoglobin of the Red Blood Cell (RBC). Haemoglobin acts as a carrier of oxygen from the lungs to the tissues and indirectly helps in the return of carbon dioxide to the lungs.

After the life span of the RBC is complete (120 days), the iron from it is removed and sent to the bone marrow where it is used for synthesis of new red blood cells (*haemopoiesis*).

Myoglobin is the iron-protein complex found in muscles, which stores some oxygen for immediate use by the cell. Transferrin or siderophilin is the circulating form of iron. Ferritin or haemosiderin is the storage form of iron.

- (b) Several oxidase enzymes such as catalase, cytochrome oxidase, xanthine oxidase contain iron as an integral part of their molecular structures.

Table 3.24 depicts the various forms in which iron exists in the body.

2. Deficiency of Iron

(a) Anaemia This deficiency is found commonly in infants, pre-school children, adolescent girls and pregnant women. Iron-deficiency anaemia is a major public health problem. Causes of iron deficiency anaemia could be due to the following:

Table 3.24 Forms of iron in the body

Iron type	Function
<i>Metabolic proteins</i>	
<i>Heme proteins:</i>	
Haemoglobin	Oxygen transport from lungs to tissues
Myoglobin	Transport and storage of oxygen in muscle
<i>Enzymes: heme</i>	
Cytochromes	Electron transport
Cytochromes P-450	Oxidative degradation of drugs
Catalase	Conversion of hydrogen peroxide to oxygen and water
<i>Enzymes: nonheme</i>	
Iron-sulphur and metalloproteins	Oxidative metabolism
<i>Enzymes: iron dependent</i>	
Tryptophan	Oxidation of tryptophan
<i>Transport and Storage Proteins</i>	
Transferrin	Transport of iron and other minerals
Ferritin	Storage
Haemosiderin	Storage

(i) Blood Loss

- **Gastrointestinal**

Diaphragmatic hiatus hernia
Drugs
Infection, inflammation or malignancy
Long distance running
Peptic ulcer disease
Telangiectasia

- **Genitourinary**

Infection, inflammation, pulmonary malignancy
Menstruation

- **Phlebotomy**

Blood donation
Diagnostic phlebotomy
Polycythemia
Self-inflicted blood loss

- **Respiratory**

Infection, inflammation or malignancy haemosiderosis

- **Surgery**

- **Trauma**

(ii) Decreased Iron Absorption or Utilization

Malabsorption syndromes
Partial gastrectomy

(iii) Inadequate Iron Ingestion/Increased Iron Requirements

Infancy and childhood

Pregnancy

Characteristic symptoms are a low serum level of iron, high iron-binding capacity, low haemoglobin, low red cell volume, low mean corpuscular haemoglobin and small and pale cells (microcytic, hypochromic).

(b) Potential Diagnosis of Anaemia The haematological picture may be based on the Complete Blood Count or Mean Corpuscular Volume.

Normocytic-Normochromic

- I. Reticulocytes—low/normal : Renal insufficiency
: Bone marrow infiltration
: (Leukaemia, Lymphoma, Metastasis)
: Anaemia of chronic disease
: Endocrine disease
: Myelodysplastic Syndrome
: Others
- II. Reticulocytes increased : Acute haemorrhage
: Haemolytic anaemia—hereditary or acquired
: Others

Microcytic-Hypochromic

- Ferritin reduced : Iron deficiency anaemia
- Ferritin normal/increased : Thalassemia
: Sideroblastic anaemia
: Anaemia of chronic disease
: Others

Macrocytic/Normo or Hyperchromic

- I. Reticulocytes low/normal
 - Non-megaloblastic : Liver disease
: Myelodysplastic Syndrome
: Hypothyroidism
: Others
 - Megaloblastic : Vitamin B₁₂ deficiency anaemia
: Folate deficiency
: Others
- II. Reticulocytes increased : Prior haemorrhage
: Prior haemolysis
: Treated deficiency diseases: Vitamin B₁₂, Folate
: Others

Adapted with modifications from Wintrobe's Clinical Haematology, 9th ed. 1993.

The symptoms are insidious and are seen when the haemoglobin drops below 7 to 8 g/dl. The symptoms are early fatigue, breathlessness, palpitations, tiredness, weakness, body ache, inability to concentrate, giddiness, fragile, brittle and cracked nails, flat, concave nails (platynychia, koilonychia) tongue may be smooth, pale

and red, difficulty in swallowing, mild hepatic splenomegaly, pica (perversion of appetite-to eat mud, ice, soap, rice, etc), menorrhagia, amenorrhoea, dry and dull hair, premature greying. In severe cases it may result in anginal pain and sometimes even heart failure.

Although green leafy vegetables are abundant in India and several are available throughout the year, they are not consumed often; and the green leaves of vegetables like cauliflower, beet and radish are thrown away while only the root or flower is consumed. This results in a loss of an important nutrient source due to ignorance.

Women suffer from anaemia more than men or children. This is due to the loss of menstrual blood every month. Delivery of every child means heavy blood loss. Due to repeated pregnancies, even before recovering from this loss a woman may conceive and this may cause a stress condition, which increases the requirement of iron. Therefore, women must make every attempt to include iron-rich foods in their diet every day. Medicinal iron in the form of iron salts and other haematinics have to be provided to correct the anaemia.

Children, due to unhygienic conditions and unclean drinking water, are prone to helmenthic diseases. These do not allow absorption of iron. In chronic stage of infection with round worm (ascaris) or hook worm (oxyuris), anaemia occurs.

(c) Haemosiderosis This deficiency occurs when there is abnormal destruction of the red blood cells as in haemolytic anaemia. An excessive intake of iron daily produces typical symptoms of cirrhosis of the liver as the iron is stored in it in large amounts.

3. Sources of Iron Liver, lean meats, fish and poultry are good sources of iron in the form of haeme. Legumes, dry fruits, whole-grain cereals and hand pounded cereals as well as green leafy vegetables are good sources.

Jaggery and rice flakes contain inorganic iron since they are processed in iron vessels and are a fair source.

The high incidence of anaemia could be due to insufficient intake of iron or poor bioavailability. The absorption of haem iron is much better than that of non-haem iron. Enhancing the bioavailability is as important as increasing the intake.

The absorption could be enhanced by including ascorbic acid and beta-carotene containing fruits and vegetables into recipes of iron containing food preparations. Improving the bioavailability of iron of food preparations will improve the iron status of women.

In view of the widespread prevalence of iron deficiency anaemia in many parts of the world fortification is being advocated. In our country, fortification of common salt with iron has been successfully developed and can prevent anaemia if used regularly in place of ordinary salt.

□ Magnesium

This mineral is found in the body in much smaller amounts than calcium and phosphorus. It is found mainly as phosphate and carbonate. Magnesium is found close to the surface of the bone. It performs the following functions in the body:

1. Functions of Magnesium

- (a) It is a catalyst in numerous metabolic reactions.

- (b) It is required to activate the enzymes involved in the oxidative phosphorylation of ADP to ATP and also for the return of ATP to cyclic AMP, which in turn regulates parathormone secretion.
- (c) It is required to be in balance in the extracellular fluid with Ca, Na and K so that transmission of nerve impulses and the consequent muscle contraction can be regulated. Magnesium is essential for the functioning of heart-beat and maintenance of blood pressure.

2. Deficiency of Magnesium A daily dietary intake should be around 350 mg. Deficiency of magnesium does not occur under normal health conditions and food intake, but a continuous poor intake of magnesium accompanied by increased excretion leads to a rapid lowering of the plasma magnesium.

Symptoms that are seen are similar to those in hypocalcemic tetany, i.e. muscle tremor, paresthesias and sometimes convulsive seizures and delirium.

Conditions of magnesium deficiency often result in chronic alcoholism, cirrhosis of the liver, kwashiorkor, severe vomiting, diabetic acidosis, and diuretic therapy. In the last two cases, loss of magnesium from the body is increased.

3. Sources of Magnesium Dairy products (excluding butter), fresh green vegetables, meat, nuts, sea food and legumes are good sources of magnesium. Cereals, pulses and nuts contain 40–200 mg of magnesium per 100 grams.

□ Potassium

Potassium is necessary for the human body mainly in all tissue cells. Like sodium, it is also found in the extracellular fluid.

1. Functions of Potassium Our body contains approximately 2.6 g of potassium per kg of our body weight, and performs the following functions:

- (a) Potassium is an obligatory component of all cells, hence, the greater the number of cells, the more is the increase in potassium.
- (b) Potassium is required for the maintenance of osmotic pressure and fluid balance within the cell. Sodium is found to perform the same function in the extracellular fluid.
- (c) Potassium is required for enzymatic reactions which take place within the cell. Some potassium is bound to phosphate in the process of formation of glucose to glycogen. When glycogen is broken down to glucose, potassium is released.
- (d) However small the concentration of potassium in the ECF, it is required to transmit nerve impulses and for muscle fibres, along with other ions.

2. Deficiency of Potassium Under normal dietary intake, potassium deficiency does not occur. But it may occur in instances of severe malnutrition, chronic alcoholism, anorexia nervosa, low carbohydrate diets and in weight reduction regimes in which food intake is restricted.

In severe tissue injury, losses may exceed replacement as in the case of burns, post-surgery period and during prolonged fevers.

Characteristics of potassium deficiency are low plasma levels of potassium (hypokalemia), and the symptoms include nausea, vomiting, listlessness,

apprehension, muscle weakness, hypotension, tachycardia (increased heartbeats), arrhythmia and an altered electrocardiogram. Heart muscle may be affected so severely that it may stop during diastole (relaxation phase of heartbeat).

3. Hyperkalemia Hyperkalemia or excess of potassium may occur in conditions of severe dehydration, renal failure, after very rapid administration of potassium and in adrenalin insufficiency. Hyperkalemia may be fatal, since heart muscles may stop during systole (contraction phase of heartbeat). Other symptoms are paresthesias of the scalp, face, and tongue; muscle weakness, poor respiration, cardiac arrhythmia and changes in the ECG.

4. Sources of Potassium Potassium is easily available in foods. Good sources are meat, poultry, fish, milk and curds. Rich sources are whole-grain cereals and pulses, vegetables and fruits, e.g. bananas, potatoes, tomatoes, carrots, celery, orange, grapes, chiku and custard apple.

Phosphorus

Phosphorus is a vital mineral forming the very matrix of the genetic substances DNA and RNA, which are substances that control heredity.

About 85 percent of it is in inorganic combination with calcium in bones and teeth. The remaining amount functions as organic compounds for the following:

- (a) It is a constituent of the sugar-phosphate linkage in the structures of DNA and RNA.
- (b) Phosphorus as phospholipids regulates the transport of cell solutes in and out of the cell. Phospholipids facilitate the transport of fats in circulation.
- (c) Phosphorus regulates many metabolic processes that involve phosphorylation. These include absorption of glucose from the intestine and its uptake by the cell, as well as resorption of glucose by the renal tubules.
- (d) Adenosine diphosphate and adenosine triphosphate system it is necessary for a continuous storage and controlled release of energy, in nicotinamide dinucleotide-nicotinamide adenine-dinucleotide phosphate and for the active form of thiamine as TPP (Thiamine Pyrophosphate).
- (e) The active forms of many vitamins are their phosphate derivatives, e.g. B₁, B₂, B₆, pantothenic acid.
- (f) High energy storage compounds are phosphate esters of organic compounds, e.g. ATP, creatine phosphate, etc.

1. Deficiency of Phosphorus Symptoms of phosphorus deficiency are rare since, diet which furnishes adequate protein and calcium fulfills the requirement of phosphorus.

Retarded growth, poor teeth and bone formation, rickets, weakness, anorexia and pain in the bones are some of the symptoms of phosphorus deficiency. Other symptoms of deficiency are almost like those of calcium deficiency.

2. Sources of Phosphorus It is widely distributed in foods. The most important sources are milk and meat.

Whole-grain cereals and flours, legumes, nuts and fish are a good source of phosphorus. However, many seeds contain phosphorus in the form of phytic acid, the phosphorus form which is often not available but renders other metal ions also unavailable.

Selenium

This trace element is a component of the enzyme glutathione peroxidase which along with vitamin E, catalase and dismutase is a component of one of the anti-oxidant defence systems of the body.

Sodium

Sodium chloride or common salt is the taste-giver in our diet. Common salt always occupied a very important position in history. The term *salary* comes from the word *salaria* (meaning salt) since salt served as a medium of exchange in the past.

1. Functions of Sodium Our body contains approximately 1.8 g of sodium per kilogram of our weight and performs the following functions:

- (a) Sodium is the principal electrolyte in the extracellular fluid which maintains normal osmotic pressure and water balance. It serves as a base in the extracellular fluid.
- (b) It contributes alkalinity to the gastro-intestinal secretions.
- (c) Along with other ions, it maintains the normal irritability of nerve cells and helps muscle contractions.
- (d) It regulates cell permeability.
- (e) It maintains electrolyte differences between intracellular and extra-cellular fluid compartments.

2. Deficiency of Sodium Sodium depletion occurs in athletes and persons engaged in heavy labour. They lose significant amounts of sodium in sweat. These losses must be replaced by eating more salt. Fluids must be taken liberally.

A hormonal deficiency of ACTH in Addison's disease leads to large losses of sodium so that the patient hungers for sodium. Other instances of sodium depletion are during continuous vomiting and diarrhoea.

Deficiency symptoms include weakness, giddiness, nausea, lethargy, muscle cramps and in case of severe depletion there is circulatory failure.

3. Sodium Imbalance It is necessary to curtail the intake of sodium from childhood as it predisposes the child to hypertension in the long run. Communities having a daily intake of salt of about 10–25 g have been found to have a high incidence of hypertension while communities consuming less than two grams salt daily do not suffer from hypertension.

4. Sodium Retention In cardiac and renal failure, excretion of sodium is reduced. It is retained in the cell along with excess of extracellular fluid and this results in oedema or swelling. Other causes of sodium retention are excessive secretion of

cortical hormones by adrenal tumours. Similarly, ACTH used therapeutically in a variety of conditions also increases the retention of sodium.

5. Sources of Sodium Table salt is the main source of sodium, containing about 40 percent of it. It is used in cooking for preserving and improving the taste of the food. One teaspoon salt contains about 2000 mg to 2400 mg sodium. Other sources of sodium are milk, egg-white, meat, poultry, fish and some vegetables such as spinach, beets, celery, etc. Other sources that contain low amounts of sodium are vegetables, fruits, cereals and legumes. Drinking water generally contains low amounts of sodium.

In India, awareness about sodium and hypertension is not much. Hence, sodium-free foods have not yet entered the market. The commonly used sodium compounds in prepared foods are baking soda, baking powder, monosodium glutamate (*ajinomoto*), sodium citrate and sodium propionate.

□ Sulphur

This mineral is present in all body cells, especially as sulphur containing amino acid—methionine, cystine and cysteine. Sulphur is a constituent of thiamine and biotin, two water-soluble vitamins. Skin, hair, nails and connective tissue are rich in sulphur.

1. Functions of Sulphur The sulphur absorbed from the intestines is mainly in the organic form as the sulphur-containing amino acids methionine, cysteine and cystine. It performs the following functions:

- (a) Sulphur is a structural constituent of mucopolysaccharides such as chondroitin sulphate which is found in cartilage, tendons, bones, skin and the heart valves. In enzymes it is present as —SH group.
- (b) Sulpholipids are found in large amounts in tissues of liver, kidney, salivary glands and the white matter of brain.
- (c) Other compounds which contain sulphur are insulin and heparin, an anticoagulant.
- (d) Sulphur compounds required in oxidation-reduction reactions are coenzymes of thiamine, biotin, coenzyme A, lipoic acid and glutathione.

2. Deficiency of Sulphur Deficiency of sulphur is unknown, since a diet that is adequate in methionine and cystine is considered to fulfil our requirement of sulphur.

3. Sources of Sulphur All protein foods rich in methionine, cystine, and cysteine supply adequate amount of sulphur. Meat, milk, eggs, fish, poultry, cheese and nuts are good sources.

□ Zinc

Zinc is an essential element for humans. It is widely distributed throughout the body, but the highest concentrations are found in the skin (the skin contains 20 percent

of the total body zinc), hair, nails, eyes and prostate gland. Traces occur in the liver, bones and blood. Also, it is a constituent of enzymes involved in most major metabolic pathways. In total, the human body contains about 2.2 g of zinc—more than any other trace element except iron.

1. Absorption, Metabolism and Excretion Less than 10 percent of dietary zinc is absorbed into the body, primarily, in the duodenum. It appears that metallic zinc as well as its carbonate, sulphate and oxide forms are all absorbed equally well. Large amounts of calcium, phytic acid or copper inhibit zinc absorption. Cadmium appears to be a zinc antimetabolite.

After zinc is absorbed in the small intestine, it combines with plasma proteins for transport to the tissues. Relatively large amounts of zinc are deposited in bones, but these stores do not move into rapid equilibrium. The body pool of biologically available zinc appears to be small but has a rapid turnover, as evidenced by the prompt appearance of deficiency signs in experimental animals.

Most of the zinc derived from metabolic processes is excreted in the intestine—in pancreatic, intestinal and bile secretions. Only small amounts are excreted in the urine.

2. Functions of Zinc Zinc is needed for normal skin, bones and hair. It imparts bloom to the hair. It is a component of several different enzyme systems which are involved in digestion and respiration. Also, zinc is required for the following functions:

- (a) Transfer of carbon dioxide in red blood cells.
- (b) Proper calcification of bones.
- (c) Synthesis and metabolism of proteins and nucleic acids.
- (d) Development and functioning of reproductive organs.
- (e) Healing of wounds and burns.
- (f) Functioning of insulin.
- (g) Normal taste acuity (the ability to taste accurately).

3. Deficiency Symptoms The most common cause of zinc deficiency is an unbalanced diet, although other factors may also be responsible. For example, the consumption of alcohol may precipitate zinc deficiency by flushing stored zinc out of the liver and into the urine.

Lack of zinc in the human diet has been studied in detail in Egypt and Iran, where the major constituent of the diet is unleavened bread prepared from low extraction wheat flour. The phytate present in the flour limits the availability of zinc in these diets, with the result that the requirements for the element are not satisfied. Zinc deficiency has also been observed in young children from middle class homes in the United States who consume less than 30 g of meat per day.

Zinc deficiency is characterized by loss of appetite, stunted growth in children, skin changes, small sex glands in boys, loss of taste sensitivity, lightened pigment in hair (dull hair), white spot on fingernails and delayed healing of wounds. In the Middle East, pronounced zinc deficiency in man has resulted in hypogonadism and dwarfism. In pregnant animals, experimental zinc deficiency results in malformation and behavioural disturbances in the offspring—a finding that suggests that the same thing may happen to human foetuses.

4. Interrelationships Zinc is involved in many relationships.

- (a) In the metabolism of carbohydrates, fats, proteins and nucleic acids.
- (b) In interference with the utilization of copper, iron and other trace minerals, when there are excess dietary levels of zinc.
- (c) In protection against the toxic effects of cadmium, when there is ample dietary zinc.
- (d) In reduced absorption, when there are high dietary levels of calcium, phosphorus and copper.

5. Recommended Allowance of Zinc Studies have shown that in healthy adults equilibrium or positive balance is obtained with intakes of 12.5 mg of zinc per day, when this intake is derived from a mixed diet. This has been accepted as a minimum requirement since, the balance studies did not take into account sweat and skin losses.

6. Toxicity Toxicity of zinc is characterized by anaemia, depressed growth, stiffness, haemorrhages in bone joints, bone resorption, depressed appetite, and in severe cases, death.

The anaemia appears to result from an interference with iron and copper utilization because addition of these two elements can overcome the anaemia caused by excessive zinc.

Zinc poisoning may result from eating foods that have been stored in galvanized containers.

7. Sources of Zinc The zinc content of the total diet is influenced by the range of food items selected as well as by the degree of refinement of any cereals included in the diet. Fat does not contain zinc and tends to lower the zinc content of the total diet. Lean meat is an excellent and a highly available form of zinc. Many staple foods and animal sources are good source of zinc. However, fats, oil, sugar and alcohol have very low zinc content. Green leafy vegetables and fruits contain moderate amount of zinc since, they contain high amount of water.

Table 3.25 shows the amount of zinc in various foods:

Human colostrum (the first secretion from the mammary glands after childbirth) is a good source of zinc. The zinc content of most municipal drinking water is negligible.

Common food sources of zinc are as follows:

Rich sources Beef, liver, oyster, spices, wheat bran.

Good sources Cheddar cheese, crab, lamb, peanut butter, peanuts, popcorn, pork and poultry.

Fair sources Beans, clams, eggs, fish, sausages and luncheon meats, turnip greens, wheat cereals, whole grain products (wheat, rye, oats, rice, barley.)

Negligible sources Beverages, fats and oils, fruits and vegetables, milk, sugar, white bread.

Supplemental sources Wheat germ, yeast (torula), zinc carbonate, zinc gluconate, zinc sulphate. (Zinc carbonate or zinc sulphate is commonly used where zinc supplementation is necessary.)

Table 3.25 Zinc content of food groups on a weight basis and in relation to their protein and energy contents*

Food	mg/kg raw wet weight	mg/gm protein	mg/MJ
Whole grains, wholemeal bread, unpolished rice	30–40	0.2–0.4	2–4
Pulses and legumes	25–35	0.1–0.2	2–3
Rice (polished) corn	10–12	0.2–0.3	1–2
Wheat, low extraction rate	8–10	< 0.1	< 1
Roots, tubers	3–5	0.1–0.2	< 1
Coconut	5	0.1–0.2	< 0.5
Milk	3–5	0.1	1–2
Cheese	30–40	0.2	2–4
Red meat (lean)	40–50	0.2–0.3	8–10
Red meat (fat)	10–15	0.1	< 0.5
Pork (lean)	20–30	0.1	3.5
Pork (fat)	4–5	< 0.1	< 0.5
Chicken	7–20	< 0.1	1–3
Fish	3–5	< 0.1	~1

* Sandstrom, unpublished data.

3.14 ACID-BASE BALANCE

Acid–Base balance is the dynamic state regulation which brings about an equilibrium in hydrogen ion concentration of the body. The arterial blood pH level must be maintained between 7.35–7.45 which is crucial for many physiologic functions and biochemical reactions. The efficient regulatory mechanisms of the kidneys, lungs, and buffering systems enable the body to maintain the blood pH level against the food acids and acids formed during tissue metabolism. An imbalance of the acid–base balance occurs when the body's regulatory capabilities cannot cope up with the load or when the mechanisms become ineffective. These disturbances may be caused by certain diseases such as diabetes, ingestion of toxins, changes in fluid status, and certain medical and surgical treatments. If left untreated, it can result in harmful effects which can even result in death.

□ Some Terms Associated with Acid–Base Balance

1. Osmotic Pressure means the pressure exerted by the cell contents on the cell membrane. The osmotic pressure of the intracellular fluid is a function of potassium in it because potassium is the predominant cation in the intracellular fluid. On the other hand, the osmotic pressure of extracellular fluid is due to its sodium content because sodium is the major cation present in extracellular fluid. Besides, sodium

and potassium ions, chloride and phosphate also influence water balance. Proteins which cannot diffuse because of their size also play an important role in maintaining osmotic equilibrium.

2. Oncotic Pressure or colloidal osmotic pressure, is the pressure at the capillary membrane. It is maintained by dissolved proteins in the plasma and interstitial fluids. It retains water within blood vessels and prevents its leakage from plasma into the interstitial spaces. In conditions of very low plasma protein levels, water from the plasma leaks into the interstitial spaces thus causing oedema.

Osmoles and milliosmoles is the expression of the concentrations of ionic constituents of extracellular or intracellular fluids.

1 mmole = gram molecular weight of a substance

1 mmole dissolved in 1L water = 1 osmole (Osm)

1 mOsm = 1/1000 of Osm

Eg. 1 mmole of NaCl = 2 mOsm

□ Osmolality and Osmolarity

In the steady state (homoeostasis), our total body-water content and salt content remain constant. An increase or decrease in water and salt intake causes an equivalent change in renal water and salt excretion. Homoeostasis is achieved through the process of glomerular filtration of plasma to produce an ultrafiltrate. The tubules then process this ultrafiltrate so that the final urine flow rate and solute excretion meet the homoeostatic needs of the body.

Osmolality and osmolarity are measurements of the solute concentration of a solution and there is negligible difference between the absolute values of the different measurements and, hence, both terms are often used interchangeably.

1. Osmolality It is the estimation of the osmolar concentration of plasma. It is proportional to the number of particles *per kilogram of solvent*; expressed as mOsmol/kg (or mmol/kg). The normal osmolality of extracellular fluid is 280–295 mOsmol/kg.

2. Osmolarity It is the estimation of the osmolar concentration of plasma. It is proportional to the number of particles *per litre of solution*; expressed as mmol/l. It is derived from the measured Na^+ , K^+ , urea and glucose concentrations. It is unreliable in various conditions such as pseudohyponatraemia, hyperlipidaemia in nephrotic syndrome, or hyperproteinaemia.

The following equations can be used to calculate osmolarity:

Calculated osmolarity = $2 (\text{Na}^+) + 2 (\text{K}^+) + \text{Glucose} + \text{Urea}$ (all in mmol/L)

OR

Calculated osmolarity = $2 (\text{Na}^+) + \text{Glucose} + \text{Urea}$ (all in mmol/L)

3. Clinical Importance The osmolality of the ECF is approximately equal to that of the ICF. Therefore, plasma osmolality is a guide to intracellular osmolality. Changes in ECF osmolality have a great effect on ICF osmolality.

- In normal people, increased osmolality in the blood will stimulate secretion of antidiuretic hormone (ADH), resulting in increased water reabsorption, more concentrated urine, and less concentrated blood plasma.
- A low serum osmolality will suppress the release of ADH, resulting in decreased water reabsorption and more concentrated plasma.

Table 3.26 Causes of changes in serum and urine osmolality

Serum osmolality	Urine osmolality	Causes
Normal or increased	Increased	<ul style="list-style-type: none"> • Dehydration • Renal disease and uraemia • Congestive heart failure • Addison's disease • Hypercalcaemia • Diabetes mellitus/hyperglycaemia • Hyponatraemia • Alcohol ingestion • Mannitol therapy
Normal or increased	Decreased	<ul style="list-style-type: none"> • Diabetes insipidus
Decreased	Increased	<ul style="list-style-type: none"> • Syndrome of inappropriate ADH secretion (SIADH)
Decreased	Decreased (with no increase in fluid intake)	<ul style="list-style-type: none"> • Overhydration • Hyponatraemia • Adrenocortical insufficiency • Sodium loss (diuretic or a low-salt diet)

Note: The above table is only indicative. The effect on serum and urine osmolality can vary depending on the individual clinical situation.

Adapted from Guyton, AC; Hall, JE: *Textbook of Medical Physiology*. 12th edition, Elsevier, London, 2010

A gain or loss of water or solute causes an osmolar imbalance.

Osmolality between 235 to 295 mOsm/L = Normal values

Osmolality less than 235 mOsm/L = Excess of water

Osmolality more than 295 mOsm/L = Deficit of water

This balance between the acids and bases of the body on any given day in a normal individual is very intricate. The mechanisms which maintain this balance are efficient in a normal healthy person. However, this is disturbed in some conditions such as:

- Uncontrolled diabetes mellitus which exhibits acidosis,
- Fasting during weight reduction
- During renal failure
- Severe dehydration.

These disturbances are listed in Table 3.27.

Table 3.27 Disturbances in acid-base balance**(A) Respiratory Imbalance****1. Respiratory acidosis**

(Increased carbonic acid)

Conditions when caused:

- Starvation cachexia
- Decreased lung surface area as in COPD or emphysema, asthma
- ARDS (Adult Respiratory Distress Syndrome)
- Restrictive or obstructive lung disease
- Certain neuromuscular diseases
- Obesity hypoventilation syndrome
- Sleep apnoea
- Aspiration of foreign object

2. Respiratory alkalosis

(Decreased carbonic acid)

Conditions when caused:

- Centrally mediated (head injury, pain, cerebro-vascular accident, anxiety, tumours)
- Peripheral stimulation (pneumonia, hypoxemia, high altitudes, pulmonary embolism, congestive heart failure, interstitial lung disease)
- Intense exercise
- Early sepsis

(B) Metabolic Imbalance**1. Metabolic acidosis** (Increased H ion concentration) Fall in pH OR Excessive loss of bicarbonates via the kidneys or intestinal tract*Conditions when caused:*

- Ketoacidosis from uncontrolled diabetes mellitus, lactic acidosis
- Uraemia
- Starvation
- High fat, low-carbohydrate diet
- Drugs
- Toxin ingestion

2. Metabolic alkalosis (Decreased H ion concentration) Rise in pH OR Increased bicarbonates (High blood pH or alkalemia)*Conditions when caused:*

- Excessive loss of acid (e.g. gastric suctioning),
- Use of diuretics
- Increased ingestion of alkali
- Vomiting
- Loss of chloride

Definition of Acid-Base Balance

Acid-base balance refers to the regulation of hydrogen ion concentration of body fluids.

Diet and production of acids and alkalis are closely related. Foods are metabolized by the body and broken down to their metabolic products. Depending on whether their final degradation products are acidic (contributing H⁺ ions) or basic (contributing OH⁻ ions), they may be classified as acid-producing or alkali-producing foods.

The net acidic or basic effect of food can be found by calculating the amount of mineral constituents in the food. The mineral acid and base forming elements are given in Table 3.28.

The evidence of this effect is given by the acidity or alkalinity observed in the body fluids and reflected in the pH of the blood plasma. The pH (H⁺ ion concentration) of normal blood plasma must be within the narrow limits of 7.35–7.45. At pH below and above these figures, the individual is very ill and therapeutic measures must be taken immediately. Generally, a person is able to survive a pH range of 6.8–7.8, at which extremes the person can be said to be ill and should be treated promptly.

Molybdenum (xanthine oxidase), selenium (glutathione peroxidase) and nickel (urease) are also necessary trace elements.

Table 3.28 Acid-forming and base-forming elements

Acid-forming elements	Base-forming elements
Sulphur (SO ₄)	Sodium (Na ⁺)
Phosphorus (PO ₄)	Potassium (K ⁺)
Chlorine (Cl ⁻)	Calcium (Ca ⁺)
	Magnesium (Mg ⁺)
	Iron (Fe ⁺⁺)
Anionic elements	Cationic elements

Certain foods like vegetables, fruits and milk, when metabolized, yield excess cations (Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺) in the body fluid. When excess of cations remains in the body fluid on metabolism of food, the food is said to produce alkaline ash. The excess of cations allow the body to retain more bicarbonate ions and produce an alkaline reaction (alkaline state).

Certain foods like meat, fish, poultry, egg, cheese and cereals, when metabolized, yield excess anions (PO₄⁻, Cl⁻, SO₄⁻) that are not removed from the body immediately. Such foods are said to produce acid ash. The excess of anions (acid state) allows less bicarbonate ions to exist in the body and thus, produce an acidic reaction.

Conversion of bicarbonate ions to carbonic acid increases the acidity. Certain foods with acid taste (sour) and containing free organic acids yield alkaline ash because the anions of the acids are quickly oxidized by the body to carbon dioxide and water, and the excess of cations left behind yield alkaline ash.

Foods such as fats, sugars and starches do not contain mineral elements. These foods, therefore, do not form excess of either cations or anions and thus do not contribute to an acidic or alkaline reaction.

Table 3.30 shows foods which are acid-forming, base-forming and neutral in their reaction.

Table 3.29 Sources, functions and deficiency symptoms of minerals (major and trace)

<i>Mineral</i>	<i>Sources</i>	<i>Functions</i>	<i>Deficiency Symptoms</i>
1. Calcium	Milk, cheese, some dark green leafy vegetables, <i>paan</i> (betel leaf smeared with calcium hydroxide), <i>ragi</i> , <i>chana dal</i> , <i>methi</i> , <i>rajma</i> , soybeans	Normal development and maintenance of strong bones and teeth, clotting of blood, nerve irritability, normal muscle activity; activates enzymes	Retarded growth, poor tooth and bone formation, rickets, slow clotting time of blood, tetany
2. Chlorine	Salt, meat, milk eggs	Osmosis, fluid balance, acid-base balance, formation of hydrochloric acid	Very rare but may occur after prolonged vomiting, nausea and exhaustion
3. Cobalt (trace)	Supplied vitamin B ₁₂	A component of vitamin B ₁₂ ; necessary for the formation of RBC	Unknown
4. Copper (trace)	Liver, legumes, kidney, nuts, brain, raisins, cocoa	Essential for the formation of haemoglobin and melanin. Component of enzymes.	Anaemia (see Iron)
5. Fluorine (trace)	Fluorinated water	Increased resistance to tooth decay	Tooth decay
6. Iodine (trace)	Salt water fish. Foods grown in soil bordering salt water, iodized salt	Formation of hormones in thyroid gland (thyroxine)	Simple goitre; if severe, cretinism.
7. Iron (trace)	Liver and other organ meats, muscle meats, legumes, dried fruits, egg-yolk, whole-grain and enriched breads and cereals, dark green and leafy vegetables, potatoes	Essential for formation of haemoglobin of the red blood cells	Anaemia characterized by weakness, dizziness, loss of weight, and pallor
8. Magnesium	Meat, nuts, milk, seafood, cereal grains, fresh green vegetables, legumes rich in sulphur-containing amino acids	Constituent of bones, necessary for healthy muscles and nerves, metabolism of carbohydrates by activation of enzymes	Unusual heart action, mental, emotional and muscle disorders
9. Manganese (trace)	Whole-grains, legumes, nuts, tea	Component of enzymes required for glucose utilization	Unknown
10. Phosphorus	Milk and cheese, egg-yolk, meat, poultry, fish, whole-grain cereals, legumes, nuts	Normal development and maintenance of strong bones and teeth, cell activity; maintenance of normal acid-base balance, normal muscle activity, metabolism of carbohydrates and fats	Retarded growth, poor tooth and bone formation, rickets, weakness, anorexia. pain in bones (symptoms are rare)
11. Potassium	Meat, poultry, whole-grain cereals, leafy vegetables, legumes, oranges, bananas, prunes	Osmosis, fluid balance, acid-base balance, regular heart rhythm, regulation of nerve impulse conduction, cell metabolism	Muscle weakness, apathy, abnormal heartbeat
12. Sodium	Salt, meat, poultry, fish, eggs, milk, pickles and chutneys, processed foods	Fluid balance, acid-base balance, osmosis; regulates muscle and nerve irritability	Nausea, diarrhoea, exhaustion, muscle cramps, abdominal cramps
13. Sulphur	Protein food rich in sulphur containing amino acids, eggs, meat, fish, poultry, milk, cheese, nuts	Helps growth of hair, nails and body tissues	Unknown
14. Zinc (trace)	Seafood, oysters, liver, meat, eggs, milk	Components of insulin and enzymes; wound-healing	Thought to be dwarfism, hypogonadism, anaemia

Table 3.30 Reaction of foods

<i>Acid-forming</i>	<i>Alkali-forming</i>	<i>Neutral</i>
Bread	All fruits	Butter
Cereals (all except <i>ragi</i>)	Milk	Coffee
Cheese	Molasses	Cooking fats
Corn	Nuts:	Cream
Eggs	Almond	Starch
Fish	Coconut	Sugars
Lentils	Charoli	Syrup
Mayonnaise	Vegetables, except corn.	Tapioca
Meat	Pulses, except lentil and	Tea
Nuts:	roasted peas.	
Brazil	Leafy vegetables	
Peanuts		
Walnuts		
Carrots		
Poultry		
Cauliflower		
Knol-khol		
Peas		
Red-gram (tender)		

3.15 NON-NUTRIENT COMPONENTS OF FOODS AND THEIR IMPORTANCE

In nature several natural substances occur which determine the overall quality of the food. Several of these compounds are designed by nature to protect the plants against external predators. These substances may have pharmacological properties or may have non-nutritional factors or toxins that affect the overall nutritional content of the food. It is, therefore, important to consider the health impact of these substances in diets based on natural foods.

□ Anti-nutritional Factors

These interfere with the assimilation of nutrients like protein, iron, zinc, calcium and iodine. They include trypsin inhibitors, phytates, oxalates, tannins, lectins and goitrogens.

□ Trypsin Inhibitors

These are proteins widely distributed in foods like legumes, egg white, soyabean, lima bean, kidney bean and duck egg white. However, the trypsin inhibitors in the former two foods are easily inactivated by autoclaving at 120°C for 15 to 30 mins. However, more drastic heat treatment is needed to inhibit the inhibitors in soya,

lima and kidney beans as well as duck egg white. Once the trypsin inhibitors are inactivated the utilization of protein in that food improves considerably. Foods contain other protease inhibitors but they do not pose a nutritional hazard.

□ **Phytates**

Chemically, phytates are hexaphosphate compounds of inositol. They are widely distributed in seeds, the richest source being unrefined cereals and millets. For the germinating seeds they act as a source of phosphorus. They bind iron, zinc, calcium and magnesium. They form insoluble complexes with iron in the presence of calcium and magnesium thereby adversely affecting the absorption of iron in cereal based diets. The phytate content of unrefined cereals is more than its refined counterpart. However, on germination of the grains, the phytate content falls down due to enzymatic breakdown of phytate.

□ **Tannins**

These are condensed polyphenolic compounds widely distributed in plants. Foods rich in tannins are the seed coat of most legumes, spices, tamarind, turmeric, certain vegetables and fruits. Millets like *bajra*, *ragi* and sorghum also contain a fair amount of tannin. Tannins bind with iron, forming compounds which are not absorbed in the gut. A typical vegetarian diet based on cereals, legumes, vegetables and spices contains 2 to 3 g of tannin. Besides this, tea also contributes to the dietaries of Indians, who as we all know are avid tea drinkers. In order to reduce the tannin content of the diet, legumes must be consumed after removing the seed coat, while intake of tamarind and turmeric (and of course tea) must be minimised in the diet. Tannins are also known to bind proteins and reduce their availability. This is a food for thought for nutritionists in planning good vegetarian diets.

□ **Oxalates**

Oxalic acid, a dicarboxylic acid or its salts (oxalates) are widely distributed in plant foods generally as calcium salts. DGLV, green vegetables and some legumes are rich sources of oxalates. The highest oxalate content is found in horsegram and *kesari dal*. Oxalates interfere with calcium salts by forming insoluble calcium salts. Dietary oxalates can be absorbed and contribute to increased excretion of oxalates in the urine, which may predispose the person to oxalate urinary stones.

□ **Goitrogens (Anti-thyroid Substances)**

These substances are found in plant foods especially in the leaves of Brassica genus and family cruciferae such as cabbage, cauliflower, rape leaves, radish, rapeseed (mustard), water cress, broccoli, brussel sprouts, turnips, etc. Soyabean and other legumes, *bajra*, peanut, lentils, common bean also contain goitrogens.

Chemically they are thiocyanate, iso-thiocyanate and their derivatives like chemline (glycoside of 3-methyl-sulphonyl propyl isothiocyanate, glucoinolates, etc.) and interfere with the uptake of iodine by the thyroid gland. They may predispose a person to suffer from goitre especially if the intake of iodine is marginal.

□ Other Toxic Agents

Kesari dal (*Lathyrus sativus*), Broad beans (*Vicia faba*) and cassava contain toxic substances but these can be made safe for consumption by appropriate heat treatments, e.g. the toxic amino acid (BOAA) from khesari dal can be removed by using a process similar to that of parboiling paddy. Similarly cyanogenic glycosides of cassava can be leached out with water.

□ Other Xenobiotics

This term is used for compounds which impart flavour or taste or may have pharmacological activity. They are normally metabolised and disposed off by the body. However, some xenobiotics have been found to be potential carcinogenics.

3.16 PHYTOCHEMICALS

Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. There are more than thousand known phytochemicals. It is well-known that a plant produces these chemicals to protect itself but recent research demonstrates that they can protect humans against diseases. Some of the well-known phytochemicals are lycopene in tomatoes, isoflavones in soy and flavonoids in fruits. They are not essential nutrients and not required by the human body for sustaining life.

□ Functions of Phytochemicals

There are many phytochemicals and each works differently. These function as the following:

1. Antioxidant Most phytochemicals have antioxidant activity and protect our cells against oxidative damage and reduce the risk of developing certain types of cancer. Phytochemicals with antioxidant activity: allyl sulfides (onions, leeks, garlic), carotenoids (fruits, carrots), flavonoids (fruits, vegetables), polyphenols (tea, grapes).

2. Hormonal Action Isoflavones, found in soy, imitate human estrogens and help to reduce menopausal symptoms and osteoporosis.

3. Stimulation of Enzymes Indoles, which are found in cabbages, stimulate enzymes that make the estrogen less effective and could reduce the risk for breast cancer. Other phytochemicals which interfere with enzymes are protease inhibitors (soy and beans), terpenes (citrus fruits and cherries).

4. Interference with DNA Replication Saponins found in beans interfere with the replication of cell DNA, thereby, preventing the multiplication of cancer cells. Capsaicin, found in hot peppers, protects DNA from carcinogens.

5. Anti-bacterial Effect The phytochemical allicin from garlic has anti-bacterial properties.

6. Physical Action Some phytochemicals bind physically to cell walls thereby, preventing the adhesion of pathogens to human cell walls. Proanthocyanidins are responsible for the anti-adhesion properties of cranberry. Consumption of cranberries will reduce the risk of urinary tract infections and will improve dental health.

□ Sources of Phytochemicals

Foods containing phytochemicals are already part of our daily diet. In fact, most foods contain phytochemicals except for some refined foods such as sugar or alcohol. Some foods, such as whole grains, vegetables, beans, fruits and herbs, contain many phytochemicals. The easiest way to get more phytochemicals is to eat more fruits (strawberries, blueberries, cranberries, cherries, apple) and vegetables (cauliflower, cabbage, carrots). It is recommended that we should take daily at least 5 to 6 servings of fruits or vegetables. Fruits and vegetables are also rich in minerals, vitamins and fibre and low in saturated fat.

□ List of Phytochemicals

Alkaloids

- Caffeine
- Theobromine
- Theophylline

Anthocyanins

- Cyanidin
- Malvidin

Carotenoids

- Beta-Carotene
- Lutein
- Lycopene

Coumestans

Flavan-3-Ols

Flavonoids

- Epicatechin
- Hesperidin
- Isorhamnetin
- Kaempferol
- Naringin
- Nobiletin
- Proanthocyanidins
- Quercetin
- Resveratrol
- Rutin
- Tangeretin

Hydroxycinnamic Acids

- Chicoric acid
- Coumarin

- Ferulic acid
- Scopoletin

Isoflavones

- Daidzein
- Genistein

Lignans

- Silymarin

Monophenols

- Hydroxytyrosol

Monoterpenes

- Geraniol
- Limonene

Organosulphides

- Allicin
- Glutathione
- Indole-3-Carbinol
- Isothiocyanates
- Sulforaphane

Other Phytochemicals

- Damnanthal
- Digoxin
- Phytic acid

Phenolic Acids

- Capsaicin
- Ellagic Acid
- Gallic acid

- Rosmarinic acid
- Tannic Acid

Phytosterols

- Beta-Sitosterol
- Saponins

Triterpenoids

- Ursolic acid

Xanthophylls

- Astaxanthin
- Beta-Cryptoxanthin

□ Some Common Plants Containing Phytochemicals

Vegetables

- Broccoli
- Fennel
- Garlic
- Tomato

- Opium Poppy
- Passion Fruit
- Periwinkle
- Wintergreen

Fruits and Nuts

- Acai
- Almond
- Blueberry
- Black Raspberry
- Blackberry
- Blackcurrant
- Cranberry
- Grape
- Mangosteen
- Olive
- Orange
- Pomegranate
- Red Raspberry

Common Herbs

- Aloe vera
- American Ginseng
- Dandelion
- Hop
- Indian Cress
- Korean Ginseng
- Lemon Balm
- Lemon Verbena
- Marigold
- Milk Thistle
- Red clover
- Rosemary
- Sage
- Tea

Medicinal Plants

- Ginkgo
- Goat's Rue
- Soyabean

Beans

- Cocoa

3.17 NUTRACEUTICALS

The earlier belief for optimal health—food should be safe containing macronutrients and micronutrients—is now replaced by the fact that it is necessary to examine the role of diet, especially its non-nutritive components in reducing chronic diseases. In India, we have been blessed with *Ayurveda*, *Unani* and such traditional medicines which were the backbone of medical practice and primary health care before the advent of allopathy. But, it appears that we have lost our faith in this traditional form of prevention and cure which was earlier known to every mother and grandmother in India. India has also been blessed with a wealth of herbs and spices, and their use needs to be optimised in maintaining the overall health of the population.

Like *Ayurveda*, there are Traditional Chinese Medicines (TCM), Tibetan herbal

medicines, Japanese herbal medicines (Kampo), Indonesian traditional medicines (Jamu), etc. which have been using traditional forms of medicine.

More importantly, the geriatric population is on the rise, and to prevent the health care facilities from buckling under pressure, it is necessary to use the beneficial effects of these forms of medicines to help prevent diseases rather than cure them. As the old adage goes—"prevention is better than cure".

The new wave of diet-based disease prevention is on the rise and hence, some knowledge of this new front of nutrition is necessary.

The earlier term for these foods was "functional foods". Then, it was termed as "designer foods" to describe foods which naturally contain or are enriched with non-nutritive biologically active chemical components of plants (phytochemicals) that are effective in reducing cancer risk. In 1989, Dr Stephen DeFelice coined the term "Nutraceutical" to refer to any substance that may be considered as food or part of a food and provides medical or health benefits, including the prevention and treatment of diseases. Since 1989, this field has been evolving rapidly as well as the terms used to describe it, namely, pharmafoods, phytofoods, phytogenic substances, performance foods, smart foods, therapeutic foods, genetically engineered foods, genomic foods and phytochemical sources.



A definition published by the Institute of Medicine in "Opportunities in the Nutrition and Food Sciences" states "functional foods" as "those that encompass potentially healthful products" including "any modified food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains."

The recent interest in this field is mainly due to the fact that the **diet is implicated as an important factor** in death, due to several diseases like diabetes mellitus,

cardiovascular diseases, cancer, liver diseases, etc. Secondly, it is found to be a factor that can prevent certain diseases which may not be fatal but are disabling diseases. Thus, the preventive aspect has gained so much importance that pharmaceuticals are now pledging their faith in nutraceuticals and have intensified their research in the field of physiologically functional foods for health promotion. Thirdly, the recent technological advances in the food industry have made it possible for functional foods to evolve.

Any health claim being made on the label (written or picture representation) should be well understood by the consumer. If not, it may be categorised as a “misinformation” or “misbranding”.

The US FDA has permitted health claims for food labelling in 7 out of 10 areas, e.g. calcium and osteoporosis, sodium and hypertension, saturated fat, cholesterol and CHD, to name a few.

The field of functional foods is vast, and if regulated and well researched in conjunction with consumer education and nutrition labelling, it can

1. Encourage product innovations
2. Help consumers in selecting foods that can lead to healthier diets
3. Eliminate consumer confusion
4. Protect consumers from unfounded, imaginary health claims.

In the long run, functional foods are bound to have a profound effect on the food industry since R and D of functional foods will be a central issue. There are several grey areas since labelling of foods and drugs are governed by different rules and regulations. Since nutritional foods are not drugs and yet make health claims, its category needs to be affirmed. Many foods such as garlic, turmeric, pepper, ginger, coriander, honey, and fenugreek have been used in India as medicine for ages to alleviate some common complaints. The consumer should have a certain level of education in order to read and understand the label, which means the level of literacy is important. After all, one of the purpose of a nutritional label is to enable the consumer to make an informed choice.

In some South-east Asian countries, functional foods are perceived as an alternative to drug therapy. There are certain classes of ingredients which are considered physiologically functional and are categorised as Foods for Specialised Health Use. This has led to a flood of functional foods in the market and R and D in a few hundred companies! In some European countries, marketing exclusivity for making health claims is granted on the basis of proprietary research. This provides an incentive for the private sector to invest in functional foods research and development.

The field of biotechnology has been expanding to achieve advances in genetic engineering to obtain technically improved foods (e.g. improved fruit ripening) as well as to develop a wide variety of agronomic effects (e.g. enhanced yields). Transgenic plants are being used as human food. These techniques are useful for mankind but food safety is of primary concern. Hence, it is of importance to use substances at the optimum levels and not allow them to be a cause of toxicity.

Impact of health claims can be tremendous for the product sales volume. This has been evident in the marketing of Kellogg's All-Bran breakfast cereal or the increased demand for oat-bran cereals. These are just a few examples of the economic need to focus on functional foods.

In future, there may be an alliance between food and pharmaceutical companies to

capitalise on the potential, beneficial actions of food ingredients, in developing new product concepts which will eventually benefit the health of the consumer.

Note: For additional reading, please refer **Nutrition Labeling Handbook**, edited by Ralph Shapiro, Marcel Dekker Inc., 1995, New York.



SUMMARY

In this chapter, some details of all the nutrients recommended by ICMR, 1981 and 1988 and 2010 have been given. An understanding of their chemistry, types, functions, deficiency symptoms and sources will enable the reader to gauge their importance in the maintenance of good health.



CASE STUDIES

- I** Mrs B is a non-vegetarian. Recently, she has come across several articles regarding the benefits of a vegetarian diet. She wants to know:
1. The advantages and disadvantages of a vegetarian and non-vegetarian diet.
 2. How she can get the best of both the dietary regimes.
- II** Mrs K is worried about her teenage daughter who has been crash dieting and recently diagnosed with iron deficiency. What will you advise Mrs K about:
1. Important nutrient requirements for teenage girls.
 2. Requisite knowledge regarding crash dieting.
- III** Mr H is an extremely health-conscious executive and likes to use a lot of multi-vitamin supplements.
1. How will you convince him to make use of dietary sources rather than artificial supplements.
 2. Make a list of at least 5 foods rich in each of these B-vitamins—B₁, B₂, B₃, folic acid and B₁₂.
- IV** Mr D is a marketing executive and has experienced repeated bouts of dehydration in recent months.
1. What will you advise him about sources of water apart from water?
 2. Give him hints to recognise the symptoms of dehydration.



REVIEW QUESTIONS

1. Define carbohydrates, fats, proteins, vitamins, fibre, minerals, and acid-base balance.
2. List and explain the functions of carbohydrates, fats, proteins, fat-soluble vitamins A, D, E, K, water-soluble vitamins of the B-complex group, vitamin C, minerals.
3. Differentiate between fat-soluble vitamins and water-soluble vitamins.
4. Which are acid-forming elements and base-forming elements?
5. What are the best food sources of carbohydrates, fats, proteins, vitamins A,

- D, E, K, vitamins B₁, B₂, B₃, folic acid, B₁₂, B₆, and pantothenic acid, iron, iodine, calcium and phosphorus?
6. What are the co-enzymes of B₁, B₂, B₃, folic acid?
 7. Which are the precursors of vitamin A, D, niacin?
 8. Write the steps showing the role of calcium in the formation of fibrin (the blood clot).
 9. Which foods are acid-forming in the body?
 10. Which foods are alkali-forming in the body?

Chapter

4



Menu Planning and Meal Preparation

Planning the menu is the most important aspect of a nutritious diet. The home-maker has to maintain variety in the diet, taking into consideration the nutritional needs of her family as well as individual likes and dislikes of specific foods. Such a plan requires skilful balance in order to promote good health.

4.1 DEVELOPING GOOD EATING HABITS

Developing good eating habits benefits a person in the long run. Our selection of food is a reflection of our habits which we have acquired over a long period of time. Our food habits are influenced by our cultural background, religious beliefs, social norms, our geographical location, and the availability of particular food items.

Customs within individual communities also influence our *likes* and *dislikes*, certain *accepted* and *contra-indicated* foods and certain *eating habits*. Many dietary habits of an individual can be traced to the association of such foods with *pleasant* or *unpleasant* experiences in childhood. The emotional and psychological needs of a person greatly influence his choice of food. Unfortunately, our physiological needs influence the least. Our dietary patterns do not always match our physiological requirements.

In India we find both vegetarians and non-vegetarians.

A vegetarian diet includes the use of dairy products, fruits, vegetables, cereals and cereal products. All animal food sources are rejected. The egg too is not eaten by many strict vegetarians. However, egg in the concealed forms as in cakes may be eaten. Jains are a vegetarian community who besides not consuming eggs, do not allow the use of all root vegetables, onion and garlic. They restrict the use of anything that grows below the level of soil. However, their diet can also be very fulfilling if items permitted in their religion are included in the right proportions everyday.

The non-vegetarian diet includes animal foods, fruits and vegetables and cereals and cereal products, and also dairy products. However, many people do not consume sufficient fruits and vegetables along with animal foods.

Good food habits can be developed. The environment plays an important part in determining what a person is and will be. Food, therefore, influences the social and emotional growth as well as the chemical and physical growth of a person.

A child's appetite determines the volume of food that a child eats. The appetite, in turn, is influenced by several factors like pleasant experiences with food, healthy atmosphere, hunger, satisfaction and physical well-being. A tired child, although hungry, may not eat with his own hands but if fed he may eat to his satisfaction.

A child imitates the food habits of those around him. If persons around the child eat all that is served to them and do not strongly exhibit their likes and dislikes then the child too eats everything. If most vegetables, fruits, cereals and *dals* are introduced to him in the first year of life, he develops a taste for a wide range of products. It should be remembered by parents that no food should be used as a reward or bribe to the child. Similarly, no food should be withheld as a punishment.

Meal times should not be used to discipline the child. Encourage the child to eat as much with his own hands as possible. He will learn to enjoy food as well as eat as much as he needs. However, the parent must know when the child is too ill, or too tired to eat by himself and needs to be fed. Also, if the child tries to play with his food, it should be casually removed.

Do not mix medications with the meal, or do not give medicines forcibly before or after the meal. Such unpleasant association mars one's appetite. Regularity in meals is a must. So also, hot foods must be served hot and cold foods cold. Extremes of temperatures should be avoided as far as possible.

4.2 FOOD MISINFORMATION

Certain foods and fallacies prevail in our country; for example, milk should not be eaten with fish and meat. The concept of *hot* and *cold* foods is engraved in our minds. All flesh foods and eggs are termed as hot while milk and curds are termed cold.

Certain foods are not given to the young child. Pregnancy is accompanied by several restrictions and taboos about eating foods. Pickles, eggs, puddings prepared with the colostrum of animals (*kharvas*), etc. are generally not eaten by an expectant mother. These and many fallacies about foods restrict their use as well as unnecessarily cause avoidance of nutritious ones. However, the effect of these on any individual should be evaluated and the fad or fallacy borne out by individual experience.

Most of the social customs and religious functions in our country are associated with food. It is a custom to distribute *mithai* or sweetmeats on any auspicious occasion. Meals for guests in marriages and other such functions are generally heavily-spiced, oily and may contain one or more sweets. This attitude towards food greatly influences our eating habits and hence, many people are *sweet-toothed*. The attitude of one's parents towards food influences the eating habits of one's children. The parents unknowingly transfer their likes and dislikes to their children by exhibiting them very strongly in front of them.

4.3 SNACKS

In today's world, the pace of life is fast and it has become virtually impossible to follow the three or four meal pattern that was traditionally accepted. Now the emphasis has shifted to include more *snacks* in the meal pattern. It has been found to be more convenient to prepare a snack which can at least partially meet the nutritional needs of the family.

It does not matter *when* one eats. It is more important to consider what one eats and *how much*. It is beneficial to have a snack time. Some people find it better than the three-meal pattern because that is the best way to receive adequate calories and

nutrients by eating more often. Children and adolescents who seem to be *always hungry* can satisfy their appetite by eating nutritious snacks. Children who have small appetites may eat more often by way of snacks, thereby meeting their physical needs.

However, as a general rule, snacks should not replace *breakfast*, which is the first and the most important meal of the day.

□ Selection of a Snack

No snack can be a perfect one. However, some snacks are more nutritious than others. A snack should be selected and planned according to the needs of the family.

It should be nutritious, supplying as many nutrients as it can. The timing of the snack should be such that it should be eaten when needed most, e.g. children returning home from school may be so hungry that potato wafers, chocolates or *chiwda* may be nibbled in order to satisfy their hunger. If a plate full of snacks is at hand, they would willingly eat them. Hence, planned intake of snacks can be an effective means of meeting the energy and nutrient needs of a growing and active child.

Most snack foods are high in energy value but contain little protein, vitamins or minerals. Table 4.1 illustrates the nutritive value of snacks. Most fruits make an excellent snack, such as a banana or an apple. A fruit yoghurt is cooling and refreshing like the fruit milk shakes.

□ Fast Foods

Nowadays, several small wholesome meals are eaten by teenagers. *Pizzas*, hamburgers, noodles are some of the western fast foods which have become popular in the metropolitan cities of our country. However, we are not new to the concept of fast foods. *Idlis*, *dosas*, *meduwadas*, *chaats* were always served in our restaurants. *Wadapav* is the latest and cheapest fast food available on our streets. Fast food can be considered to be nutritious food. It should be cautioned here that fast food should be eaten only once in a while. If not supplemented with a balanced diet, they could prove to be recipes for disaster. A fast food can never replace a good, wholesome meal.

Many people in the urban areas prefer *fast food* since it is a relatively low-cost food purchased at an outlet which gives quick service and, is convenient. Fast food, many a time referred to as *junk food*, makes an important contribution to the nutrient requirement, e.g. a cheese or chicken burger with a little lettuce, tomatoes and onions, if eaten along with some french fries and a milk shake, is nutritionally as adequate as a meal.

□ Nutrients Supplied by Snacks and Fast Foods

1. Proteins Fast foods supply good amounts of protein if prepared using animal sources such as fish, beef, chicken, cheese and milk, or in a cereal—pulse combination as in *idli* or *dosa*.

2. Fat Some of the major components of fast foods, like beef, cheese, mayonnaise and deep-fat frying, causes the foods to be a rich source of fat. People who are on a reducing diet need to avoid such foods.

Table 4.1 Nutritive value of snacks

S. No.	Snack	One Serving Size	Calorie Value (kcal)	Protein (gram)
1.	<i>Chiwda</i> (puffed rice and peanuts)	3/4 cup	154	3.7
2.	<i>Batatawada</i>	2 medium	190	4.0
3.	<i>Chiwda</i> (rice flakes and peanuts)	3/4 cup	210	4.3
4.	<i>Batata pohe</i>	3/4 cup	170	2.3
5.	Potato chips	10 pieces	100	—
6.	Vegetable sandwich	2 pieces	150	3.2
7.	Cheese sandwich	2 pieces	230	9.3
8.	Egg sandwich	2 pieces	230	9.8
9.	Plain <i>dosa</i>	1 dosa	210	5.6
10.	<i>Medu wada</i>	2 medium	200	5.0
11.	<i>Uttappam</i>	1 medium	205	5.5
12.	<i>Potato bhajia</i>	5 medium	210	6.3
13.	Fruit yoghurt	1 medium cup	150	3.0
14.	Plain yoghurt (Dahi or curd)	1/2 cup	85	4.3
15.	Apple	1 medium	60	—
16.	Banana	1 medium	120	1.2
17.	Misal	3/4 medium cup	215	10.2
18.	Fruit milkshake	1 medium glass	150	3.0
19.	<i>Chana usal</i>	3/4 bowl	220	6.6
20.	Groundnut <i>chikki</i>	4 pieces 2" × 2"	290	7.0
21.	<i>Rava upma</i>	3/4 cup	150	2.5
22.	<i>Rava sheera</i> (using milk)	3/4 cup	280	4.6
23.	<i>Sabudana khichdi</i>	3/4 cup	310	4.3
24.	<i>Dahiwada</i>	2 medium	200	6.4
25.	<i>Sukhadai</i>	2 pieces 2" × 2"	159	1.5

3. Carbohydrates and Fibre Carbohydrates are found in some of the foods like soft drinks, shakes, fried foods, etc. However, the fibre content of most fast foods is low except when green vegetables, tomatoes, carrots, cucumber, onions, etc. are added to them.

4. Calories The calorie value of snacks and fast food is generally very high.

5. Vitamins Most fast-food meals provide adequate amounts of vitamins, mainly thiamine, riboflavin, niacin, pyridoxine and cyanocobalamin. Vitamin A is relatively low except in foods where use of carrots, dark green leafy vegetables, and tomatoes is in abundance.

6. Minerals Most shakes and milks are high in calcium and phosphorus. Hamburgers prepared with meat are a good source of iron. However, sodium is found in very high amounts in salted fast foods such as chips, french fries, etc. Therefore, people advised to lower their salt intake should eat such fast foods sparingly.

One of the main drawbacks of a fast-food restaurant is its lack of variety. This is especially so for people who frequently visit them. It may, therefore, be best to incorporate balanced meals with food eaten at fast food outlets. This will assure an adequate nutrient intake.

Fast foods also contain several synthetic additives such as preservatives, artificial colours, artificial sweeteners, which if consumed over a long period of time, can be harmful. Also, fast foods cost about twice as much as when prepared at home. For more information on ‘Fast Foods’ refer Chapter 19 on ‘Foods Commodities.’

4.4 FAST-FOOD CONSUMPTION AND ITS IMPACT ON HEALTH

A “fast food” can be defined as “food that can be prepared quickly and easily and is sold in restaurants and snack bars as a quick meal or to be taken out.”

There have been substantial increases in mean body weight in wealthy countries and even developing countries. These changes have been accompanied by dramatic transformations in people’s dietary patterns, most importantly, an increase in the consumption of ultra-processed foods, including fast foods.

Although some feel that fast-food consumption has played a negligible role in the obesity epidemic, several studies have shown that it is actually the opposite.

It has been seen that persons who visited fast-food restaurants more than twice a week, gained significant weight in the long run. Significant associations have been found between the density of fast-food restaurants and obesity in certain areas.

Increased findings suggest strong association between soft-drink consumption and higher rates of overweightness and obesity.

Some studies show that the spread of fast food and obesity is co-related with several factors such as the following:

- Trade liberalization and foreign investment in the food-and-beverage industries have resulted in the proliferation of large transnational food companies.
- High-income countries with market-liberal welfare regimes have easier access to fast food.

However, a reassuring factor is that regulations in the agricultural sector are negatively correlated with obesity.

In the US, the availability and consumption of fast foods is much more compared to our country. The observations of one study indicate that almost 30% of children in the age group of 4 to 19 years consume fast food. Due to this, their consumption of total calories, total fat, total carbohydrates, and added sugars is far more than their recommended dietary intakes. On the other hand, their intake of total fibre, milk, fruits and non-starch vegetables is to a very great extent, low. It is, thus, not surprising that the problem of overweight, obesity and associated non-communicable diseases is on the rise.

In India, aping the west in the consumption of fast foods is bound to have similar outcomes.

Reference

1. "Effects of Fast-Food Consumption on Energy Intake and Diet Quality among Children in a National Household Survey" Shanthy A. Bowman, Steven L. Gortmaker, Cara B. Ebbeling, Mark A. Pereira, David S. Ludwig; *Pediatrics*, Vol. 113, No. 1, pp. 112–118, Jan 1, 2004.

A study by WHO was carried out using the number of per-capita fast-food transactions (local and transnational) in order to test the hypothesis that rising fast-food consumption has been a major determinant of population increases in Body MIndex (BMI) among high-income countries belonging to the Organization for Economic Co-operation and Development (OECD). They also examined whether market deregulation may have contributed to higher BMI by facilitating the spread of fast food.

The study provides novel findings on the association between fast-food consumption and mean population BMI and on the influence of market deregulation as a contributor to higher fast-food consumption and BMI. The WHO study has important implications for policy. *In particular, the findings suggest that government regulations hindering the spread of fast-food consumption might help mitigate the obesity epidemic.* It also found that nations that have adopted more stringent market regulations have experienced slower increases in both. The WHO study points the way for more research to confirm whether deregulation is a significant contributor to body weight and to determine what types of government interventions could mitigate the obesity epidemic and curb the spread of transnational fast-food companies.

Reference

2. "The Influence of Market Deregulation on Fast-food Consumption and Body Mass Index: A Cross-national Time Series Analysis" Roberto De Vogli, Anne Kouvolanen, David Gimeno *Bulletin of the World Health Organization*, 2014; 92:99–107A

doi:<http://dx.doi.org/10.2471/BLT.13.120287>

4.5 MENU PLANNING FOR THE FAMILY

Implementation of the principles of nutrition in one's daily diet in an appetizing way is *menu planning*. It is necessary to plan foods needed daily by the family properly in order to ensure good nutrition. A meal plan proves to be a time, energy and money saver. It also avoids unwanted, unappetizing and unsatisfying meals. It is more important to plan the meals for a family with a low budget to ensure sufficient and nutritionally balanced food in order to make the best utilization of the available money resources.

Any meal plan needs to be *flexible* enough to take into account changes due to price fluctuations, seasonal foods, family tastes and desires, holidays, fasts, special family functions and guests.

Every member of the family requires the same basic foods. However, the quantity and texture may have to be altered in case of children and old members of the family.

Milk is required in larger amounts by children than adults. However, children require smaller quantities of foods than adults. Very young children may require smaller servings and also a change in the method of preparation, e.g. spices and oil may be restricted in foods to be served to small children. Weight watchers in the family need the same basic foods but some modifications in the foods such as use of skim milk instead of whole milk, trimmed meat (fat is removed), use of broiling, steaming and roasting rather than deep frying, use of more fresh fruits and raw vegetables than sweets and desserts.

Similar changes in the family meal may be made when any member of the family is under therapeutic control of a disease such as diabetes, high blood pressure, etc.

Good meal planning is both a science and an art. *Science* shows us the way to include nutritious foods in the diet, while *art* is involved in combining the needed nutritious foods into meals that are attractive, appetizing and satisfying in all ways.

Following are some of the factors which should be considered when planning meals for the family.

1. Include foods from all the *basic five food groups* every day.
2. Each meal should have at least three of the five basic food groups. Besides these a good source of protein should be included in every meal (one serving from the protein-rich group).
3. Variety in appearance of food.
 - *Colour* Should be attractive and appealing. Avoid a menu of all white or neutral coloured foods.
 - *Texture* Use contrasting textures such as soft foods and crisp foods.
 - *Flavour* Both types of flavours, bland and spicy, should be well blended.
 - *Shape* Different shapes in a dish make it more attractive. Round, flat, shredded, sliced or diced, cubes, spheres are the different shapes that may be used.
 - *Satiety value* A meal should be satisfying. Fat and protein have a higher satiety value than carbohydrates.
 - *Variety of foods* Including all foods rich in proteins or carbohydrates or fats is monotonous. A combination of carbohydrates and protein food interspersed with fat add variety. Emphasis should be equally placed on all foods. The greater the variety of foods used from day-to-day, the better it is for health. The foods served may be cooked using different methods such as boiling, broiling, roasting, frying, baking, stewing, etc. to add variety to a meal. Raw salads increase visual appeal.
4. *Sociological preference* They include religious and social customs. These influence the food that is eaten on *fast* days. It may be necessary to alter the plan on such days and use appropriate substitutes.
5. *Personal preference* Old people cannot eat hard foods that involve a lot of chewing (mastication). Very young children cannot tolerate highly spiced and oily foods. A diabetic person cannot eat concentrated carbohydrate foods. But the menu that is planned for such a family should give them all the required nutrients.

6. *Time and Energy* These are factors of prime importance to the working woman. Not only does she have limited time for cooking at her disposal but her energy is used up in both places—at home and at the place of work. Efficient organization on her part can help to balance between the two. Not only the working woman but even the housewife needs to save time and energy since, she too may have some hobbies and social activities. It is not necessary to spend the whole day or most of the time in the kitchen to prepare balanced meals. She has, therefore, to plan simple, easy-to-prepare yet tasty and nutritious items.
7. *Appearance* The general appearance of the food that is served whets or kills one's appetite. A clean plate in clean surroundings is pleasant. A dish placed on a table where a lot of food has been split or which is cluttered with utensils is certainly not a pleasant sight for the eater, especially one with an aesthetic sense.
8. *Economical use of fuel* It is necessary to save time and the amount of fuel that is consumed. Elaborate cooking methods and long-winded recipes use up a lot of fuel. Maximum use of the pressure-cooker saves not only the fuel but a lot of nutrients.
9. *Food costs* People generally spend a lot of money on food and its preparation. It cannot be definitely stated that a specific amount of money should be spent on food but roughly the following division of expenditure on food may work as a guideline.
 - 25 percent on meat, fish, eggs, cheese, poultry, legumes and pulses.
 - 20 percent on milk.
 - 20 percent on fruits and vegetables.
 - 20 percent on cereals, breads and biscuits.
 - 15 percent on fats and sweets.

If storage space is available in the house, one can store food-items like rice, wheat, *dals*, oils, sugar and jaggery during the seasons in which they are available in plenty and at relatively lower cost than in the off-season.

A refrigerator can lower wastage and thereby decrease the cost of meals. Leftover food may be slightly modified to be used as new dishes.

In India, the urban family has one major meal, i.e. dinner. Breakfast is taken in a hurry and most members of the family carry packed lunch to work. After coming home in the evening, a cup of tea or coffee is accompanied by light snacks like savoury biscuits. Dinner is the meal at which all members of the family join together. Therefore, more stress is to be laid on dinner to supply the necessary nutrients to the family members according to their requirements.

Careful planning is necessary for the other meals too. A typical meal pattern usually followed by an urban family is shown in Table 4.2.

A non-vegetarian family may substitute *dal* with fish or meat sometimes but generally on weekends a fully non-vegetarian diet accompanied with salads may be enjoyed.

Soups and desserts are not normal in the diet of an urban household where the man and woman are both working. However, a clever housewife can plan some

Table 4.2 Typical meal pattern for an urban family

<i>Non-vegetarian</i>		<i>Vegetarian</i>
Milk, tea or coffee Bread with butter Egg fried or boiled Banana/seasonal fruit	Breakfast	Milk, tea, coffee <i>Vada/idli</i> with <i>chutney</i> or <i>sambhar</i> Banana/seasonal fruit
<i>Lunch (Packed for Office)</i>		
<i>Chapatis, parathas or puris</i> Dry vegetable (generally from the other vegetable group) or <i>usal</i> (legume preparation) Banana/some seasonal fruit		
OR		
<i>Rice and dal or pulao</i> Carrot/cucumber salad or <i>usal</i> /vegetable curry Banana or some seasonal fruit		
OR		
Sliced bread with butter Boiled or fried egg or omelette Banana or some seasonal fruit		
<i>Snacks with tea</i>		
Tea or coffee Biscuits, <i>chiwda</i> or <i>farsan</i> (savoury mixture)		
<i>Dinner (At Home)</i>		
<i>Chapatis/parathas/puris</i> <i>Dal</i> or curry (vegetable/fish/meat) Rice Vegetable or <i>usal</i> Salad Curd or buttermilk		

sweets and also soups for dinner. A typical meal plan for an urban family is shown in Table 4.3.

While planning packed lunch for children who are in school for the major part of the day, the mother should pack nutritious foods and discourage them from eating outside. Table 4.4 shows some sample packed lunches.

In general, planning meals in advance helps to balance the required nutrition. It is not only more economical with regard to time and money but also ensures balanced and attractive meals.

Table 4.3 Typical meal plan for an urban family

<i>Family</i>	Husband	—	35 years	Office-going sedentary workers
	Wife	—	30 years	
	Daughter	—	7 years old—School-going	
	Son	—	3 years old—Nursery-going	
Recommended Dietary Intake				
			<i>Energy (kcals)</i>	<i>Proteins (grams)</i>
	Husband	—	2220	55.0
	Wife	—	1900	45.0
	Daughter	—	1750	35.0
	Son	—	1220	22.0
Balanced Diet Master list (No. of exchanges per food exchange group)				
<i>S. No.</i>	<i>Exchange group</i>	<i>Husband</i>	<i>Wife</i>	<i>Daughter</i>
		<i>V*</i>	<i>NV**</i>	<i>V*</i>
1.	Milk	2	1	2
2.	Legumes and Pulses	2	1	1
3.	Flesh food	—	—	—
4.	Vegetable A	2	2	2
5.	Vegetable B	3	3	2
6.	Fruit	1	1	1
7.	Cereal	12	12	10
8.	Fat	3	4	3
9.	Sugar	30 g	30 g	30 g

* V = Vegetarian

* V = Vegetarian

(Contd.)

Table 43 Family menu plan (Contd.)

S. No.	Name of Meal	Husband	Wife	Daughter		Son	
		Veg.	Non Veg.	Veg.	Non Veg.	Veg.	Non Veg.
1.	Tea	1 cup	1 cup	1 cup	1 cup	—	—
2.	Breakfast	2 slices	—	2 slices	—	1 slice	—
	Sliced bread with butter and cheese	—	2 slice	—	2 slice	—	1/2 slice
	Milk	1 cup	1 cup	1 cup	1 cup	1 cup	1 cup
	Banana	1	1	1	1	1	1
3.	Lunch (Packed)	2	2	2	2	1	1
	(a) Chapatis	2	1 cup	1 cup	1 cup	1/2 cup	1/2
	(b) Other vegetables	—	—	—	—	1 egg	—
	(c) Egg	—	—	—	—	1/2 cup	1/2 cup
	(d) Rice	—	—	—	—	1/2 cup	1/2 cup
	(e) Usal (Legume preparation)	1/2 cup	1/2 cup	1/2 cup	1/2 cup	1/4 cup	1/4 cup
	(f) Chikki	2 pcs	2 pcs	2 pcs	2 pcs	2 pcs	2 pcs
	(g) Fruit banana/ apple	1	1	1	1	1	1
4.	Snack Time	1 cup	1 cup	1 cup	1 cup	1 cup milk	1 cup milk
	Tea, Biscuits	2	2	2	2	2	2
5.	Dinner	2	2	1	1	1	1
	(a) Chapatis	2	1 cup	1 cup	1 cup	1/2 cup	1/2
	(b) Spinach curry	1 cup	1 cup	1 cup	1 cup	1/2 cup	1/2 cup
	(c) Rice	1 cup	1 cup	1 cup	1 cup	1/2 cup	1/2 cup
	(d) Dal or fish curry	1 cup dal	fish curry with 2 pieces	1 cup dal	fish curry with 2 pieces	1/2 cup dal	1/2 cup fish curry with 1 piece
	(e) Curds	1 cup	1/2 cup	1 cup	1/2 cup	1 cup	1/2 cup
6.	Bedtime milk	1 cup	1/2 cup	1 cup	1/2 cup	1 cup	1/2 cup

Table 4.4 Some Sample Packed Lunches*

	<i>Chapati</i>	<i>Pizza</i>	<i>Paratha</i>	<i>Puris</i>	<i>Bread</i>
<i>Bhaji</i> (dry)	**	**	**		Stuffed <i>bhaji</i> or sandwich (vegetable, cheese, paneer, egg, chicken)
<i>Usal</i> (dry) or egg preparation	**	**	**	**	Plain bread—all according to other groups
Pickle	**	**	**	**	**
Sweet— <i>chikki, kopra pak, sukhadi, burfi</i>	**	**	**	**	**
Fruit—Banana, apple, <i>chiku</i> , orange, sweet lime	**	**	**	**	**

* Provide about one-third of daily requirements (about 700 kcal and 14 g protein)

** Variations in the packed lunch, especially for those who are predominantly rice eaters, can be achieved by packing *dal* and rice/rice *khichdi*/fried rice/lemon rice/tamarind rice/tomato rice/egg rice or *dosa, idli, uttappam* instead of wheat preparations, along with other items as listed above.

4.6 MENU PLANNING IN HOSPITAL SETTINGS

The menu is a central management tool which directs and controls any food service operation. The homemaker in the home or a dietitian in a hospital, develop the menu, taking into consideration the items to be purchased, the cost, the staff and resources required and the type of service needed. So whether on a small or large scale, menu planning is intricate. It is based on the following:

1. Knowing the needs of the persons for whom it is planned.
2. Exercising control in the processes of purchase, storage and preparation of the commodities.
3. Accurately standardizing the product as well as its portioning.
4. Effectively controlling every step from purchase to service.
5. Devising measures to prevent plate waste.
6. Restructuring and modifying taking into account the feedback from the client.

Good menu planning requires a lot of skill and it forms the core of other activities for the homemaker in the home or the dietitian in a hospital and a food and beverage manager in a hospitality establishment.

Persons who are involved in menu planning must have a fair knowledge of the variety of foods, methods of food preservation especially ways to optimize the retention of nutrients in them, presentation skills and the likes and dislikes of the persons for whom the menu is being planned.

Planning is an activity which helps in achieving the desired goal since, selection, purchase and storage of raw materials can be done in advance. It avoids chaos in time management as well as saves efforts whether it be a kitchen in a home or in a large hospital. Since, there may be variations in the diets of patients in a hospital, the dietitian must hone her skills in hospitality management.

Good menu planning entails:

1. Using a variety of foods and yet maintaining consistency in quality.
2. Selection of recipes that can be easily prepared according to seasonal availability of raw materials.
3. Selection of preparations which are generally used day to day.
4. Selecting menus which use ingredients that are easy to utilize hygienically.

There are several types of menus namely a la carte, table d'hôte, special function, ethnic, institutional menus (offices, boarding schools, hostels, etc). However, hospital menus are entirely different from these menus in that the dietitian, in consultation with the physician treating the patient, decide the menu **since, no food that can be detrimental to the health of the patient be given to him**. Besides this, the patients in a hospital are a captive clientele. Their preference for a vegetarian or a non-vegetarian diet may be noted on the menu card since, it is important to respect their religious preferences.

Hospital menus are of 2 or 3 courses. Cyclical menu pattern is the most suitable since, the menus are compiled for a given period of time such as one month or 3 months. The menu plan is rotated at odd days cycle. At the end of the period the menus can be used all over again. The menu cycle can be predetermined according to the time of the year and availability of foods. These type of menus require careful monitoring. Patient's requirements and weather conditions may affect the demand for certain dishes.

Cyclical menus offer certain advantages:

1. Save time since menu plans are for long periods.
2. Standardization of recipes and portions is sufficient for the entire cycle.
3. Better efficiency in time and labour.
4. Lower need for holding stocks of commodities and help in storage requirements.
5. Cost efficient.
6. Ensure that good menu planning is practised.
7. Construction of menus can be well balanced in terms of texture, colour ingredients, temperature, structure, etc.
8. Menus can be planned taking into account the kitchen and service equipment as well as the capability of the staff.
9. The quality of the food preparation is better since the service staff is familiar with the recipes and have prepared them repeatedly.

The disadvantages of cyclical menus are:

1. The pre-planned and pre-designed menus may be too limited and may not appeal to all the patients.
2. They may reduce job satisfaction for the staff who have to prepare and serve the menu repetitively.
3. They can become monotonous if the cycle is short particularly for the patient who has been hospitalized for a long period of time.

Menu planning in a hospital setting does not have much freedom since diets may be restricted in several ways. A hospital menu plan is based on a normal diet with variations in nutrients and texture according to disease, age, stage of recovery, nutritional requirements. Seasonal variations may affect the fruits and vegetables that are being served.

However, the dietitian can exercise creativity in devising variations especially in case of patients who may require special attention. At all times she needs to check the amount of food wastage and exercise control in order to minimize food wastage.

While constructing the cyclic menu, a dietitian must:

- Decide on the menu plan
- Decide as to the flexibility it offers.
- Decide the variations of the main dish for the cycle, so that variations in colour, taste, texture can be done in other food items in the menu.
- Repetition of any menu item on consecutive days must be avoided.
- Food items which may generally not be liked should not be made a part of the daily menu but as a variation.



SUMMARY

The importance of menu planning and developing good food habits has been shown to be of great relevance to the family's health. Adaptation of a normal family diet plan to improve the health of the family members, taking into account the fluctuations of prices, seasons, etc. can be easily done. Some factors which should be considered in planning meals for the family have been given.



CASE STUDIES

- I. As a dietitian working in a 100-bedded multi-specialty hospital, you are required to plan a normal menu of 3 weeks cycle. List the points that you will bear in mind while planning this menu.
- II. A mother of 3 kids, aged 3, 7 and 11 years, living in a joint family of 3 adults, aged between 45 to 68 years, needs advice on planning meals for her family. The family consumes a mixed diet and is generally healthy. What will your advice be with regards to:
 1. Meal plans for the children.
 2. Meal plans for the adults.
 3. Cycle for purchasing the perishable items.
 4. Cycle for purchasing the non-perishable items.



REVIEW QUESTIONS

1. Why is it important to develop good eating habits in children?
2. Write a short note on the nutritional contribution of fast foods in our diets.
3. Which factors must be considered when planning a meal for the family?

4. Why should snacks be planned in the daily meal? Which foods can be consumed in the form of snacks?
5. What are the safety precautions to be exercised when reusing previously cooked foods?
6. How will you ensure wholesomeness in a packed lunch?
7. Which factors must be considered when planning a menu for a family?
8. Plan a menu for a family of six which includes 2 grandparents, a working middle aged couple and 2 young children aged 6 and 11 years old.
9. List five ways of preventing the wastage of nutrients while cooking foods.
10. Make a list of snacks prepared by 5 families known to you.

Chapter

5



Balanced Diet and Nutrition During Normal Life Cycle

The human body requires a continuous supply of nutrients. These nutrients are utilized by the body to maintain health. The nutrients ought to be supplied daily in the right proportion for optimum utilization and proper body maintenance. This can be achieved by taking a balanced diet every day.

5.1 BALANCED DIET

A balanced diet is one which includes all the nutrients in correct proportion or adequate amounts to promote and preserve health.

The recommended food and dietary allowances as per the ICMR 2010 have been shown in Appendix III. Tables 5.1, 5.2, 5.3 and 5.4 give the food items that are required to be eaten in a balanced diet by the different age groups.

These tables give weights that should be considered as raw food weight, e.g. an adult sedentary woman should consume 300 g cereals. Cereals may include wheat, rice and millets depending on the dietary habits of the family. If a family includes any one cereal in their diet, then the raw weight of that cereal should be taken into account. However, if the family includes three or four cereals and millets daily in the diet, the total uncooked weight of the cereals and millets together should be taken into account. The daily intake of articles, as given by ICMR, may appear to be heavy but it is aimed at giving optimum nourishment according to the Recommended Dietary Intakes given in Appendix III. However, the intake may be affected by the prevailing weather conditions and eating habits.

5.2 DIETS DURING A NORMAL LIFE CYCLE

Diets for different age groups, stress periods and work can be classified into groups. The life cycle of each person goes through five basic stages. These are as follows:

- (i) *Pregnancy* : in which human life begins and develops to birth.
- (ii) *Infancy* : is the rapid first year of growth.
- (iii) *Childhood* : is the period in which the child goes through a lot of dietary changes from the age of two onwards. He also begins attending elementary school.
- (iv) *Adolescence* : is the teenage of rapid growth and sexual maturing.
- (v) *Adulthood* : is the period during which growth levels off and gradually a plateau is reached.

Table 5.1 *Balanced diet for an adult man***

	Sedentary work		Moderate work		Heavy work	
	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)
Cereals	400	400	475	475	650	650
Pulses	70	55	80	65	80	65
Green leafy vegetables	100	100	125	125	125	125
Other vegetables	75	75	75	75	100	100
Roots and tubers	75	75	100	100	100	100
Fruits	30	30	30	30	30	30
Milk	200	100	200	100	200	100
Fats and oils	35	40	40	40	50	50
Meat and fish	—	30	—	30	—	30
Eggs	—	30	—	30	—	30
Sugars and jaggery	30	30	40	40	55	55
Groundnuts	—	—	—	—	50	50*

* An additional 30 g of fats and oils can be included in the diet in place of groundnuts.

** Source: Nutritive Value of Indian Foods, NIN, Hyderabad, 1985.

Table 5.2 *Balanced diet for an adult woman***

	Sedentary work		Moderate work		Heavy work		Additional allowance during:	
	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Pregnancy (g)	Lactation (g)
Cereals	300	300	350	350	475	475	50	100
Pulses	60	45	70	55	70	55	—	10
Green leafy vegetables	125	125	125	125	125	125	25	25
Other vegetables	75	75	75	75	100	100	—	—
Roots and tubers	50	50	75	75	100	100	—	—
Fruits	30	30	30	30	30	30	—	—
Milk	200	100	200	100	200	100	125	125
Fats and oils	30	35	35	40	40	45	—	15
Sugar and jaggery	30	30	30	30	40	40	10	20
Meat and fish	—	30	—	30	—	30	—	—
Eggs	—	30	—	30	—	30	—	—
Groundnuts	—	—	—	—	40*	40*	—	—

* An additional 25 g of fats and oils can be included in the diet in place of groundnuts.

** Source: Nutritive Value of Indian Foods, NIN, Hyderabad, 1985.

Table 5.3 *Balanced diet for children**

	Pre-school children				School children			
	1–3 years		4–6 years		7–9 years		10–12 Years	
	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)
Cereals	150	150	200	200	250	250	320	320
Pulses	50	40	60	50	70	60	70	60
Green leafy vegetables	50	50	75	75	75	75	100	100
Other vegetables	30	30	50	50	50	50	75	75
Roots and tubers								
Fruits	50	50	50	50	50	50	50	50
Milk	300	200	250	200	250	200	250	200
Fats and oils	20	20	25	25	30	30	35	35
Meat and fish	—	30	—	30	—	30	—	30
Eggs	—	30	—	30	—	30	—	30
Sugars and jaggery	30	30	40	40	50	50	50	50

* Source: *Nutritive Value of Indian Foods*, NIN, Hyderabad, 1985.

Table 5.4 *Balanced diet for adolescent boys and girls***

	Boys				Girls	
	13–15 Years		16–18 Years		13–18 Years	
	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)	Veg. (g)	Non-veg. (g)
Cereals	430	430	450	450	350	350
Pulses	70	50	70	50	70	50
Green leafy vegetables	100	100	100	100	150	150
Other vegetables	75	75	75	75	75	75
Roots and tubers	75	75	100	100	75	75
Fruits	30	30	30	30	30	30
Milk	250	150	250	150	250	150
Fats and oils	35	40	45	50	35	40
Meat and fish	—	30	—	30	—	30
Eggs	—	30	—	30	—	30
Sugar and jaggery	30	30	40	40	30	30
Groundnuts	—	—	50*	50*	—	—

* An additional 30 g of fats and oils can be included in the diet in place of groundnuts.

** Source: *Nutritive Value of Indian Foods*, NIN, Hyderabad, 1985.

5.3 NUTRITION DURING PREGNANCY

The gestation period is a rapid growth period. Growth of the foetus and other developments that take place to facilitate its maintenance throughout pregnancy and delivery of the child involve an increase in the nutritional requirements of the pregnant woman. The fertilized ovum attaches itself to the uterine wall and with help of the placenta, enables the developing foetus to respire, acquire nourishment and eliminate wastes. Exchange of nutrients and wastes take place in the placenta much as they do in the gastro-intestinal tract; oxygen and nutrients pass in from the mother to the foetus; carbon dioxide and metabolic wastes pass the opposite direction. Water and the fat-soluble vitamins diffuse to the foetal circulation. Other nutrients such as amino acids, glucose, the water-soluble vitamins and minerals such as calcium, sodium and iron are actively transported.

An exception to the passage of nutrients is the protein molecule. These do not cross the placenta as they are too large to penetrate the cells of the placental villi. The exception to this phenomenon is a specific maternal antibody which is structurally able to penetrate and which provides the foetus with invaluable immuno-resistance to infections that lasts for six months or more after birth.

So, the increase in the nutritional requirements of a pregnant woman can be attributed to:

- Rapid growth of the foetus
- Development of the placenta
- Enlargement of maternal tissues namely the breast and uterine tissues
- Increase in maternal circulating blood volume
- Formation of amniotic fluid
- Storage reserves
- Mineralization of the skeletal and bone structure of the foetus as well as tooth buds

To meet the additional nutritional requirement, foods which supply all the nutrients in greater amount to sustain and support the pregnancy must be consumed by the pregnant woman.

□ Exercise During Pregnancy

During pregnancy, the woman should exercise at a level that keeps her heart rate below 140 bpm. A good fitness program would be about 1 hour of physical activity 3 days in a week. The intensity should be such that it maintains the maternal heart rate between 120 and 130 bpm. Walking, jogging, stationary cycling, and swimming are exercises that provide the best cardiovascular and psychological benefits with the least pregnancy risks. Besides, these exercises, the pregnant woman should perform her daily chores as she would do earlier in order to remain active until the delivery.

□ Protein Requirement

The requirement of protein in pregnancy increases by about 30 percent over the normal requirement, e.g. if the normal requirement of an adult woman is 45 grams per day, during pregnancy she would be required to take an additional 14 g per day as

per the RDI during the second and third trimester of pregnancy. Good quality protein as that obtained from milk, meat, fish, eggs and cheese should be eaten. Additional requirement of protein for vegetarians may be obtained from a combination of whole grains, legumes and nuts.

□ Calorie Requirement

Calories should be sufficient to meet energy and nutrient demands and to spare protein for tissue-building. The RDI includes an increase of about 300 calories in the second half of pregnancy.

□ Mineral Requirement

Calcium and iron are the two minerals the need for which is urgent during pregnancy. Increased calcium is required for the growth and development of bones as well as tooth buds in the growing foetus. It is also an important constituent of the blood-clotting mechanism. More calcium is needed in the third trimester of pregnancy as rapid mineralization of the skeletal tissues takes place during the period. Dairy products are the primary sources of calcium. Additional calcium may be obtained from legumes and leafy vegetables. The physician may, in addition, advise the intake of calcium tablets. A woman requires more iron than a man in normal situations. She needs to maintain a daily intake of 32 mg of iron throughout her child-bearing years. This amount not only replenishes her menstrual losses but also restore her tissue reserves after each pregnancy. The physician usually recommends intake of iron supplements to dietary sources to meet the iron requirement of pregnancy.

□ Vitamin Requirement

All the vitamins, especially vitamins A, B complex, C and D, and folic acid are required in increased doses during pregnancy.

Vitamin A requirement increases by about 25 percent over the usual adult intake. This requirement can be met by consuming good food sources of this vitamin which include liver, egg-yolk, butter, dark green and yellow vegetables and fruits.

In the B complex group, folic acid supplementation may be required to protect against megaloblastic anaemia. Requirements for folic acid increase during pregnancy in order to keep up with the demands for maternal erythropoiesis, for foetal and placental growth, and to prevent Neural Tube Defects (NTDs). The neural tube closes by 28 days of gestation, before most mothers realize that they are pregnant. Hence, folic acid supplementation must begin before conception.

In folic acid deficiency, Deoxyribonucleic Acid (DNA) synthesis and mitotic activity in individual cells is markedly reduced. Symptoms of megaloblastic anaemia develop in the most advanced stage of foliate deficiency, which may not be until the third trimester. However, white cell morphologic and bio-chemical changes may be seen before the symptoms of anaemia appear. Foliate deficiency may cause spontaneous abortion and obstetric complications such as preterm labour and LBW. The importance of folic acid during pregnancy cannot be underestimated in its role in preventing NTD's, which are among the most common birth defects. The other B vitamins, especially thiamine, riboflavin and niacin, are also required in larger quantities since they are the co-enzymes in a number of metabolic activities, especially

energy production and in the functioning of muscle and nerve tissues. Vitamin B6 helps the pregnant woman to synthesize the non-essential amino acids needed for growth. It also helps to synthesize vitamin B6 – dependent niacin from tryptophan. Vitamin B6 has been found to help alleviate severe nausea and vomiting during pregnancy. It catalyzes numerous reactions involving neurotransmitter production. Large doses of vitamin B6 have been found to be necessary to achieve anti-emetic effects. However, this must be done under only close medical supervision.

Vitamin C, besides its normal functions, is involved in developing the connective tissue and vascular system as well as in the absorption of iron. It may be obtained by eating fresh fruits and drinking fresh fruit juices.

The need for calcium and phosphorus is increased hence, the requirement of vitamin D cannot be overlooked as it is involved in their absorption and utilization. As plenty of sunshine is available in our country, the requirement of vitamin D can be easily met through its biosynthesis in the skin. Food sources include butter, liver, egg-yolk and fish liver oil.

A typical diet plan for pregnant woman is given in Table 5.5.

Table 5.5 *Diet in pregnancy*

Requirements: energy— $2200 + 300 = 2500 \text{ kcal}$

Protein— $45 + 14 = 59 \text{ g}$

Food Exchange List				
	<i>Food group</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1.	Milk	4	20.0	400
2.	Legumes and pulses	2	12.0	200
3.	Flesh food	1	10.0	100
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruits	3	—	150
7.	Cereals	9	18.0	900
8.	Fats	5	—	500
9.	Sugar	40 g	—	160
			60.0	2510

Menu Plan				
<i>Tea</i>	: 1 cup	<i>Tea</i>	: 1 cup	
	Dry biscuits — 2		Roasted	
<i>Breakfast</i>	: Milk 1 glass		peanuts — 2 tablespoon	
	Bread butter — 2 slices	<i>Dinner</i>	: <i>Chapatis</i> — 2	
	Boiled egg — 1		<i>Dal palak</i> — 1 cup	
	Banana — 1 small		Rice — 1/2 cup	

(contd.)

(contd.)

<i>Lunch</i>	: <i>Chapatis</i>	2	<i>Mung Usal</i>	— 1 cup
Rice	— 1/2 cup		Curds	— 1 cup
<i>Dal</i>	— 1 cup	<i>Bedtime</i>	: Fruit milk	— 1 glass
Tomato			shake	
<i>palak</i> soup	— 1 bowl			
<i>Parwar</i> curry	— 1 cup			
Curds	— 1 cup			

5.4 COMPLICATIONS DURING PREGNANCY

□ Toxaemia

Preeclampsia is a leading cause of maternal and perinatal mortality.

Toxaemia is the general term given to an acute hypertensive disorder appearing after about the 20th week of pregnancy or following delivery and accompanied by increased oedema, protein (albumin) in urine and in severe cases convulsions and coma, especially if treatment is delayed. The syndrome involves reduced placental perfusion and maternal endothelial dysfunction.

Toxaemia accounts for many maternal deaths and for the majority of deaths of all newborn infants. Malnutrition is the cause of toxæmia and it could be prevented by good parental care which should always include attention to good nutrition. If toxæmia is found to be present in a pregnant woman, adequate quantities of proteins of high biological value may be included in her diet. Restriction of salt was previously held to help relieve toxæmia but now it is recognized that salt is needed in pregnancy and that a normal amount should be supplied. Vitamins and minerals are the regulatory agents which are particularly needed to avoid the general state of malnutrition which precedes toxæmia. Several risk factors are nutrition related such as maternal obesity, diabetes, hypertension and homocystinemia.

□ Anaemia

Anaemia is common during pregnancy. Severe anaemia in pregnancy is defined as haemoglobin of less than 40 g/L and is a medical emergency. Eliminating severe anaemia in pregnancy can reduce maternal disease burden. Several pregnant women suffer from anaemia which may be classified as follows:

1. Iron-Deficiency Anaemia This is the most common anaemia in pregnancy because the requirement of iron by a pregnant woman far exceeds her reserves and hence, anaemia may result if her diet is not enriched with iron-rich foods.

2. Haemorrhagic Anaemia This is more likely to result after delivery than during pregnancy since loss of blood during delivery is heavy. However, blood loss may occur in pregnancy if there is an abortion or ruptured tubal pregnancy. Most such patients receive blood transfusion but iron therapy in addition may be indicated to support the formation of haemoglobin needed for adequate blood replacement.

3. Megaloblastic Anaemia In this condition large, immature red blood cells containing little or no haemoglobin are formed and this malformation in red cells is the result of folic acid deficiency. Folic acid requirement is greatly increased in pregnancy and deficiency is manifested in nausea, vomiting and anorexia. As anaemia progresses, loss of appetite is even more, aggravating nutritional deficiency. Most of the morning sickness symptoms characteristic of pregnancy could be due to deficiency of folic acid and pyridoxine.

□ Nausea and Vomiting

This is commonly called *morning sickness*. This is usually a mild complaint limited to early pregnancy. It occurs more often after rising than later in the day; hence, the term morning sickness. The reasons are physiological and also psychological due to the tensions and anxieties concerning pregnancy itself. Simple treatment usually improves the person's tolerance towards food. Dry biscuits eaten before rising from the bed decrease nausea. Small meals with liquids taken in between meals rather than with the meals give better results. If excessive, persistent and prolonged vomiting (*Hyperemesis gravidarum*) is seen, then the doctor may hospitalize the patient and feed her intravenously to prevent complications and dehydration.

□ Constipation

Generally, this is a minor complaint of pregnancy. The pressure of the enlarging uterus on the lower portion of the intestine causes some difficulty during elimination. Including roughage in the diet such as that obtained from eating fruits with their skins (*chiku*, guava, apple, pear, peach), whole wheat *chapatis*, fruit juices and green leafy vegetables usually induces regularity. Laxatives should not be used except under medical supervision.

□ Pica Pica is an eating disorder. It can be defined as “the persistent ingestion of non-nutritive substances for at least 1 month”. It is seen in persons at an age for which this behaviour is developmentally inappropriate. In some pregnant women, it may be observed as a craving for non-food substances like chalk, earthen materials, etc. Pica may not cause harm in many cases, but it can have life-threatening consequences also.

The resultant problems of pica vary and depend upon the substances ingested. In poisoning or exposure to infectious agents, the reported symptoms are extremely variable and are related to the type of toxin or infectious agent ingested.

Physical findings may include the following:

- Manifestations of toxic ingestion (e.g. lead poisoning)
- Manifestations of infection or parasitic infestation (e.g. toxocariasis and ascariasis)
- GI manifestations (e.g. mechanical bowel problems, constipation, ulcerations, perforations, and intestinal obstructions)
- Dental manifestations (e.g. severe tooth abrasion, surface tooth loss)

Complications of pica, if any, must be addressed with urgency.

Diabetes and Pregnancy

A pregnant woman who has been diagnosed with gestational diabetes or who was diabetic prior to the pregnancy has nutritional requirements essentially the same as those of a pregnant woman without diabetes. However, pregnancy magnifies the importance of abiding by the principles of nutrition management, controlling glucose levels and avoiding ketonuria.

1. Nutritional Management of Diabetic Pregnancies There are specific nutritional issues that surround the management of pregnant women with diabetes. The nutritional needs of women with pre-existing Type 1 diabetes and Type 2 diabetes differ from those for women who become glucose-intolerant in pregnancy.

Ideally, nutritional advice should start before pregnancy and should be modified at each antenatal visit by the dietitian who is an integral part of the multidisciplinary diabetic-obstetric team. The dietitian must take into account the metabolic and physiological changes associated with a diabetic pregnancy.

Over the last few decades, the antenatal population has become older, more obese and less physically active. These changes explain the rise in the number of pregnant women with preexisting Type 2 diabetes and gestational diabetes. It is important that perinatal morbidity and mortality in diabetic pregnant women is higher than for non-diabetic pregnant women. Active dietary management for all types of diabetic pregnancies can lessen complications during pregnancy and improve pregnancy outcome for the mother and child.

2. Consequences of a Diabetic Pregnancy Maternal hyperglycaemia results in excess maternal-foetal transfer of glucose which results in foetal hyperglycaemia and foetal hyperinsulinaemia and this can lead to congenital malformations. Diabetic mothers are seen to deliver large-for-gestational-age (LGA) infants, especially in poorly controlled diabetic pregnancies. By managing the diabetic pregnancy effectively, one can reduce the long-term risk of the child becoming obese and insulin-resistant in adult life.

3. Therapeutic Aim The aim in the management of all diabetic pregnancies is to achieve normoglycaemia while avoiding maternal hypoglycaemia. This approach will optimize foetal growth and minimize short- and long-term complications. Many women with gestational diabetes (GDM) will be able to achieve them with dietary intervention alone. The use of oral agents that do not cross the placenta or insulin should be done under medical supervision.

Dietary advice must be based on sound nutritional principles and the patient closely monitored. Folic-acid supplementation is necessary as for other non-diabetic pregnancies.

Women with diabetes must be encouraged to achieve the best glycaemic control during the preconception period. Congenital malformations can be significantly reduced when HbA_{1c} levels are within the normal range. Dietetic input is required to build confidence, reduce hypoglycaemia and limit unnecessary weight gain.

Achieving near-normal glycaemic control is possible in most women with Type 2 and Type 1 diabetes. However, in women with a long duration of Type 1 diabetes and significant autonomic neuropathy, the risk of severe hypoglycaemia is high. The diet counsellor must ensure that adequate carbohydrate intake and low glycaemic index snacks are being consumed between meals.

A weight-reducing diet in obese women prior to conception has been shown to improve both glycaemic control and pregnancy outcome.

4. Some General Guidelines for Diabetic Pregnant Women

Once pregnancy has been confirmed, the diet must contain

- The recommended intakes of minerals, vitamins including folate and iron
- Adequate amounts of antioxidants including vitamins C and E to reduce the risk of pre-eclampsia and congenital malformation
- Adequate amounts of calcium and vitamin D as well must take supplements during both pregnancy and lactation

Nutritional intake should be monitored from the beginning of the pregnancy. Caloric intake should be adequate. Caloric requirements are based on pre-pregnancy weight, height, age, activity level, and usual intake. In the first trimester, the daily caloric intake should be between 30 and 38 kcal/kg of the ideal pre-pregnancy weight. This should be increased to 36 to 38 kcal/kg of ideal pre-pregnancy weight in the second and third trimesters. This increase in caloric intake is for increases in maternal blood volume and increases in breast, uterus, and adipose tissue; placental growth; foetal growth and amniotic fluids. It must be borne in mind that close monitoring of blood glucose levels and weight must be done.

Besides adequate calories, pregnant women need adequate protein (0.75 g/kg per day plus an additional 10 g per day). The meal distribution would generally be three meals and three snacks spaced about 2 hours apart.

The distribution of calories is as follows:

<i>Carbohydrate</i>	<i>Protein</i>	<i>Fat</i>
40% to 50% of total calories	20% to 25% of total calories	30% to 40% of total calories

During the first trimester a pregnant woman having normal weight should gain 2 to 5 pounds. Thereafter, gain of 1 pound per week is acceptable. However, underweight women should gain 1.1 pounds per week, and overweight women should gain only 0.7 pound per week.

An underweight pregnant woman must gain about 25–40 lbs during the pregnancy, as against 25–35 lbs and 15–25 lbs for a normal and overweight person respectively.

5.5 NUTRITION DURING LACTATION

A mother derives great satisfaction if she is able to nurse her baby at least for a period of three to six months. Breastfeeding has several advantages for the baby, but for the mother its two main advantages are physiological and emotional. Physiologically, breastfeeding helps the uterus regain its normal size from the enlargement during pregnancy, and it promotes emotional bonding between the mother and the baby as she holds the child close to her body while feeding.

When a mother is nursing her baby, it makes greater demands on her body. The nutritional requirements of pregnancy continue in lactation except that they are increased during the latter.

1. Protein Requirement An increase in protein intake is recommended for women during lactation. The average protein content of breast milk of the Indian woman is 1.2 g/dl. The efficiency of conversion of dietary protein is not known and it is generally assumed that protein is used for milk protein synthesis as efficiently as for body protein synthesis. An average milk volume of 850 ml during the lactating period, from birth to six months, increases the protein allowance of an adult woman from 45 grams per day to 70 grams per day, i.e. an increase of 25 grams per day. This additional requirement is in excess since, the efficiency of synthesis of milk protein is not definitely known.

2. Calorie Requirement On an average, a lactating woman secretes about 800–850 ml milk, the calorific value of which is about 500–600 calories (about 65 calories per 100 ml milk). So also the metabolism involved in producing this amount of milk requires about 200–400 calories.

In view of these two amounts totalling to about 700–1000 calories, the mother who feeds her baby must have adequate stores of energy required during the entire lactating period.

3. Mineral Requirement Calcium and iron required by the lactating mother are the same as required during pregnancy. The calcium that was used for mineralization of bones of the foetus during pregnancy is now diverted to the production of milk.

Iron is not secreted much into the milk hence, the requirement of iron remains the same as during pregnancy.

4. Vitamin Requirement The increase in vitamin C requirement indicated during pregnancy continues during lactation. However, no further increase is needed since, milk contains very little vitamin C. The requirement of vitamin A and B complex vitamins, especially riboflavin and niacin, is also increased as they are secreted into milk.

5. Fluid Requirement Intake of fluid is increased. Water and beverages such as juices, tea, coffee and milk help in providing the fluid necessary to produce milk.

□ Role of Galactagogues

Galactagogues are substances that are used to induce, augment, or maintain lactation. The most popular of the galactagogues are given below.

1. Fenugreek Fenugreek, *Trigonella foenumgraecum*, is a herb from the Fabaceae family, which includes peas and peanuts. This herb is very commonly recommended as a supplement to increase lactation. The active ingredients are present in the seed, although, the mechanism of action is not clear. It should be used in small amounts. In Indian cuisine, fenugreek is widely used in daily cooking. Side effects include diarrhoea and flatulence, but the most noticeable is a body odour which is similar to maple syrup. In some cases it may elicit allergic reactions.

2. Blessed Thistle Blessed Thistle, *Cnicus benedictus*, is another herb which is used to enhance lactation. It is distinctly different from milk thistle. It is a member of the Asteraceas/Compositae family. The plant may have bacteriostatic, antitumour,

and antihistamine activity. Its mechanism of action as a galactagogue is unknown. Side effects include gastrointestinal irritation and mild allergic reaction.

3. Alfalfa Alfalfa is a common, mild galactagogue that is often used along with other more powerful galactagogues like fenugreek. Alfalfa is a highly nutritive plant which is very high in essential vitamins, minerals and other micronutrients. It is, perhaps, these nutrients that may boost milk supply in breastfeeding mothers.

4. Anise Anise is a member of the apiaceae family of flowering plants and is native to the Mediterranean and Southwest Asia region. The herb has been traditionally used as a galactagogue in India, China and other parts of Asia. Anise does have estrogenic compounds which perhaps contribute to its use as a galactagogue.

5. Fennel Fennel is in the same family as anise, also a herbal galactagogue. Fennel is a commonly used and highly effective herbal galactagogue that is often used in concert with other herbal galactagogues. Fennel is widely used in tonics and over-the-counter preparations for breastfeeding mothers. Fennel is native to Southern Europe and Southwestern Asia where it is used amply in local cuisine.

6. Goat's Rue Goat's rue is a traditional galactagogue that has been used for centuries. Goat's rue, like fenugreek, belongs to fabaceae family of flowering plants.

□ Rest and Relaxation

Physical and mental rest, relaxation and adequate exercise are conducive to production of milk in the lactating mother, but these are often neglected.

A typical diet plan for a lactating woman is shown in Table 5.6.

5.6 NUTRITION FROM INFANCY TO ADOLESCENCE (EARLY GROWTH PERIOD)

There are four phases in the life of a human being, namely infancy, childhood, adolescence and adulthood.

Why is it necessary to treat diet for children separately from that for adults? Although the nutritional needs of children are similar to those of the adults, i.e. energy, protein, mineral elements and vitamins, yet they differ from those of adults in three main respects.

1. Their energy requirement per unit of weight is higher than that of adults.
2. Their food should contain a higher proportion of tissue-building materials, namely proteins and mineral elements as well as of vitamins, than that of adults.
3. Their diet should be made up of foods which are suitable to the digestive abilities of any given age, and the scope of the foods that can be readily handled should increase as the child grows older.

□ Infancy

This period, which spans from birth to one year of life, is a rapid growth period. By the end of the first six months after birth a child nearly doubles his birth-weight and by

one year he triples it. So a newborn 2.7 kg at birth, will be about 5.4 kg at six months and eight kilogram by one year. During this period a child begins to crawl, babble, sit and some may even walk. Girls are generally quicker in these aspects than boys.

Table 5.6 Diet during lactation (up to six months)

Requirements: energy— $2200 + 550 = 2750 \text{ kcal}$

Protein— $45 + 25 = 70 \text{ grams}$

Food Exchange List				
	<i>Food group</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1.	Milk	6	30.0	600
2.	Legumes and pulses	3	18.0	300
3.	Flesh food	1	10.0	100
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruits	4	—	200
7.	Cereals	11	22.0	1100
8.	Fats	5	—	500
9.	Sugar	40 g	—	160
			80.0	3060

Menu Plan			
<i>Tea</i>	:	1 cup	
<i>Breakfast</i>	:	<i>Rawa</i> porridge	— 1 bowl
		Boiled egg	— 1
		Banana/orange	— 1
<i>Mid-morning</i>	:	<i>Methi laddoo</i>	— 1
<i>Lunch</i>	:	<i>Chapatis</i>	— 2/ <i>Bhakri (bajra roti)</i> 1 and 1/2
		<i>Rajma-urad usal</i>	— 1 cup
		<i>Methi</i> leaves curry	— 1 cup
		<i>Dal</i>	— 1/2 cup
		Rice	— 1 cup
		Curds	— 1 cup
<i>Tea</i>	:	1 cup	
		<i>Batata pohe</i>	— 1 cup
	:	<i>Chiku</i>	— 1
<i>Late evening</i>	:	1 glass fruit milk shake	
<i>Dinner</i>		<i>Chapatis</i>	— 2
	:	<i>Pumpkin-gavar</i> curry	— 1 cup
		<i>Mung usal</i>	— 1 cup
		<i>Dal</i>	— 1/2 cup
		Rice	— 1 cup
		Egg	— 1
		Buttermilk	— 1 glass
<i>Bedtime</i>		Hot milk	— 1 glass

□ Childhood

This period is a slow growth period in which occasional spurts of growth may occur but generally it is not as demanding as infancy and adolescence. On an average the child gains about 5–10 cm height and 1.8–3.6 kg weight per year. During the second and third year of the child's life there may be decline in the growth-rate which generally spurts up at the time of puberty and reaches a maximum during adolescence, which begins somewhat earlier for girls than for boys, and then gradually declines until growth ceases and body structure stabilizes.

Heredity and environment play a major role in the growth and development of a child. It is important for a child to have a weight proportionate to his height. Deviations in weight and height are of concern only when they are extreme or when the child shows other evidence of lack of vigour.

Many children could grow to a larger size if the best kind of diet were furnished to them and all conditions of optimum nutrition made as favourable as possible. Today, parents are realizing this and adequate nourishing diets as well as vitamin and mineral supplements are given to their children who, therefore, grow taller and bigger in stature than their parents.

□ Adolescence

At the time of puberty, the second rapid growth spurt occurs. Because of the hormonal changes involved, multiple body changes occur including growth of long bones (such as femur), development of sex characteristics and fat and muscle development. This growth period is earlier for girls, beginning at around eight years and ending by 13 to 15 years of age. For boys this period begins slightly later—around nine years of age—and ends by around 18 years.

□ Adulthood

This is the final growth phase of a normal life cycle. Growth spurt stops and continues on the adult plateau and then gradually declines during old age. The nutrients are required for the maintenance of health and for providing energy for the physiological and physical activities.

5.7 WAYS OF MEASURING GROWTH

A child grows in more than one way. It relates to his physical, mental, emotional, social and cultural growth. One is apt to compare one's child with others of his age group. It should be remembered by parents that children are *individuals* and should not be compared.

□ Physical Growth

This can be judged by various parameters such as the following:

1. Anthropometric Methods Alteration in body measurements is not a very early manifestation of malnutrition. This is so because physiological changes take place before structural changes, and these can be tested by biochemical tests. The most affected structural change is in the fat and muscle mass, which is reflected in

the body weight, and arm and calf circumferences. The exact age of the child must be recorded to interpret anthropometric measurements correctly.

Weight and Height These are common general measures of physical growth. However, it is a crude index which does not take individual variations into consideration, although it has served a useful parameter. Measurement of weight and height is relatively easy. Low weight or failure to gain weight gives an adequately reliable indication of the nutritional status. Height is not greatly affected by early malnutrition.

2. Body Measurements These are helpful indications of the child's growth. The mother can keep track of the infant's growth by measuring his length as he is lying flat and later by measuring his standing height as he grows older. Other measurements may include head circumference, measures of chest, abdomen and leg from the calf, pelvic breadth, skin-fold thicknesses and similar measure. One should look for all the signs indicative of the well-being of the individual including both physical and mental aspects. In a newborn child the head circumference is greater than the chest circumference. This becomes equal by nine to twelve months of age. In malnourished children the head continues to remain bigger up to 30–38 months.

The weight/head circumference ratio reflects the changes in the weight. This ratio is especially useful if a child's age is not known. The mid-arm circumference is a measurement taken when the left arm is hanging by the side of the trunk. Between two to five years age it is found to be between 16.25–16.75 centimetres. Children with measurements below 80 percent of the average, i.e. 12.8 centimetres, are malnourished.

The measurement of subcutaneous fat at mid-triceps is one of the reliable methods of assessing the nutritional status of children below five years of age.

The mid-arm/head circumference ratio can also be used to detect malnutrition since, it is not much affected by age and sex.

In the field as well as in the medical health centres it is necessary to use a quick and economical method to assess the health of a child. For this a modified QUAC-stick method is used. In this method a strip of paper mentioning the height in centimetres, figures of arm circumference and against these the percentage denoting the nutritional status are given. This can be hung on a wall or a stick which can be fixed to the ground anywhere. It is a simple, fairly reliable, inexpensive and objective method to detect the nutritional status.

3. Biochemical Tests The laboratory tests include studies of blood and urine, X-rays (Roentgenograms) of the wrist to observe degree of bone development. The biochemical tests are based on the alterations that take place in protein metabolism, hence, limited to extreme cases of protein malnutrition. The parameters involved are serum albumin, non-essential/essential amino acids ratios in urine and serum, hydroxyproline excretion in urine, urinary creatinine/height ratio, urinary urea/creatinine ratio, serum transferin and many others.

4. Nutritional Analysis The general eating habits of a child may be observed and this will give a general measure of the adequacy of his diet.

□ Mental Growth

This development is gradual as the child grows. Mental growth involves testing the child's ability to speak and use other forms of communication. As the child grows, his capacity to handle abstract and symbolic ideas improves. He can handle single ideas and develop constructive concepts. The IQ (Intelligence Quotient) of children born of well-nourished mothers is generally higher than those whose mothers were undernourished during pregnancy and lactation periods. The first three years of a child's life are an important milestone in determining his mental growth and the full potential to which it can develop.

□ Emotional Growth

This is measured by the child's capacity for love and affection and the ability to handle frustration, anxiety and ability to control aggressive impulses. As he matures he is able to channel his impulses from destructive to creative or constructive activities, which should be encouraged.

□ Social and Cultural Growth

The social development of a child is measured in terms of his ability to relate to others and how he can participate within a group. His social and cultural behaviour is first learned through his relationship with parents and family. As he grows, his circle of friends widens and he develops friends outside his family. As his horizons broaden, his interaction with outsiders increases and improves.

5.8 RELATIONSHIP OF NUTRIENTS TO THE GROWTH PROCESS

It is necessary at this stage to review the role of nutritional requirements during growth.

□ Calories

During childhood the need for calories is greater. Increase in physical activity demands a lot of calories. Also, the basal metabolism of children is higher than that of adults. The major portion of this requirement of calories by children must be met by carbohydrates since they spare proteins. This will ensure that protein which is vital for their growth will not be diverted for energy needs. Fats too should be supplied in sufficient quantity so that essential fatty acids, especially linoleic acid is supplied. However, an excess of fat, especially animal fats, should be avoided.

□ Protein

Protein is the *growth factor*. It should be supplied in sufficient quantities so that amino acids which are necessary for building of new tissue and for compensating the wear and tear of the tissue are supplied in ample quantities. It is essential to remember the *all or none law* governing protein synthesis, according to which all the amino acids necessary for tissue synthesis must be present simultaneously in proper amounts and proportion. Hence, a variety of protein food sources is recommended at the same time.

□ Water

Water is vital for life. Infants—whose body contains a greater percentage of water than that of adults—tend to lose it more easily and need more water than adults. Generally, an infant consumes water equivalent to about 10–15 percent of his body weight while an adult consumes water equivalent to 2–4 percent of his body weight.

□ Minerals

All minerals are necessary for the overall growth of the child. However, two minerals namely calcium—necessary for rapid growth of bones and developing teeth—and iron—necessary for the formation of haemoglobin—need special emphasis and should be adequately supplied.

□ Vitamins

All vitamins, viz. the fat-soluble A, D, E and K and the water-soluble vitamin C and the B complex group, should be supplied in adequate amounts for the variety of functions that they perform.

Hypervitaminosis A and D should be guarded against since parents, out of ignorance, misunderstanding or carelessness, feed large doses of vitamin A and D, which may lead to toxicity. Symptoms of excess vitamin dosage, such as loss of appetite, slow growth, drying and cracking of the skin, enlargement of the liver and spleen, are reported. Toxicity symptoms of vitamin D include nausea, diarrhoea, weight loss, excess or night urination. Eventually, it leads to calcification of even soft tissues including those of the kidneys, blood vessels, bronchi, stomach and heart.

5.9 NUTRITIONAL REQUIREMENTS OF DIFFERENT AGE GROUPS

The needs of every age group are given in the Recommended Dietary Intakes prepared by the NIN Expert Committee and are shown in Appendix I.

The nutritional requirements for each of the age groups are discussed here.

□ Infant (Birth to One Year)

An infant grows rapidly in the first year of his life. Hence, his energy requirements are very high. ICMR recommends an intake of 120 cal/kg body weight in the first six months, and 100 cal/kg body weight in the next six months. Rapid growth also demands higher intake of protein. Simple easily digestible protein, ideally supplied through breast milk, is recommended. The ICMR has recommended a protein intake of 2.3–1.8 g/kg body weight in the first six months and 1.8–1.5 g/kg body weight in the next six months.

Simple carbohydrates should be fed initially since, amylase, the enzyme which digests starch, is not produced. However, as starch is introduced in the third or fourth month, this enzyme begins to function. More fluids are necessary for the urinary excretion. The infant has no teeth, so liquid or semi-solid food should be given until teeth begin to develop. As he has limited iron stores, supplementation with iron, vitamins and minerals, especially calcium and phosphorus, is necessary. They may

be given as drops of liquid oral preparation initially, and later mixed with milk or fruit juices, avoiding excess amounts.

Breast milk is the ideal milk for an infant, but if a working mother has to resume her office when the infant is three or four months old, it is necessary to wean him off the breast and begin to bottle-feed so that he adjusts well to the new method of feeding.

□ Food and Feeding

Breast milk has several advantages over tinned milk or infant milk powder formulations. If the mother cannot breastfeed the child owing to lack of adequate milk-flow or other health complications, only then the doctor may suggest infant milk formulae suited to the infant. Cow's milk is a better substitute to breast milk than infant milk formulae since its composition is closest to that of breast milk as compared to other milks and infant milk formulae. However, importance of breast milk in the first few months of the child's life cannot be underestimated.

Breast milk is ideally suited for the physiological, nutritional and psychological needs of all infants. Breastfeeding usually meets the needs of the young infant up to the age of four to six months. Colostrum is the milk secreted during the first three to five days after childbirth before the formation of true milk is established. The colostrum contains less fat and lactose than mature milk and more sodium, chlorine and zinc. It is high in antibody-rich protein especially immunoglobulin A (IgA) and lactoferrin. It guards the infant against infection and also helps to clear out the meconium. The proportion of PUFA (mainly long chain) is much higher in colostrum than in mature milk. Several misconceptions about colostrum prevail in our country because of which it may be discarded and not given to the infant.

Mature milk which is secreted after about five days following delivery has several advantages over other milks. They are:

- Human milk provides all nutrients in the right proportion as needed for the rate of growth of the infant and in easily digestible forms.
- Human milk forms a much finer and more flocculent curd in the stomach than does cow's milk. Buffalo milk curd has highest curd tension, hence difficult to digest by infants.
- Since the mother feeds the baby and milk flows directly from the nipples in the infant's mouth, no possibility of contamination is feared. However, adequate care of the nipples during pregnancy and their cleaning before and after nursing the child must be done.
- The protein level, though low as compared to cow's milk, especially the proportion of casein being low, result in soft curd and easy digestibility.
- The major carbohydrate, i.e. disaccharide lactose is high and plays a major role in maintaining low electrolyte concentration.
- Fat in breast milk comprise PUFA especially linoleic acid and alpha linoleic acid which are higher in breast milk than cow's milk. The concentration of fat in mature milk may go up to 40 g/litre.
- The fat-soluble and water-soluble vitamins are in good amounts but their concentration depends largely on the mother's diet.
- Among minerals, the sodium content is low, a fact which is of considerable clinical importance because of the limited capacity of the newborn's kidneys to

deal with a heavy load of solute. Calcium and phosphorus, though lower than other milks, are supplied because of the ample intake of the milk. Iron content, though low in breast milk, is well-absorbed.

- Human milk contains specific immunological factors such as lymphocytes. These help in the production of immunoglobulin A (IgA).
- Breast milk contains antibodies that can protect the infant against infections such as *E. coli*. It is remarkable that human milk contains IgA antibodies which counter act against several antigens from microorganisms usually found in the gut. Other non-specific anti-infective factors in human milk are phagocytes, lactoferrin, lysozyme, lactoperoxidase and the *bifidus factors* (nitrogen-containing polysaccharides found in human milk). All these help in preventing infections in the breast-fed infant.
- Human milk has anti-allergic properties and is invaluable especially for infants who are at a high risk of developing atopic allergy. Breast-feeding of infants at risk, by avoiding foreign proteins, may diminish the risk of developing allergy.
- During breastfeeding the child is very close to the mother and this feeling of security and warmth forms a very strong, emotional bond between the mother and the child, which is not formed in any other type of feeding. The WHO has done a great deal to clarify the controversy regarding breast milk vs. infant formula milk. The large-scale advertisement campaign by the manufacturers of infant milk formulae has led many mothers to put their infants on formulae milk instead of breast feeding in spite of their ability to do so. Although, the sale of formula milk went up, the incidence of malnutrition and death in infants also rose due to their improper use. This led to a campaign by WHO to educate mothers all over the world to breast-feed their babies as far as, and as much as possible at least for three to six months. Cow's milk is recommended next for the infant. The composition of cow's milk as compared with mother's milk can be seen from Table 5.7.

Table 5.7 Composition of cow milk and breast milk

	<i>Water</i>	<i>Fat</i>	<i>Lactose (Milk sugar)</i>	<i>Protein</i>	<i>Mineral</i>
	<i>%</i>	<i>%</i>	<i>%</i>	<i>%</i>	<i>%</i>
Buffalo (Indian)	81.76	8.10	5.00	4.33	0.82
Cow (Indian)	85.28	5.67	4.69	3.69	0.76
Cow	87.70	3.61	4.65	3.29	0.75
Breast Milk	88.20	3.30	6.80	1.50	0.20

1. Bottle Feeding The objective in mixing a formula for feeding an infant is to modify cow's or buffalo's milk to make it as nearly like human milk as possible.

Since, the carbohydrate content of cow's milk is lower than that of human milk, dilution of cow's milk will have to be accompanied by addition of an external carbohydrate source, such as table sugar, to the formula. Hence, the ingredients of a dilution formula are milk, water and sugar. Initially the dilution of the formula may be more and as the number of feeds per day decreases, the dilution may be gradually reduced. Up to two weeks a 50 percent dilution may be required which may be

decreased to 25 percent by the time the infant becomes two months old. After two months the dilution may be decreased to give the child whole milk by the time he is five to six months old.

Care should be taken to use thoroughly boiled water for dilution. The feeding bottle and nipples should be boiled to sterilize them every time before using. A simple evaporated milk formula is usually the most economical one.

In any type of feeding the mother should hold the child upright and allow him to burp by gently patting his back.

2. Advantages and Disadvantages of Formula Feeding

(a) Advantages

- When the baby has some medical condition, it is important to know the volume of milk being received at each feed. Formula/bottlefeeding allows exact measurement.
- The baby who is receiving formula feeds is not affected if the mother is taking medications or is physically unable to breastfeed.
- The entire family can become intimately involved in all aspects of the baby's care, including feedings. It allows the mother to get more rest.
- Formula-fed babies actually need to eat somewhat less often since formula is less readily digested by the baby than human milk.

(b) Disadvantages

- It is expensive.
- No formula milk can exactly duplicate the ideal composition of breast milk.
- It does not contribute to the immunity-giving antibodies present naturally in breast milk.

3. Advantages of Breastfeeding (for Infants) The breastfed infants have several metabolic advantages over formula-fed infants, most importantly, providing natural protection because of the readily available antibodies in mother's milk. The other areas of protection are:

Infectious Morbidity: Several innate immune factors in milk provide protection against infection. Glycoproteins prevent binding of intestinal pathogens such as *Vibrio cholerae*, *Escherichia coli* and rotavirus. Glycosaminoglycans in milk reduce the risk of HIV transmission. Human milk lipids contribute to innate immunity, with activity against *Giardia lamblia*, *H influenzae*, group B streptococci, *S epidermidis*, respiratory syncytial virus (RSV), and herpes simplex virus type 1 (HSV-1).

Otitis media: Nearly 44% of infants will have at least one episode of otitis media in the first year of life; risk among formula-fed infants is doubled in comparison to infants who are exclusively breastfed for more than 3 months. Oligosaccharides prevent attachment of common respiratory pathogens, such as *Haemophilus influenzae* and *Streptococcus pneumoniae*, to respiratory epithelium. Oligosaccharides and antibodies in human milk provide protection from infection to common respiratory pathogens in the infant's environment.

Gastroenteritis and other digestive disorders: Bioactive factors in human milk appear to facilitate the more favourable gut colonization in breastfed infants. These oligosaccharides, cytokines and immunoglobulins regulate gut colonization and

development of gut-associated lymphoid tissue and govern differentiation of T-cells that play a role in host defence and tolerance.

Formula-fed infants face an increased risk of gastroenteritis and diarrhoea. In many cases, it may be also due to unhygienic conditions of handling and preparing the formula feeds. Premature infants who do not receive breast milk have been found to be at an increased risk of *Necrotizing Enterocolitis* (NEC).

Lower respiratory tract infections: Infants who are not breastfed face a very high risk of hospitalization for lower respiratory tract infection in the first year of life compared to infants who were exclusively breastfed for more than 4 months. The majority of respiratory hospitalizations for infants result from infection with RSV. Lipids in human milk appear to have antiviral activity against RSV.

Infants not breastfed are prone to elevated risks of childhood obesity, type 1 and type 2 diabetes, leukemia, and Sudden Infant Death Syndrome (SIDS). Formula feeding is associated with a higher risk of infant mortality compared with breastfeeding.

Formula-fed children are at a very high risk of developing asthma with a positive family history of asthma or atopic dermatitis and those infants without a family history of asthma are also at a high risk as compared to those who are breastfed for 3 months or more.

4. Advantages of Breastfeeding (for Mothers) For mothers, breastfeeding reduces the incidence of

- Pre-menopausal breast cancer
- Ovarian cancer
- Retained gestational weight gain
- Type-2 diabetes
- The metabolic syndrome

5. Feeding of Solid Foods (Supplementary Feeding) There is no set pattern for adding solid foods to the basic milk diet of the infant. Also, the individual needs and responses of the infants vary. However, when the infant has developed sufficient muscular coordination, involving the tongue and swallowing reflex to be able to eat solid foods, they may be introduced gradually.

Some do's and don'ts about introducing solid foods are as follows:

- Do not start solid foods until the infant is three to five months old. This timing is considered appropriate both from the developmental point of view as well as physiological and nutritional needs.
- Do not introduce more than one food at a time.
- The first supplementary foods should be those supplying iron and of smooth texture to be acceptable.
- Cereals in the form of puddings or *kheer* may be initially given along with cooked and strained mashed fruit.
- Egg may be given using at first only the egg white and gradually adding the yolk. Later, the whole egg may be given.
- Strained cooked vegetables, meat and potato may be added then. By the end of one year, the infant usually should consume a basic meal pattern of three meals and intervening snack.

- If the child refuses a food, do not force him to eat it. He may develop an aversion to it.
- Initially, very small portions of the food such as half to one teaspoon may be given and gradually the portion size may be increased.
- Check that the temperature of the food is neither too hot nor too cold.
- Avoid giving a heavily-spiced food to the child. Slight seasonings such as turmeric, coriander-cumin powder, asafoetida and cinnamon may be used.
- Feed the baby every day at the same time and in the same room with the other members of the family. A pleasant room and the company of the other family members enhances appetite and establishes a wholesome pattern for the future.
- Finger foods such as sticks of carrot, pieces of cucumber, a piece of meat, and toast should be given after six months when a coordination of the hand and mouth has been established and gums are getting tougher.
- If a new food has been refused by the child, it may be reintroduced a second time after some days. A new food should be introduced when the child is hungry.

A list of supplementary foods is given in Table 5.8.

Commercial weaning foods available in the market, such as Nestum, Cerelac, Farex, etc. are either rice-based or wheat-based. They contain besides cereal, milk powder. Sometimes they may be fortified with iron, B group vitamins as well as the fat-soluble vitamins. They are ready to serve and may be mixed with fruits or soft-cooked vegetables to enhance their nutritive value and appeal.

Table 5.8 Supplementary foods for infants

Name of the food	Age at which to introduce	Approximate quantity per feeding	Remarks
1. Fruit juice and soups, prepared using tomato, onion, carrot, spinach, <i>mung dal</i> and a little rice.	Five months	One to two teaspoons twice a day	All fruit juices may be given without adding sugar. Soups may be seasoned only with salt and a dash of pepper. A blob of butter may enhance taste. Quantity may be increased slowly to the acceptable limits.
2. Mashed banana, <i>chiku</i> , stewed apple, prepared, with cream, milk or as such, papaya—stewed or boiled, pear, mango.	Five months	One to two teaspoons twice a day	Banana or sour fruit may cause cough or cold especially in winter. Therefore, they may preferably be introduced in summer.

(Contd.)

(Contd.)

Name of the food	Age at which to introduce	Approximate quantity per feeding	Remarks
3. Porridge prepared using roasted <i>rava</i> with a little <i>ghee</i> and milk. Other cereals that can replace <i>rava</i> are <i>dalia</i> (broken wheat) <i>ragi</i> (<i>nachni</i>), sago, rice powder and custard, prepared using flavoured custard powder and milk.	One week after starting banana or any other fruit listed above	One to two teaspoons twice a day	Quantity may be increased every three to four days.
4. Soft boiled egg	One week after introducing porridge	One teaspoon yolk	Egg should be boiled for a minute and immediately cooled under running water to prevent discolouration. Gradually increase quantity of egg-yolk and include egg-white. By four weeks from the day egg was introduced the child should be able to eat one whole egg.
5. Mashed and well-cooked vegetables	One week after introducing egg,	One to two teaspoons twice a day	Potato, pumpkin, dark green leafy vegetables, carrot and peas, boiled to soften completely.
6. Curds	One week after introducing vegetables	Two to four teaspoons	Fruit yoghurts may also be given. Curds should be just enough set and not be too sour.
7. Mashed and well-cooked rice, <i>dal</i> or <i>khichdi</i>	One week after introducing curds	One to two teaspoons	Seasoned with a little <i>ghee</i> and may add a little oil or butter while serving. A dash of <i>haldi</i> may be used.

* Other foods that may be introduced are biscuits, *chapati* soaked in thin *dal* or in milk, bone marrow and minced meat, but without spices.

The nutritive value of commercial weaning foods is shown in Table 5.9. Compared to supplementary foods which are made with readily available food commodities at home, they are much more expensive. Home-cooked supplementary foods also

Table 5.9 Nutritive value of commercial weaning foods*

Name of product	Ingredients	Nutritive value (per 100 g)				
		Carbohydrate (g)	Protein (g)	Fat (g)	Iron (mg)	Cal.
1. Farex	Cereal powder, milk powder, sugar, vitamins, minerals	68	15.5	10.0	7.5	424
2. Nestum	Rice, sugar, vitamins, minerals	86	6.0	1.0	18.5	373
3. Cerelac	Milk, wheat flour, sugar, corn oil, minerals, vitamins	67.4	15.5	9.0	7.5	413

* As declared on the respective labels.

prepare the child for normal meals which he will soon be consuming along with the other family members and give him a sense of belonging.

□ Nutrition in Childhood

1. Toddler (One to Three Years) Growth during infancy is very rapid, and the dietary needs are correspondingly high. Toddlers eat less food and have less appetite. In the second year and through the years of childhood, the child's muscle development is more and bones begin to lengthen although the skeletal growth is slower. Hence, during this period the child needs less calories but more protein and minerals for growth. Teething continues from infancy to early childhood.

Food and Feeding As seen earlier, the emphasis in these years is on proteins, minerals and vitamins. If supplementation of the diet has been done carefully then the child consumes a three meal pattern diet but without heavy spices, oils and fats. So also all bran and coarse cereal must be avoided. It is necessary in the case of some toddlers who dislike milk, to feed them with curds or milk solids in mashed potatoes, soups, custards or puddings. On the other hand, some toddlers may drink more milk than required and exclude some solid food in the diet. For such children, food and mealtimes may be made more attractive so that acceptance of food is readily accomplished.

It must be emphasized here that refined sweets and fried foods must be totally avoided. A variety of foods must be offered in smaller amount to provide key nutrients.

The mother may encourage some degree of food choice and self-feeding so that eating can be a pleasant and positive means of development.

2. Pre-Schooler (Three to Six Years) Growth during this period is in spurts. While at times the child is engaged in continuous and active play, he is passive at other times. The mental capacities of the child are also being developed. His growth is fostered by a new environment in school.

During these years specific nutrients such as protein, calcium and iron need emphasis since bone growth and muscle development continues. Protein requirements also remain high. Vitamins, especially C and A, are required for growth and development of tissues.

Food and Feeding The pre-schooler demands a lot of variety in foods. Sometimes he may gorge himself, at other times he may appear disinterested in food. He generally prefers single foods with simple flavours rather than complicated foods and dishes such as heavily-spiced curries. The child appears to be interested in the texture, colour and form of the food. His need is to identify each food on the basis of its characteristics and name it. Finger foods such as raw fruit and vegetables cut in finger size are much acceptable in this age group.

Milk is less preferred by the pre-schoolers. The emphasis of the diet should be on quality and quantity. If a child is given smaller servings, a greater number of them may be consumed. As they prefer to do things by themselves, they should be given opportunities to do so.

In the nursery and school, there may be situations where group-eating habits are developed. In this age food habits widen and the child forms new relationships.

Table 5.10 shows a sample menu for a pre-schooler.

3. Young School Age (Six to Twelve Years) During this period the child's growth is not rapid but continues gradually. Boys and girls have to build up resources for the adolescent period that lies ahead of them, the period in which growth of every tissue is very rapid. Boys usually grow slower during these pre-adolescent years than girls.

Food and Feeding During this period the growth of the child is slow and the requirement of food per unit body weight is less. This decline continues until the preadolescence spurt. Likes and dislikes may have developed in the earlier years. Eating of snacks, especially in the mid afternoon, becomes increasingly common and it is here that the mother's role gains importance in offering a wide variety of nutritious meals and snacks.

A sample menu for a school-going child is shown in Table 5.11.

Some snacks that may be of interest to school-going children are listed here.

- Groundnut *chikki*
- *Chiwda* prepared with puffed rice or rice flakes with groundnuts
- *Besan laddoo*
- *Shakkarpara* (sweet)
- *Shakkarpara* (hot)
- *Sukhadi*
- *Thalipith*
- *Farsipuri* (with pepper)
- Bread butter with jam/cheese/egg
- *Coconut burfi*
- *Mawa cake*
- *Karanji*
- *Nankhatai*

- *Khakra*
- Toast and milk

4. Adolescent (Twelve to Eighteen Years) The adolescent period is characterized by the onset of puberty which is the final growth spurt of childhood. Maturation of children varies widely. Boys tend to mature later than girls. This fluctuation in development accounts for the wide differences in metabolic rates, in requirement of food and in scholastic capacity.

Table 5.10 Diet for toddler

Requirements: energy—1200 kcals; proteins—22 g

Food Exchange List			
<i>Food Group</i>	<i>No. of Exchanges*</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1. Milk	3	15.0	300
2. Legumes and pulse	1	6.0	100
3. Flesh food	1/2	5.0	50
4. Vegetable A	1	—	—
5. Vegetable B	1	—	50
6. Fruit	2	—	100
7. Cereal	4	8.0	400
8. Fat	2	—	200
(Use one exchange for nuts)			
9. Sugar	25 g	—	100
		34.0	1300*

Menu Plan			
<i>Breakfast</i>	:	Milk	— 1 glass
		Bread with butter	— 1 slice
		Egg boiled/fried	— 1
<i>Lunch</i>	:	<i>Chapati</i>	— 1/2 or <i>phulka</i> —1
		Rice	— 1/2 cup
		<i>Dal</i>	— 1/2 cup
		Potato curry	— 1 cup
		Curds	— 1/2 cup
<i>Midafternoon</i>	:	Banana or orange	— 1 small
		Milk	— 1 glass
		Two teaspoon roasted nuts	
<i>Dinner</i>	:	Tomato/ <i>palak</i> soup	— 1/3 bowl
		<i>Chapati</i>	— 1/2 or <i>phulka</i> —1
		Rice	— 1/2 cup
		Pumpkin vegetable	— 1/2 cup
		<i>Dal</i>	— 1/2 cup
		Curds	— 1/2 cup

* For a pre-schooler whose calorie requirements are 1500 kcals, increase 15 g sugar (60 kcals) and one exchange cereal (100 kcals).

Table 5.11 Diet plan for a school-going child
Requirements: energy—2000 kcal; proteins—40 g

Food Exchange List				
	<i>Food Group</i>	<i>No. of Exchanges*</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1.	Milk	3	15.0	300
2.	Legume and pulse	2	12.0	200
3.	Flesh food	1/2	5.0	50
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	2	—	100
7.	Cereal	8	16.0	800
8.	Fat	3	—	300
9.	Sugar	35 g	—	140
			48.0	1990

Menu Plan		
<i>Breakfast</i>	:	Bread toast — 2 slices with butter
		Egg omelette — 1
		Fruit milk shake — 1 glass
<i>Lunch</i>	:	Potato <i>paratha</i> — 1 medium
		Cucumber <i>raita</i> — 1/2 cup
		<i>Dal palak</i> — 1/2 cup
		Rice — 1/2 cup
		Curds — 1 cup
<i>Snacks</i>	:	Milk — 1 cup
		Cornflakes/Oats — 1/2 cup
		Banana/any seasonal fruit — 1
<i>Dinner</i>	:	<i>Phulka</i> — 4
		Mixed vegetables — 1 cup
		Rice — 1/2 cup
		<i>Dal</i> — 1 cup
<i>Bedtime</i>	:	Milk — 1 glass

* Quantities of the foods will vary according to the age.

The body changes in girls and boys are the result of the hormonal changes that regulate the development of sex characteristics. This difference in growth pattern also emerges as a difference in other aspects such as in the case of girls there is an increase in the accumulation of subcutaneous fat, especially, in the abdominal area. There is increased bone development, especially/around the pelvic region. Boys, although slow in growth, beat the girls in height and weight since they put on much more muscle mass and there is growth of the long bones. The sweat glands show more activity and acne of the face and back is a common problem in this age group.

Food and Feeding The adolescent period is characterized by heavy demands of calories and proteins. The appetite of the child increases and he tends to consume

more carbohydrate foods and fewer protein foods. The need for calcium and iron to support bone and muscle growth continues. In the case of girls, menstrual iron losses may predispose them to simple iron deficiency anaemia. Their needs, for iron are more than those of boys of similar age.

Since, the rate of metabolism is high, the need for iodine is also increased. This nutrient must be taken care of in areas lacking adequate iodine in soil and, therefore, in foods. It can easily be supplied through use of iodized salt. The B vitamins are required in greater amounts by boys than girls to meet their extra demands of energy and muscle tissue development. Intakes of vitamins C and A may be low due to improper habits of eating snacks.

It is necessary to take more care of girls than boys, who may be vulnerable to malnourishment. If the physical activity of a girl does not match her intake, it may result in excessive fat deposits.

Secondly, if she is figure-conscious she may follow some crash diets which will predispose her to malnutrition. The hazards of such crash diets can be gauged from the fact that her body is preparing itself for motherhood which in conditions of undernourishment or malnutrition can spell danger for the future mother.

A sample menu for an adolescent boy and girl is shown in Table 5.12.

5.10 NUTRITION FOR THE AGING AND THE AGED

We have seen the three phases of a normal life cycle pattern. Adulthood and the old age are the last phases of this life cycle.

The aging process continues throughout life. Although physical growth is completed by early adulthood, the body tissues and cells remain in a dynamic state, with catabolism slightly exceeding anabolism, resulting in a net decrease in the number of cells. Several theories have been put forward to ascribe the changes while aging to several factors. Aging is probably multifactorial, resulting from the interaction of several mechanisms.

After the years of adolescence which cause upheavals in the life of the person, the individual struggles to emerge as an adult who knows who he is and what his goals are.

Adulthood may be divided into three such phases. These are:

Young Adulthood	—	18 to 40 years
Middle Adulthood	—	40 to 60 years
Old Adulthood	—	60 to 80 years and above

□ Young Adulthood

It is a phase characterized by years of stress and also fulfilments. The person who can settle down comfortably will enter into marriage and build an intimate and close relationship with his spouse. These are years of building one's career, establishing one's own home, of parenthood and of bringing up young children through the same stages of life. In these years the adult struggles to make a niche for himself and his family.

Table 5.12 Diet plan for adolescent boy and girl (16–18 years old)*
RDI: energy—2820 kcal; proteins—53 g

Food Exchange List				
	<i>Food Group</i>	<i>No. of Exchanges*</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1.	Milk	4	20.0	400
2.	Legume and pulse	2	12.0	200
3.	Flesh food	1	10.0	100
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	4	—	200
7.	Cereal	12	24.0	1200
8.	Fat	4	—	400
9.	Sugar	50 g	—	200
			66.0	2800

Menu Plan				
<i>Breakfast</i>	:	Bread toast	—	3 slices with butter
		Poached egg	—	1
		Fruit milk shake	—	1 glass
<i>Lunch</i>	:	Potato <i>paratha</i>	—	2
		Cucumber salad	—	1/2 cup
		<i>Rajmah-urad usal</i>	—	1 cup
		Rice	—	1 cup
		Buttermilk	—	1 glass
<i>Snacks</i>	:	Milk	—	1 cup
		<i>Rava laddoo</i>	—	1
		Banana	—	1
<i>Dinner</i>	:	<i>Chapatis</i>	—	2
		Mixed vegetables curry	—	1 cup
		Rice	—	1 cup
		<i>Dal palak</i>	—	1 cup
		Curds	—	1/2 cup
<i>Bedtime</i>	:	Milk with protinules	—	1 glass

* For an adolescent girl reduce milk exchange to three and cereal exchange to eight.

□ Middle Adulthood

The children have now grown and there is an emptiness in one's life. It is a period in which the adult can reminisce on all that has passed in his life and he must come to terms with what life has offered. This period can be fulfilling if engaged in activities through which the adult regenerates his life in the lives of young persons following the same path.

□ Older Adulthood

This is the last stage of life. If the earlier years have been fulfilling, the older adult arrives at this phase equipped to face the problems that this age poses. If on the other

hand, there is no sense of completeness it torments the old person. He feels unneeded and unwanted.

Many families in our country are closely knit. The old in such homes have a sense of belonging, and are an essential part of the family. The old have been enriched by life's experience in their maturing process. Such old people in turn try to enrich the lives of others and such relationships are mutually rewarding.

□ Biological Changes in the Aging Process

As a person grows older his organs show reduced ability to perform physiological functions. This is because there is cell loss and reduced cell metabolism. For example, rate of blood flow through kidney is reduced by 65 percent. In a glucose tolerance test, the blood sugar level takes a longer time to return to the normal level. Such and similar changes take place while aging.

Some changes, that take place in old age may affect food patterns, such as decreased secretion of digestive juices, decreased motility of the gastro intestinal tract and decreased absorption and utilization of nutrients.

□ Problems of the Aging process

It is necessary to take into consideration the changes that ageing brings with it. Generally, the elderly have a higher percentage of body fat, a lower lean body mass, and a lower calorie requirement. The decrease in calorie needs depends on health status and activity levels.

Eating patterns in the elderly are determined by many physical, mental, and emotional factors, such as impaired vision, smell, hearing, taste, poor teeth or ill fitting dentures. There is decreased dexterity and work capacity, poor memory; loneliness and depression; illness and multiple medications; limited financial resources; and problems of mobility and transportation.

Foods which are fibre-rich, such as fresh fruits, vegetables, or whole-grain cereals or breads, are more difficult to chew. The aged thus, tend to eat foods low in fibre, high in sugar and fat. Depression and physical limitations can limit access to food or their ability to prepare it.

It is best to keep the meal-planning regimen of the elderly simple. Nutritional goals should be to provide simple, balanced, consistent meals that fit their eating habits and their physical and psychological needs. It is futile trying to change their long-standing food habits. It must be remembered that many elderly have the time and interest in their health management and will eagerly follow instructions.

□ Nutritional Requirement of Adults

The requirement for all nutrients continues. If the dietary habits have been well formed and set during adolescence then it is necessary to maintain the same pattern even in adulthood since the same body processes are taking place in the adult years.

1. Calorie Requirement (Energy Requirement) The requirement for calories decreases with advancing age. After the growth spurt seen in adolescence the energy requirements decrease steadily. This is because the basal metabolism of an adult is reduced, accompanied by decrease in his physical activities.

Thus, after the age of 23 years, the calorie requirement is decreased by 7.5 percent for every 10 years. The calorie requirement then can be considered adequately met for the adult if he maintains his *normal* weight. However, the calorie requirement for two individuals of the same age will be different because the physical and physiological activity of each individual varies.

2. Carbohydrates Since, the calorie requirement of adults is lowered, it is necessary to control the intake of carbohydrates especially the simple sugars like table sugar and glucose. Consumption of complex carbohydrates can be encouraged to include foods such as whole grain cereals, potatoes and dried legumes in the diet. These foods should supply about 40 to 50 percent of the total calorie requirement. About 5 to 10 percent of the total energy requirement may come from sugars. It is important to include high amounts of soft fibre foods in the diet especially for the older adults since, it helps to maintain the intestinal function and prevent constipation.

3. Fats It is necessary to consume fats comprising about 10–15 percent of the total calorie intake. This is because many adults are prone to heart disease for which this preventive measure needs to be paid attention to. Serum cholesterol levels increase after the age of 50 years. Therefore, one should completely avoid foods containing high levels of cholesterol such as egg yolk, whole milk, organ meats, etc. Adequate use of polyunsaturated fats, less or no fried foods and trimmings of all visible fats from meats would minimize the intake of saturated fats.

4. Proteins The rate of protein synthesis decreases every year as age advances. No new tissue is formed except that there is maintenance of worn out tissues. The requirement for dietary protein decreases by about 30 percent. It is necessary to supply protein at about 15–20 percent of the calorie requirement. This applies to people who have good health and do not suffer from any problems. Older persons suffering from gastro-intestinal problems, infection or changed metabolic efficiency as a result of disease or medication should increase their protein intake appropriately.

5. Vitamins The requirement for these is similar as for adults. However, due to the normal aging process, the ability to store fat-soluble vitamins decreases. The problem of vitamin deficiency in the old may stem from inadequate intake rather than from increased need. The need for the fat-soluble vitamins, especially A and D, may be met easily through the diet but their absorption and storage may be hampered due to lack of dietary fat, inadequate bile secretion, use of laxatives and antibiotics, and/or pancreatic insufficiency.

Special attention needs to be given to vitamin D since, bone decalcification is very common in the later years. If its requirement is not met through the diet, supplements may have to be given. Other fat-soluble vitamins may be supplied through diet.

Older adults may require supplementation of B vitamins especially thiamine, pyridoxine, cyanocobalamin, and folic acid because their daily food intake is decreased, hence, the decreased intake of dietary vitamins. The increased needs for these vitamins may be due to less efficient absorption or altered metabolism and excretion resulting not only from physiological change but also from certain medications. (Refer to Table 7.1 on drug-nutrient interaction in Chapter 7.)

6. Minerals Special attention needs to be given to two minerals, iron and calcium, since, these may be lacking in poor diets and may need to be supplemented. The requirement of iron for women may be higher than that of men until they attain menopause. But after completion of menopause their requirement for iron is similar to that of men.

Absorption of calcium decreases with age, resulting in osteoporosis and fragile bones which fracture easily. Calcium is also important for maintaining health of the oral tissues.

7. Water The need for this important nutrient factor varies with the environment. Adequate amounts of fluids should be consumed every day. In most old persons this is ignored resulting in decreased urine output and constipation.

5.11 COMPLICATIONS COMMONLY OCCURRING IN LATE ADULTHOOD

□ Overweight and Obesity

These two are a cause for concern since, they make the adult prone to other more dangerous diseases such as heart diseases. This is so because the adult continues his food habits as in the developing years or younger age, which results in accumulation of fat and, finally obesity. Such individuals should be persuaded to reduce energy intake before it is too late.

□ Diabetes Mellitus

This disease is characterized by high levels of sugar in blood and urine due to inadequate supply of insulin in the body. Onset of diabetes during maturity normally sets in after the age of 40. Diabetes has shown to have an adverse effect on almost all systems of the body. Diabetes in middle and old adulthood can usually be controlled by diet, weight loss and medication. Insulin therapy is very rarely necessary.

□ Digestive System Concerns

Dentition is a matter of concern since most people lose all their teeth above the age of 65 years. Chewing, therefore, becomes very difficult. Those who have satisfactory artificial dentures do not face much problems, but those who have ill-fitting dentures or those who cannot afford them cannot chew food and this limits their food intake.

□ Peptic Ulcer

Ulcers are lesions or scars in the lining of the gastrointestinal tract. Gastric ulcers occur in the stomach while duodenal ulcers are located in the upper part of the small intestine. Ulcers may cause gastric discomfort for several hours after eating, when the stomach is empty and its excessive acid content is in direct contact with the stomach or intestinal lining.

Treatment for ulcers consists of rest, antacid therapy and regular and frequent bland meals.

□ Gall-Bladder Disease

The incidence of this disease increases with age. Formation of cholesterol-containing gall stones may necessitate the removal of the gall bladder. A high fat diet aggravates the pain of such people, hence, a low fat diet is recommended. Surgical removal of the gall bladder helps such persons to revert to their normal diet.

□ Malabsorption

Malabsorption is the inability of the body to absorb nutrients. This often occurs in the case of vitamin B₁₂ and calcium due to advancing age, possibly as a result of lower gastric acidity.

□ Diverticulosis

Occurs when pouching (diverticulosis) forms in the intestinal wall due to intraluminal pressure. This disease is accompanied by severe pain. Lack of dietary fibre has been pointed to as a contributing factor.

□ Constipation

May result due to intake of foods containing low amounts of fibre or roughage, such as processed foods and easy to chew foods. It is also a side effect of constant intake of antacids that contain aluminium and carbonates. The treatment preferred for constipation is consumption of high-fibre foods which increase the bulk of stools and reduce transit time through the gastrointestinal tract. Such a diet should be accompanied by a generous fluid intake and exercise.

□ Anaemia

Reduced levels of haemoglobin in the red blood cells means anaemia. Nutritional anaemia occurs more often in older people due to multiple deficiency of iron, protein, B₁₂, folacin and/or ascorbic acid along with reduced gastric acidity.

□ Atherosclerosis and Coronary Heart Diseases

These diseases result due to narrowing of the blood vessels because of accumulation of fatlike substances such as cholesterol, resulting in reduced blood supply to the organs which then cannot function optimally. When such a condition occurs in case of arteries leading to the heart it can result in heart attack and ultimately heart failure.

Many causative factors have been pointed at, which lead to atherosclerosis and coronary heart diseases. They are obesity, stress, lack of exercise, smoking, excessive dietary cholesterol, saturated fat and sodium, excessive intake of cola, alcohol and caffeine found in all stimulating beverages. Men as well as women face the risk of coronary heart diseases. Timely diagnosis can respond to medication, weight loss and nutritional management as well as to behavioural and life style changes to reduce stress and other contributing factors.

□ Hypertension

Increased blood pressure is implicated as a risk factor for coronary heart disease. Lowered intake of sodium can lower the blood pressure and so also can weight loss.

□ Bones and Joints

Diseases of the joints and bones are common afflictions of the old. Diseases such as arthritis which affect the joints are osteoporosis and osteomalacia which reduce bone mass occur in many persons in their middle and later years. No nutritional therapy has been devised for arthritis except weight control to minimize the burden on joints and aspirin taken with food, milk or an antacid.

Osteoporosis and osteomalacia are due to decrease in the calcium content of the bones. While the former affects women mainly due to relative estrogen deficiency, physical inactivity and inadequate calcium intake, the latter affects older adults who do not drink milk or get enough sunlight or who have conditions which interfere with calcium absorption, such as liver or kidney disease, or who take anticonvulsions medication.

Treatment of both these deficiency diseases is to use calcium and vitamin D supplements.

□ Osteoporosis

Osteoporosis is the most common disease in the world, and it is becoming even more significant as the global population grows and ages. The World Health Organization (WHO) has identified the bone disease as a “priority health issue” along with other major non-communicable diseases.

According to the International Osteoporosis Foundation, the lifetime risk for a woman to have an osteoporotic fracture is 30–40%. The prevalence of osteoporosis in men is higher than previously thought, with approximately 20% men affected.

1. Osteoporosis is Both Preventable and Treatable Unfortunately, many people are not diagnosed in time to receive effective therapy during the early phase of the disease, because there are no warning signs before a fracture occurs.

Following are the recommendations for prevention, risk assessment, diagnosis and treatment of postmenopausal osteoporosis, based on guidelines published by the National Osteoporosis Foundation (NOF) <http://www.nof.org/phsguide/>.

2. Risk Assessment Characterized by low bone mass, microarchitectural deterioration, compromised bone strength, and an increase in the risk of fracture, osteoporosis is often defined clinically by an intermediate outcome: low Bone Mineral Density (BMD).

Bone Mineral Density (BMD) measurements are effective in assessing fracture risk, confirming a diagnosis of osteoporosis and monitoring the effect of treatment.

After menopause, all women should be evaluated clinically for osteoporosis risk in order to determine the need for BMD testing. The more risk factors a woman has, the greater her risk of fracture.

The major factors, associated with an increased risk of osteoporotic fracture in post-menopausal woman are

- Personal history of fracture as an adult.
- History of fragility fracture in a first-degree relative.
- Low body weight (< 127 lbs)
- Constant smoking.
- Use of oral corticosteroid therapy for more than 3 months.

Additional risk factors include impaired vision, estrogen deficiency at an early age (< 45 years), dementia, poor health, recent falls, lifetime low calcium intake, a sedentary lifestyle, and high alcohol consumption.

Osteoporosis can also result from numerous medical conditions and certain medications, including anticonvulsants, cytotoxic drugs, gonadotropin-releasing hormone antagonists, lithium, long term heparin use, and tamoxifen.

3. Diagnosis In general, BMD testing should be performed on all women aged 65 and older, regardless of risk factors, younger postmenopausal women with one or more risk factors, and postmenopausal women who present with fractures (to confirm diagnosis and determine severity of the disease).

It is important to note that women with slight builds will usually have a lower BMD. In addition, metabolic bone diseases other than osteoporosis, such as hyperparathyroidism or osteomalacia, may also be associated with a low BMD.

The following tests are good predictors of future fracture:

- Dual X-ray Absorptiometry (DXA)
- Peripheral Dual X-ray Absorptiometry (pDXA) and Single-energy X-ray Absorptiometry (SXA)
- Quantitative Computed Tomography (QCT)
- Ultrasound densitometry

Markers of bone turnover in the serum or urine are sometimes used to help assess risk of fracture, predict bone loss, or assess response to antiresorptive therapy. However, biochemical marker tests cannot replace BMD testing. Several interventions to reduce fracture risk include an adequate intake of calcium and vitamin D, lifelong participation in regular weight-bearing and muscle-strengthening exercise, avoidance of tobacco use, identification and treatment of alcoholism, and treatment of other risk factors for fracture such as impaired vision.

4. Treatment Considerations Before initiating drug therapy, it is important to counsel all patients about reducing risk factors and adhering to universal recommendations about calcium, vitamin D, and exercise. Physicians should also evaluate patients for secondary causes of osteoporosis and have central DXA measurements, when available.

FDA-approved pharmacologic options for the prevention and/or treatment of postmenopausal osteoporosis include, bisphosphonates (alendronate, alendronate plus D, ibandronate and risedronate or risedronate with 500 mg of calcium as the carbonate), calcitonin, estrogens (estrogen and/or hormone therapy), parathyroid hormone [PTH (1–34), teriparatide], and selective estrogen receptor modulators or SERMs (reloxifene).

5. Monitoring Treatment Osteoporosis needs lifelong management. It is important that patients adhere and be encouraged to comply with their therapies to reduce fracture risk.

Changes can be monitored every year during pharmacologic therapy for osteoporosis. It is important to note that the drugs may decrease a patient's risk of fracture even when there is no apparent increase in BMD. As with most tests, BMD has some precision error.

Biochemical markers of bone turnover can be used to monitor response to treatment. The decrease in turnover and the increase in BMD induced by antiresorptive therapies contribute to their antifracture efficacy. Biochemical markers show considerable variability within individuals such that fairly large changes are required to indicate a treatment effect; however, with antiresorptive therapy, the changes are often substantial.

It must be remembered that with increasing life expectancy, osteoporosis will continue to increase in prevalence.

□ Neurological Disorders

1. Alzheimer's Disease Alzheimer's disease is a brain disorder named for German physician Alois Alzheimer, who first described it in 1906. Some features about Alzheimer's:

- **It is a progressive and fatal brain disease.** All over the world several million people are living with Alzheimer's disease. Alzheimer's destroys brain cells, hence there are problems with memory (which are the characteristic of Alzheimer's) and even thinking and behaviour. These may be severe enough to affect work, lifelong hobbies or social life. It gets worse over time, and it is fatal.
- **It is the most common form of dementia.** Dementia is the general term for loss of memory and other intellectual abilities of a person which can be serious enough to interfere with daily life. Vascular dementia is caused by reduced blood flow to parts of the brain. In mixed dementia, Alzheimer's and vascular dementia occur together. A person could be in any stage of dementia—early, middle or late. Experts estimate that today several people in their 30s, 40s and 50s have Alzheimer's disease or a related dementia.
- **It has no cure presently.** However, there are some treatments for some symptoms. Most important is the availability to the right services and support. There is a worldwide effort to find better ways to treat the disease, delay its onset, or prevent it from developing.

Causes The abnormality in the brain is found to develop due to the plaques build up between nerve cells. They contain deposits of a protein fragment called beta-amyloid. Tangles are twisted fibres of another protein called tau. The plaques and tangles tend to form in a predictable pattern, beginning in areas important in learning and memory and then spreading to other regions. It is believed that somehow they block communication among nerve cells and disrupt activities that cells need to survive.

In the early-stage of Alzheimer's disease there are problems with memory, thinking and concentration. Individuals in the early-stage need very little assistance with simple daily routines. The term younger-onset refers to a person under age 65. Since, such individuals may be employed or have dependent children, there are numerous issues which the family has to cope with.

2. Parkinson's Disease (PD) Parkinson's disease is a motor system disorder. It occurs as a result of the loss of dopamine-producing brain cells.

The four primary symptoms of PD are:

- tremor, or trembling in hands, arms, legs, jaw, and face;
- rigidity, or stiffness of the limbs and trunk;
- bradykinesia, or slowness of movement;
- and postural instability, or impaired balance and coordination.

As these symptoms become more pronounced, patients may have difficulty walking, talking, or completing simple tasks. This disease usually affects people over the age of 50. Early symptoms are subtle and occur gradually. In case of some people the disease progresses more quickly than in others. As the disease progresses, the shaking, or tremor, which affects the majority of PD patients may begin to interfere with daily activities. Other symptoms may include depression and other emotional changes; difficulty in swallowing, chewing, and speaking; urinary problems or constipation; skin problems; and sleep disruptions.

Presently, there are no laboratory tests to diagnose sporadic PD. Hence, the diagnosis is based on medical history and a neurological examination. Doctors may sometimes refer to the brain scans or laboratory tests of patients in order to rule out other diseases.

Treatment At present, there is no cure for PD, but a variety of medications provide dramatic relief from the symptoms. Usually, patients are given levodopa combined with carbidopa. Carbidopa delays the conversion of levodopa into dopamine until it reaches the brain. Nerve cells can use levodopa to make dopamine and replenish the brain's dwindling supply. Although levodopa helps several Parkinsonian cases, not all symptoms respond equally well to the drug. Bradykinesia and rigidity respond best, while tremors may be only marginally reduced. Problems with balance and other symptoms may not be alleviated at all. Anticholinergics may help control tremor and rigidity. Other drugs that are being tried are bromocriptine, pramipexole, and ropinirole,

In some cases, surgery may be required. A therapy called Deep Brain Stimulation (DBS) is used in which, electrodes are implanted into the brain and connected to a pulse generator that can be externally programmed. DBS reduces the need for levodopa and related drugs, which in turn decreases the involuntary movements called dyskinesias that are a common side effect of levodopa. It also helps to alleviate fluctuations of symptoms and to reduce tremors, slowness of movements, and gait problems. DBS requires careful programming of the stimulator device in order to work correctly.

PD is both chronic and progressive. Its symptoms grow worse over time. While some people become severely disabled, others experience only minor motor disruptions. Tremor is the major symptom for some patients, while for others tremor is only a minor complaint and other symptoms are more troublesome. The symptoms and the intensity of the symptoms also varies from person to person.

Presently, research in this field is using animal models to study how the disease progresses and to develop new drug therapies. Scientists are looking for the cause and to search for possible environmental factors, such as toxins, that may trigger the disorder, and also study genetic factors. Work is on to develop new protective drugs that can delay, prevent, or reverse the disease.

A sample menu for an old person is shown below.

Table 5.13 Diet plan for an old person (60–80 years)
 Energy requirement for a 65 years old—1757 kcals*
 Protein—55 g

Food Exchange List				
	<i>Food Group</i>	<i>No. of Exchanges</i>	<i>Protein (g)</i>	<i>Energy (kcal)</i>
1.	Milk	4	20.0	400
2.	Legumes and pulses	2	12.0	200
3.	Flesh food	1/2	5.0	50
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	2	—	100
7.	Cereal	6	12.0	600
8.	Fat	2	—	200
9.	Sugar	25 g	—	100
			49.0	1750

Menu Plan													
<i>Tea</i>	: 1 cup												
<i>Breakfast</i>	: <table> <tr> <td>Bread</td><td>— 3 slices with 1/2 tsp butter</td></tr> <tr> <td>Egg (soft-boiled)</td><td>— 1</td></tr> <tr> <td>Milk</td><td>— 1 cup with sugar</td></tr> <tr> <td>Banana</td><td>— 1 small</td></tr> </table>	Bread	— 3 slices with 1/2 tsp butter	Egg (soft-boiled)	— 1	Milk	— 1 cup with sugar	Banana	— 1 small				
Bread	— 3 slices with 1/2 tsp butter												
Egg (soft-boiled)	— 1												
Milk	— 1 cup with sugar												
Banana	— 1 small												
<i>Lunch</i>	: <table> <tr> <td><i>Chapati</i></td><td>— 1</td></tr> <tr> <td>Rice</td><td>— 1/2 cup</td></tr> <tr> <td><i>Dal</i></td><td>— 1 cup</td></tr> <tr> <td><i>Alu palak</i></td><td>— 1 cup</td></tr> <tr> <td>Curds</td><td>— 1/2 cup</td></tr> <tr> <td>Orange or sweet lime</td><td>— 1</td></tr> </table>	<i>Chapati</i>	— 1	Rice	— 1/2 cup	<i>Dal</i>	— 1 cup	<i>Alu palak</i>	— 1 cup	Curds	— 1/2 cup	Orange or sweet lime	— 1
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<i>Bedtime</i>	: <table> <tr> <td>Warm milk</td><td>— 1 cup</td></tr> </table>	Warm milk	— 1 cup										
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* Energy requirements at 25 years of age is 2400 kcals. For every 10 years, decrease energy requirements by 7.5 percent.



SUMMARY

Infancy, childhood, adolescence, adulthood and old age are the various stages in a life cycle. A balanced diet at every stage can be beneficial to the health and well-being of a person. A pregnant and lactating mother has greater responsibility towards the health

of her child since her nutritional status during these periods affects the baby's physical and mental development. Balanced diets for every stage of life have been specified.



CASE STUDIES

- I** A young pregnant woman, aged 27 years and in her third trimester, has approached you for advice about improving her weight since she is slightly underweight. She is suffering from morning sickness and showing signs of toxæmia. She is also slightly anaemic. Write a note as to how you will guide her for the same.
- II** A lactating mother needs information on supplementary feeding for her 5-month-old infant. Can you guide her? Give the steps which she should follow for successful weaning.
- III** Plan a week's menu for a 7-year-old boy who carries a lunch tiffin to school everyday. Also, list out snacks that his mother can cook to feed him when he returns from school in the evening.
- IV** A BPO executive is suffering from hyperacidity and complains of a burning sensation in the epigastric region. State what dietary and lifestyle changes he needs to make.
- V** A woman aged 72 years is living by herself and cooks her own food. She has lost all her teeth and suffers from constipation. She is also slightly hypertensive and has hypothyroidism since the last 5 years. Outline the following:
 1. Foods which she should use more often.
 2. Dietary and lifestyle changes which she needs to make in order to be able to overcome the problem of constipation.
 3. Hints to manage hypothyroidism.



REVIEW QUESTIONS

1. What is a balanced diet?
2. What are the five important stages in a man's life cycle?
3. Why is it important for a pregnant woman to meet her additional nutritional requirements adequately?
4. What is the importance of mother's milk to an infant?
5. What are the advantages of breast-feeding to the lactating mother?
6. What precautions must be exercised in early adulthood in order to ensure a healthy old age?

Chapter

6



Nutrition for Fitness and Sports

Today, the competitive sportsman has been made aware of the important role that nutrition can play in both training as well as competition. There is clear evidence to show that improved eating habits not only benefit health but also influence an individual's endurance and capacity to perform exercise. Changing your diet will not automatically make you run faster or jump higher. Diet is just one of the many factors involved in improving athletic performance.

Exercise is the master conditioner for the healthy and a major therapy for the ill. Fitness implies a dynamic homeostasis, the ability to respond to life's physical, emotional and social demands. Exercise allays anxiety with resultant relaxation. It is nature's sedative for the tense and tired individuals.

Mild exercise consumes calories without increasing food intake, thus slowly but steadily reducing body weight. More strenuous exercise increases food intake but within limits—only enough to offset the increased metabolism and, therefore, no weight increase follows.

Goals of persistent and strenuous exercise are an improvement of the organic vigour, the performance, the physique and the participation of the individual as an effective member of his home and his wider social group.

Sports and energy consuming recreational activities endow several benefits to the body, which include flexibility, coordination, equilibrium, agility, speed, strength and endurance.

6.1 FITNESS AND ITS MEASUREMENT

Fitness can be gauged through conducting various tests, i.e. performing tasks and measuring the score, which can be compared with standards, and ranking can be done. The ranking is generally descriptive, i.e. (1) Fair, (2) Good, (3) Very good, and (4) Excellent. The scores vary with weight, height, age, sex, etc. The scores given here are for normal average adults.

Several commonly used terms with reference to sports are:

1. Flexibility
2. Coordination
3. Equilibrium
4. Speed
5. Agility
6. Strength
7. Endurance

Their description and test performed to gauge the ranking is as follows:

Note: Each of these test actions has to be performed with ease and without stretching or straining.

1. Flexibility It is the ability to move the body easily and smoothly during various actions such as bending, twisting and stretching. Ease of action and capacity to reach various positions without injury is a measure of flexibility.

Test Stand with your feet together and bend down slowly to touch toes and floor without bending your knees. Do not bounce.

Score Fair: Touch toes easily.

Good: Touched floor.

Very good: Touched knuckles to floor.

Excellent: Touched palms flat to floor.

2. Coordination It is the smooth working of the entire body. It involves coherent and meaningful movements of the organ to achieve a particular task or goal. For example, the combined action of eyes and hand to hit the moving the ball in cricket, tennis, volleyball, football, etc. Coordination improves with practice.

Test Stand about six feet from a flat wall. Using one hand toss a tennis ball underhand against the flat wall. Catch the ball with the other hand and quickly toss it back. Repeat this action speedily in succession. Keep a count of the number of catches in one minute.

Score Fair 48–50 catches

Good: 54–56 catches

Very good: 62–64 catches

Excellent: 70–72 catches

3. Equilibrium It is the ability to balance oneself without much swaying or losing balance.

Test Stand on your toes. Stretch you hands in front of or above your shoulders, touching the ears and try to stay in this position as long as you can. Time yourself.

Score Fair: 15 seconds

Good: 20 seconds

Very good: 25 seconds

Excellent: 30 seconds

4. Speed A measure of movement of the body parts, e.g. to run, chase, etc.

Test Run 100 m and time it.

Score Fair: 20 seconds

Good: 18 seconds

Very good: 16 seconds

Excellent: 14 seconds

5. Agility It is the quickness of reaction with fast and sure movements. Springing to your feet, and dodging are examples of being agile.

Test Use a skipping rope. Keep a track of the number of times you can skip without tripping in one minute.

Score Fair: 90 skips

Good: 110 skips

Very good: 130 skips

Excellent: 150 skips

6. Strength It is the ability to use muscle power to lift, push, pull, etc.

Test It can be tested by static or dynamic methods. There is no correlation between the result of these two methods. Here, the scores are based on the hand grip dynamometer. Readings are in kilograms.

Score	Males	Females
Fair	49–52	29–31
Good	53–55	32–34
Very good	56–58	34–36
Excellent	59+	36+

7. Endurance It is the most important test of physical fitness. Even if you are excellent or very good or good in all the other tests, poor endurance can be a sign considered as being physically unfit. It is the ability of the body to withstand stress for a prolonged period of time: the shorter the time, the poorer the endurance; the longer the time, the stronger the endurance. Performance of the heart and oxygen carrying capacity of the blood mainly determines the endurance. It depends on the number of times the person can repeat the movement. It is measured in terms of floor push-ups, pull ups (chin-ups), dips on the parallel bars, sit-ups and squat jumps.

The score depends upon the type of movement and strength of the body.

Score: (Number of pushups)

	Males	Females
Poor	Less than 10	Less than 7
Fair	15	12
Good	20	15
Very good	25	18
Excellent	30	21

It can also be measured in terms of time taken to cover a fixed distance or the distance covered in a fixed given time by normal speed of walking. Under any circumstances returning to normal breathing and heartbeats within 10 minutes after the test is an indication of good and normal health (cardiovascular performance).

6.2 OBJECTIVES OF NUTRITIONAL MANAGEMENT

1. To provide adequate nutrients in terms of energy, protein, vitamins and minerals according to the individual needs.
2. To maintain fluid and electrolyte balance for optimum performance and also for proper hydration (to prevent dehydration).
3. To formulate tailor-made diets ideal for the sports person during training, competitions and after competitive sports.

Performance is an intricate combination of factors like heredity, training, nutrition and coaching.

The hereditary factors cannot be controlled, but all the other factors can be combined for optimal performance.

6.3 MEASUREMENT OF BODY COMPOSITION

The composition of an individual's body can be measured directly and indirectly. The methods used are as follows:

1. Direct Methods These are not performed on live subjects and involve measurement of body fat and fat-free components of the body. This requires chemical analysis of the animal carcass or human cadaver. One technique uses a chemical solution, which literally dissolves the body for determining the fat-free components of the mixture.

Another technique involves the physical dissection of fat, fat-free adipose tissue, muscle and bone. Such analyses are not only time consuming but tedious and require highly specialized laboratory equipment. Also, since they involve post-mortem methods, they raise ethical questions and legal problems and cannot be used for live subjects.

2. Indirect Methods Hydrostatic weighing (weighing a person under water) can be used to compute the body fat from the body density. This method can be used on live subjects. Other procedures used to predict body fat are measurement of skin fold thickness and girth, x-ray, total body electrical conductivity or impedance, near infra-red interactance, ultrasound, computed tomography, air plethysmography and Magnetic Resonance Imaging (MRI).

6.4 METHODS OF MEASURING ENERGY EXPENDITURE

Since, an athlete's success depends largely on his body's capacity for peak performance, energy metabolism plays a key role.

There are two main methods of measuring energy expenditure. These are:

1. Directly, i.e. by measuring heat given off by the body.
2. Indirectly, i.e. by measuring the rate at which oxygen is consumed.

Measuring heat production is the most appropriate way of determining energy expenditure but practically it has several drawbacks. Hence, the latter method is used to measure the rate of metabolism.

Oxygen uptake (VO_2) of an individual at rest is relatively low, i.e. around 0.2 to 0.4 litres per minute. It is determined by collecting the air exhaled by an individual, at rest or during exercise, and measuring the amounts of oxygen removed from the atmosphere and CO_2 produced. The highest VO_2 achieved is designated as the maximal oxygen uptake ($\text{VO}_2 \text{ max}$). $\text{VO}_2 \text{ max}$ is determined primarily by hereditary factors although training can influence it to a certain extent. The greatest $\text{VO}_2 \text{ max}$ is seen in the elite endurance athletes, especially rowers, cyclists and marathon runners who record values as high as five to six litres per minute. In contrast, $\text{VO}_2 \text{ max}$ for an untrained individual is generally around two to three litres per minute.

6.5 SOURCES OF ENERGY IN THE BODY

Our body's ability to obtain energy from food nutrients and transfer the energy to the contractile elements in the skeletal muscles determines our capacity to swim, run, cycle and ski long distances at high intensity. The energy is obtained from carbohydrates, fats and proteins.

The following table shows the approximate contribution of these macronutrients in energy metabolism, at rest and during various intensities of exercise:

<i>Nutrient</i>	<i>At rest</i>	<i>Light/moderate exercise</i>	<i>High-intensity, short duration exercise (e.g. sprint)</i>	<i>High-intensity, long duration endurance exercise</i>
Protein percent	2–5	2–5	2	5–8
Glucose and glycogen percent	35	40	95	70
Fat percent	60	55	3	15

- Average values based on various reports.

Energy transfer occurs through many complex aerobic and anaerobic biochemical reactions that require macro and micronutrients along with a continual supply of oxygen, if the process is aerobic.

Activities are of different types, and the energy pathway that will be used by the body depends upon the speed with which the energy is demanded by the action and nutrient available for its release, as well as the stores of the body.

Table 6.1 depicts the energy pathway used by our body according to the energy requirements of the sporting event.

Aerobic pathway requires oxygen in the energy reaction while anaerobic pathway involves chemical reactions that generates energy rapidly for short duration without oxygen.

Rapid energy transfer maintains a high standard of performance in maximal short-term efforts such as sprinting in track sports and swimming or repeated stop-and-go sports like soccer, basketball, water polo, lacrosse, volleyball and field hockey.

Therefore, anaerobic and aerobic breakdown of ingested food nutrients supply energy in order to synthesize the fuel, which powers all forms of biological work.

Table 6.1 Energy pathways used by the body for various sporting events

S. No.	Event	Duration	Energy source	Fuel used
1.	Sprinting—100 m dash, throws, jumps, weightlifting, ski-jumping, diving, vaulting in gymnastics	Up to 10 secs	Anaerobic—Alactic ATP produced absence of oxygen	Phosphate system (ATP and C P stored in muscle)
2.	Swimming—100 to 400 m; speed skating 800 m; most gym events; 100 m cycling track	10 to 40 secs	Anaerobic—lactic acid system	Glycogen to lactic acid
3.	Swimming 100 m, track 800 m, canoeing 500 m speed skating 100-m floor exercising—gymnastics, alpine skiing, 1000 m cycling track	40 secs to 2 mins	Aerobic pathway	Glycogen completely utilized in the presence of oxygen
4.	Middle-distance swimming, speed skating, canoeing 100 m, boxing, wrestling, martial arts	2 to 6 mins	Aerobic pathway	Glycogen completely utilized in the presence of oxygen
5.	Long-distance track, swimming, speed skating, canoeing, cross country skiing, rowing, cycling, road racing	Up to 2 hours	Aerobic pathway	Fats utilized in the presence of oxygen
6.	All events at no. 5	Up to 3 hours	Aerobic pathway	Proteins utilized in the presence of oxygen

Biological work may be of three types, namely:

- Mechanical, such as muscle contraction;
- Biochemical, such as synthesizing cellular molecules; and
- Transport work that concentrates substances in the Extra Cellular Fluid (ECF) and Intra Cellular Fluid (ICF).

Figure 6.1 is depicting the metabolism of nutrients in various pathways.

□ Energy Phosphate Bonds

The ATP molecule is present in all body cells and is used for all cellular activities including muscle contraction. It carries free energy obtained from carbohydrates, proteins and fats. The energy is released in the following manner:

All inter-conversions are possible as seen in the figure, except fatty acids which cannot contribute to glucose synthesis.



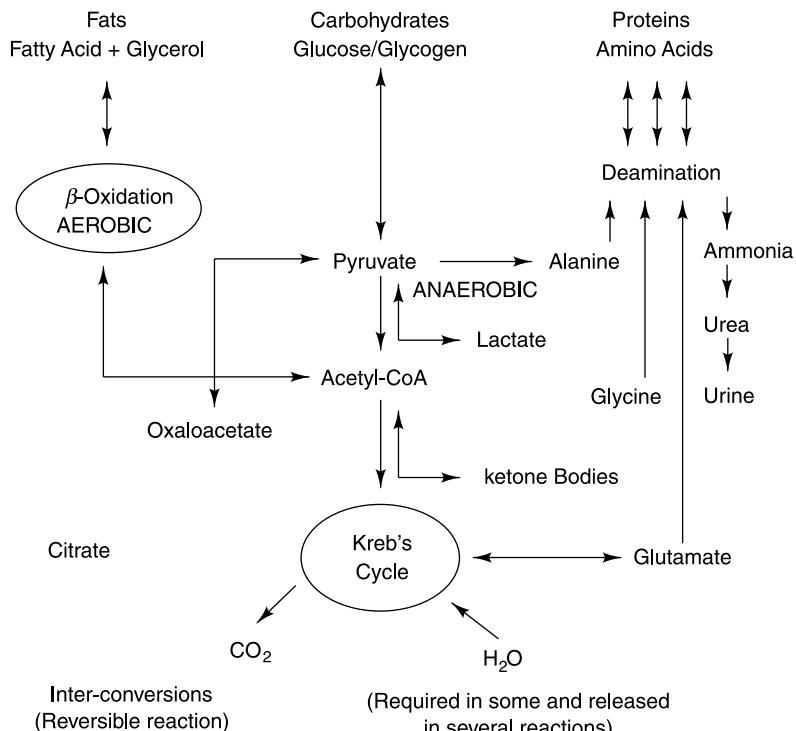


Fig. 6.1 Metabolism of nutrients in various pathways

Since energy from ATP powers all forms of biological work, it is said to be the cell's "energy currency". Oxygen is not required to split the ATP molecule; hence, it is an anaerobic reaction. Therefore, all activities that need an instantaneous supply of energy can be performed with the help of intra-muscular ATP energy. For example, push-ups, sprinting, and sprint-swim.

A continuous replenishment of the ATP from the ADP molecules must be done during any activity. Our body stores some amount of ATP, which is sufficient for several seconds of exercise spurt. Hence, an alternate source of a high-energy phosphate bond, i.e. Creatine phosphate, (CP) which is found in skeletal muscle, may be utilized. The body stores about four to six times more CP than ATP. Under anaerobic condition, hydrolysis of CP releases energy in about 10 seconds. CP cannot be used directly as an energy source to power muscular contraction. When energy is required immediately, ATP is broken down to ADP and is then restored very rapidly by CP under the influence of creatine kinase, as follows:



After the work is over, CP is resynthesized using a reverse process, which is fueled by new ATP created during oxidative metabolism. Because of the role of CP in keeping energy in the form of ATP, it is sometimes called "ATP saver". If energy is required for more than 10 to 15 seconds, glucose must be utilized anaerobically by the glycolytic pathway. By this pathway ATP is produced, so also is lactic acid.

This source can last for work up to one minute. Longer duration bouts require a decrease in intensity and the use of oxidative pathways, which use both, sugars as well as fats.

Fat as well as glycogen can transfer energy under anaerobic conditions. Energy released from glycogen is about four times faster than that released from fat. This is due to the high activity rate of the creatine phosphokinase reaction present in the muscle.

□ Energy from Carbohydrates

The first phase of metabolizing carbohydrates to obtain energy is glycolysis. It is a series of 10 enzymatically controlled chemical reactions which create two molecules of pyruvate from the anaerobic breakdown of glucose. When NADH oxidation does not keep pace with lactic-acid formation in glycolysis, lactic acid accumulates in the muscle, i.e. when excess H ions from NADH combine temporarily with pyruvate.

The second phase is the Kreb's cycle, which is also known as Citric Acid Cycle or Tri Carboxylic Acid cycle. Here, the pyruvate enters the second metabolic pathway. As seen from the earlier figure, pyruvate irreversibly converts to Acetyl CoA, a form of acetic acid. Acetyl CoA degrades to CO₂ and H atoms within the mitochondria. The H atoms are oxidized during electron transport by oxidative phosphorylation with subsequent regeneration of ATP molecules.

Oxygen does not participate in Kreb's cycle reactions. A major portion of the chemical energy in pyruvate transfers to ADP through the aerobic process of electron-transport oxidative phosphorylation. In the presence of adequate oxygen, including enzymes and substrate NAD⁺ and FAD, regeneration takes place and Kreb's cycle metabolism continues in a cyclic, uninterrupted manner.

□ Energy from Fats

Triglycerides are broken down into their glycerol and fatty acid components. After being released from adipocytes, glycerol and free fatty acids (FFA) are transported by blood, the FFA being bound to plasma albumin. Fats which are stored in the muscle also degrade to glycerol and fatty acids to provide energy.

During glycolysis, glycerol enters the energy pathway. The fatty acids enter the kreb's cycle through Beta-oxidation. The electron transport chain accepts hydrogen, which is released during glycolysis, Beta-oxidation and Kreb's cycle metabolism.

The energy contribution of fat depends upon the athlete's current nutritional and fitness status as well as the intensity and duration of the exercise.

□ Energy from Proteins

The role of protein is significant as an energy substrate especially during endurance type activities and heavy training. The amino acids, mainly the branched-chain ones like leucine, isoleucine, valine, glutamine and aspartate must be first either deaminated or transaminated. The nitrogenous waste products are discarded via the urine and sweat after being dissolved in water. The carbon skeleton, which remains behind, goes through the Kreb's cycle and forms ATP molecule. See Figure 6.2.

Some amino acids like alanine are gluconeogenic, i.e. they form intermediate products required for gluconeogenesis. Alanine forms pyruvate, which can be

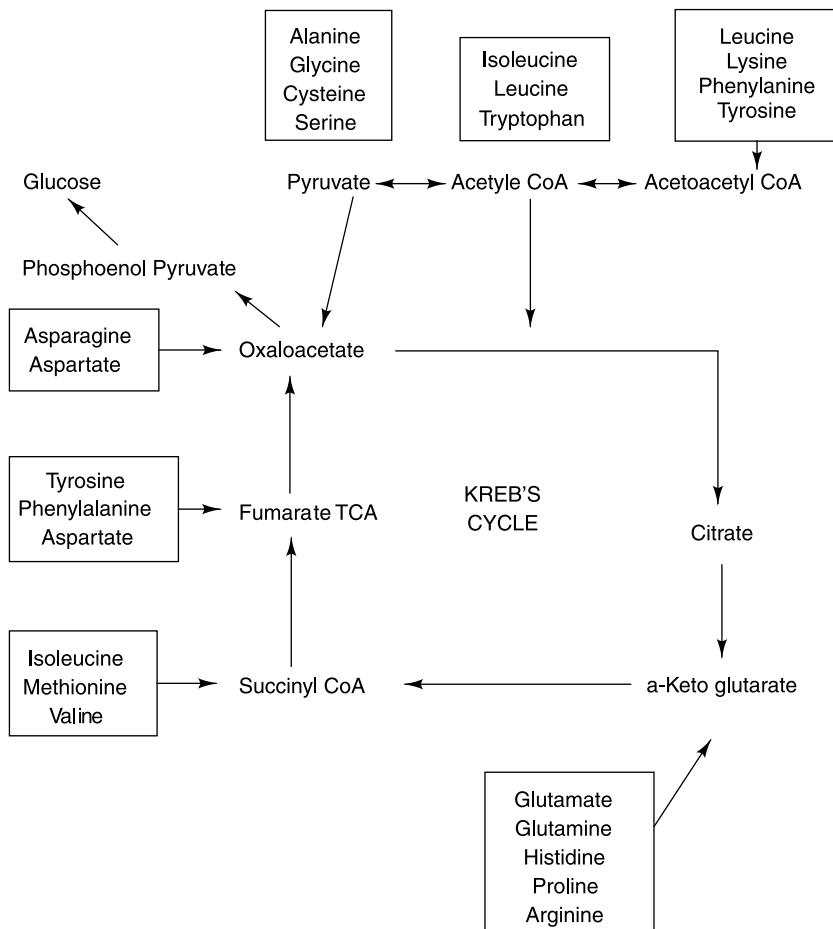


Fig. 6.2 Kreb's cycle and stage of entry of the carbon skeleton of 20 amino acids

synthesized to glucose. During prolonged exercise, this gluconeogenic step keeps up a continuous supply of energy. Regular exercise has shown to enhance the liver's capacity for gluconeogenesis.

Some amino acids like glycine are ketogenic and form intermediary products of the Kreb's cycle. These compounds cannot be converted to glucose. Instead they are converted to fat or are catabolized for energy in the Kreb's cycle.

It must be borne in mind that excessive protein catabolism increases the body's needs for fluids.

6.6 FACTORS AFFECTING FUEL UTILIZATION

Five main factors dictate the relative utilization of fuel during exercise, namely:

- Intensity
- Duration

- Type of exercise
- Training status
- Preceding diets of the individual

Higher intensity and shorter duration activities place a greater demand on anaerobic energy transfer, while light and moderate, repetitive activities of longer duration are of lesser intensity and rely on aerobic energy transfer.

Exercise and training increases the capacity of the muscles to oxidize carbohydrates and store glycogen. In addition, if the exercise intensity is tapered off, it helps to increase the glycogen stores of the body.

A high carbohydrate diet in which about 80 percent of the energy requirements are met by carbohydrates, increases the endurance capacity of the muscles by almost three times than a high fat diet. A diet which is deficient in carbohydrates, rapidly depletes muscle and liver glycogen. Such a diet also affects the performance in short-term (anaerobic) exercises and in prolonged high intensity endurance (aerobic) activities. In all conditions, carbohydrates, especially muscle-glycogen, play the role of the major fuel particularly during aerobic exercises of high intensity.

Fat, on the other hand, is oxidized during exercises of low-intensity. About 22 to 25 percent of the energy requirements during aerobic exercises are met by its oxidation. As the exercises continue beyond an hour or so, the oxidation of fat increases to a great extent. However, during moderate exercises, the energy contribution of carbohydrates and fats is almost equal. If the athlete performs aerobic exercises regularly, it improves the muscles ability to oxidize long chain fatty acids and triglycerides stored within the active muscles during mild and moderate intensity exercises. Such training adaptations help the endurance athlete to exercise at the highest absolute level of sub-maximal exercises before being fatigued due to glycogen depletion.

In contrast to carbohydrates and fats, proteins (amino acids) are broken down only moderately with exercise. On the other hand, synthesis of muscle proteins rises markedly following both endurance and resistance type exercises. Utilization of proteins (amino acids) as energy fuel depends on the nutritional status and the intensity of the exercise training. This is applicable especially to branched-chain amino acids that oxidize within the skeletal muscles rather than within the liver.

6.7 NUTRITION AND ATHLETIC PERFORMANCE

It is a firm belief that physical activity, athletic performance and recovery from exercise are enhanced by optimal nutrition. Hence, it is necessary that appropriate selection of foods and fluids, timing of intake, and supplement choices for optimal health and exercise performance is ensured.

It is imminent that the sports nutritionist is update with all scientific facts related to energy needs, assessment of body composition, strategies for weight change, nutrient and fluid needs, special nutrient needs during training and competition, the use of supplements and ergogenic aids, nutrition recommendations for vegetarian athletes, and above all the roles and responsibilities of the sports dietitian.

Energy and macronutrient needs, especially carbohydrate and protein, must be met during times of high physical activity to maintain body weight, replenish glycogen stores, and provide adequate protein to build and repair tissue. Fat intake should be sufficient to provide the essential fatty acids and fat-soluble vitamins and to contribute energy for weight maintenance.

It must be borne in mind that exercise performance can be affected by body weight and composition. Adequate food and fluid should be consumed before, during, and after exercise to help maintain blood glucose concentration during exercise, maximize exercise performance, and improve recovery time.

Athletes should be well hydrated before exercise and drink enough water and fluids during and after exercise to balance losses of body fluids. Sports beverages containing carbohydrates and electrolytes may be consumed before, during, and after exercise to help maintain blood glucose concentration, provide fuel for muscles, and decrease risk of dehydration and in the long run, hyponatremia.

Vitamin and mineral supplements are generally not needed if sufficient energy to maintain body weight is consumed from a well-balanced diet having variety of foods. However, athletes who restrict energy intake, use severe weight-loss practices, restrict or sometimes even eliminate one or more food groups from their diet, i.e. consume unbalanced diets with low micronutrient content may require supplements.

Nutritional ergogenic aids should be used with caution and only after careful evaluation of the product for safety, efficacy, potency and legality. A qualified sports dietitian should provide individualized nutrition direction and advice after a comprehensive nutrition assessment of the athlete.

6.8 EFFECTIVE HYDRATION FOR FITNESS AND SPORTS

Water is the most essential component of the human body as it plays an important role in the functioning of cells. More than half weight of the human body is made up of water and it is impossible to sustain life without it. Some important functions of water include transport of nutrients, elimination of waste products, regulation and maintenance of body temperature through sweating, maintenance of blood circulation and pressure, lubrication of joints and body tissues and facilitation of digestion.

Dehydration is the loss of fluids and salts essential to maintain normal body function. Dehydration occurs when the body loses more fluids than it consumes. Symptoms of dehydration include muscle fatigue, loss of coordination, inability to regulate body temperature, muscle cramps, decreased energy and athletic performance.

Normally, exercise increases body temperature, which depends on the intensity and duration of exercise, environmental conditions, clothing worn and metabolic rate. Exercise can cause heavy loss of water and electrolytes from sweat leading to dehydration especially among athletes. If these losses are not replaced, the performance and overall health of the athlete will be adversely affected.

To check the hydration status, an athlete must weigh himself before and after exercise. Based on this, drinking enough fluids to replenish these losses will maintain hydration. As a rule of thumb, loss in body weight over 1% indicates dehydration and over 5% indicates serious dehydration. Thirst is not a good indicator of hydration and should not be used to monitor hydration status.

Another important indicator of hydration status is the colour of urine. A large amount of light-coloured urine indicates good hydration. As the level of dehydration increases, the colour of the urine becomes darker.

Intake of alcohol increases urine output and decreases hydration. Palatability of a fluid can be improved with added flavour, salt (sodium) and by cooling it (15–21°C).

A sports beverage helps replenish the glycogen stores and its electrolytes help in rehydration. Sports beverages generally contain 4–8% carbohydrate, 20–30 meq/L sodium and 2–5 meq/L potassium. Sports drinks should not exceed 8% carbohydrate.

Ideally, half to one litre of a sports drink should be ingested each hour to maintain hydration. Over-hydration or water intoxication can result in behavioural changes, confusion, drowsiness, nausea, vomiting, hyponatremia, weight gain, muscle cramps, weakness, paralysis and risk of death.

6.9 NUTRITIONAL REQUIREMENTS OF ATHLETES

□ Proteins

According to the RDA, a normal person is required to consume 0.8 g to 1.0 g protein/kg body weight. However, since, the consumption of calories for the different categories of sports events ranges between 50 to 80 cals/kg/day, the amount of protein ingested by the athlete also rises proportionately. About 15 percent of the energy requirement is met by proteins, of which 55 percent must be met by animal protein. In case of vegetarians, complementing the vegetable protein sources help to meet their daily requirements. Soya-protein, nuts, oilseeds, legumes and pulses, milk and milk products can be used to fulfil the protein requirements adequately.

It is necessary to draw the attention of sports persons who believe in the fallacy that if simple amino acids are taken, they will be absorbed easily and it will bring about expected muscle growth. It must be remembered that only training can bring on desired muscle growth and tone. Heavy workouts will improve strength or power. In fact, there is no evidence to show that amino acid supplementation in any form above the RDA significantly increases muscle mass or improves muscular strength, power or endurance. On the contrary, a concentrated solution of amino acids draws water into the intestine, which may lead to irritation, cramping and diarrhoea.

□ Lipids

According to National Institute of Nutrition (NIN), about 30 percent of the energy requirement must be met through lipids. Of this, about 70 percent should come from the unsaturated fatty acids. It must be noted that significant reduction in the lipid content of the diet would compromise exercise performance. It would be difficult to increase carbohydrate and protein intake to bridge the energy gap caused by lowering lipid intake. This may affect the body weight and muscle-mass of the athlete. Also, adequate lipid intake helps to fulfil the essential fatty acids and fat-soluble vitamin requirements through the diet.

□ Carbohydrates

The National Institute of Nutrition (NIN) has recommended that about 55 percent of the energy requirement must be met through carbohydrates. If lower levels of carbohydrates are consumed, they may result in glycogen depletion, resulting in staleness that affects performance in training and competition.

A large proportion of unrefined complex carbohydrate foods must be included in the daily diets of athletes. This includes whole-wheat flour, millets like *jowar*, *bajra*, *ragi*, legumes especially *moong*, *matki*, *chawli* (lesser of the gas forming legumes like *chana*, *vaal*, *rajmah*, etc.), vegetables and fruits. Athletes undergoing heavy training must consume about 10 g of carbohydrates per kilogram of body weight. The recommendations made by the NIN closely match the carbohydrate requirements of athletes.

In order to improve the glycogen reserves in the body, carbohydrate loading is practised. This involves a period of exercise during which carbohydrates intake is restricted, followed by a high carbohydrate diet, which super-compensates muscle glycogen levels much beyond the normal pre-exercising levels. This is a specific diet-exercise technique, which is practised prior to the endurance competition.

In the first stage, carbohydrates are depleted in the diet to about 100 g or 400 kCal per day. After this, in the second stage, 400 to 625 g of carbohydrates are fed, which amounts to 1600 to 2500 kcal per day. A particular combination of diet and exercise result in a significant “packing” of glycogen in muscle. This is the technique used by endurance athletes for carbohydrate loading or glycogen super-compensation. Normally, a muscle contains 1.7 g glycogen per 100 g while glycogen loading increases it to 4 to 5 g.

One must remember that muscle glycogen takes time to replenish; liver glycogen restores at a faster rate. It takes about one to two days of rest or light exercise combined with a high carbohydrate intake to re-establish the pre-exercise muscle glycogen levels after exhaustive training or competition.

□ Vitamins

The requirement for vitamins is no different from that recommended for normal individuals in the RDA. However, since intake of carbohydrates is high, a proportionate increase in the B-complex vitamins must take place. The B-complex vitamins play key roles as co-enzymes in important energy-yielding reactions during carbohydrate, fat and protein catabolism. They are also required in haemoglobin synthesis as well as RBC production. Vitamin C intake through fresh fruits and vegetables will increase the level of antioxidants in the body, vital in the removal of free radicals that are formed during heavy bouts of aerobic exercise. Free radicals tend to overtake the body's natural defences and pose a health risk from an increased level of oxidative stress. They also promote muscle injury, especially eccentric muscle action and unaccustomed exercise. Rich dietary sources of antioxidants are:

1. β -carotene foods, i.e. carrots, dark green leafy vegetables like spinach, colocasia, fenugreek, coriander, amaranth (red and green), beet, pumpkin, sweet potatoes, mangoes and papaya.

2. Vitamin C rich foods like citrus fruits and juices, cabbage, berries, *amla*.
3. Vitamin E rich foods namely poultry, seafood, vegetable oils, wheat germ, fish liver oil, whole grain breads and fortified cereals, nuts and oilseeds, green leafy vegetables and eggs.

Selenium and other trace minerals such as copper, manganese and zinc may also possess antioxidant properties due to its incorporation within the structure of glutathione peroxidase and other enzymes, which protect plasma membranes from free-radical damage. Vitamin C also helps decrease upper respiratory tract infections. Free radicals are injurious to the body and antioxidants are required for their removal.

As generally believed, vitamin supplements do not improve exercise performance or increase blood levels of these micronutrients.

❑ Vitamin and Mineral Supplements and Exercise—Some Facts and Myths

The use of vitamin and mineral supplements by sportspersons and fitness-conscious persons is widespread. A cursory estimate is that more than half the endurance athletes regularly consume vitamin and mineral supplements. Use of daily supplements is also prevalent among other groups of athletes. Proponents of vitamin and mineral supplementation argue that daily consumption of these supplements enhances performance, provides a source of energy and prevents illness and injury. There is no scientific evidence to support these claims.

Physical activity may increase the need for some vitamins and minerals which can be met by consuming a balanced diet based on a variety of foods. Persons who consume a low-energy diet for extended periods of time are at risk for low vitamin and/or mineral intake and may develop marginal, subclinical nutrient deficiency. There is no scientific evidence to support the general use of vitamin and mineral supplements to improve athletic performance or its ergogenic benefit.

It is, thus, best to consume foods rich in Vitamins A, C and E like carrots, whole milk, skim milk, peanuts, papaya, oranges and its juice, sweet lime, broccoli, spinach, DGLV, apple, *amla*, melon, strawberries, etc.

❑ Minerals

Minerals are of great importance since loss of water and mineral salts, primarily sodium and potassium, through sweat and their replenishment poses a challenge. Excessive loss of water and electrolytes can lead to severe dysfunction in the form of heat cramps and lead to heat strokes. It may surprise the reader that an athlete can lose about four kilograms of water from sweating during a game lasting for about two hours. This corresponds to about six to eight grams minerals lost through sweat.

Vigorous exercise causes release of hormones such as vasopressin, renin and aldosterone, which minimize loss of water and sodium through kidneys. Trace minerals like copper, selenium, chromium, manganese and zinc are involved in intricate functions involving metabolism of carbohydrates, fats and proteins. They are also required as enzyme and co-enzyme factors as well as in antioxidant functions.

A normal, balanced diet will provide adequate minerals (including trace minerals). Hence, trace mineral deficiency does not pose a problem. Also, it must be remembered

that by consuming mineral supplements above recommended levels on an acute or chronic basis, the athlete does not benefit in terms of exercise performance or training responsiveness. Such indiscreet use may result in chronic toxicity.

6.10 WATER AND OTHER FLUIDS

During exercise, when the rate of energy utilization rises, the rate of heat produced also increases. Therefore, in order to prevent an excessive rise in body temperature (hyperthermia), the body tries to dispose of this additional heat.

The body loses heat by radiation, convection or conduction depending on the relative temperatures of the body and the environment surrounding it. The constant body temperature is between 37°C to 38°C (98°F to 100°F). Sweating is a very effective way of cooling the body and maintaining body temperature. For every one litre of sweat about 600 kcal/2500 kJ of heat may be released from the body. Losses of fluid that are equivalent to two percent of body weight can seriously impair the capacity to perform muscular work. Most athletes may lose one to five percent of their body weight during prolonged exercises even when the climate is temperate and fluids are taken regularly. Under extreme conditions, when temperature and humidity are high, body weight decreases by as much as eight to ten per cent. Loss of fluid results in reduction in plasma volume and movement of water between ICF and ECF. About 50 mEq of sodium and 5 mEq of potassium are lost with every litre of sweat.

When sweat losses greatly exceed replacement, the following effects may be seen in the body:

1. The circulatory system is unable to cope and skin blood flow falls.
2. As sweating continues, the volume of blood available for circulation decreases. This makes it more difficult to satisfy the energy demands of the muscle and promote heat transfer through the skin.
3. Due to reduction in the plasma volume, the amount of blood pumped by the heart with each beat drops. Heart rate therefore increases and blood flow to the skin decreases.
4. If the athlete continues the exercise, body temperature increases to the danger zone, i.e. 41°C or 105°F. Performance of the sports person falls off rapidly. Ultimately, this may lead to heart exhaustion with potentially fatal consequences.

Great care must be exercised to attend to the fluid intake of an athlete since, sweat losses can increase up to 30 ml/min, which amounts to about 18 kcal/min lost during maximal exercise. The body temperature can rise by 1°C every five to seven minutes. Rise in body temperature is harmful and may be fatal at 41°C. Hence, adequate hydration is necessary at all times. Pre-exercise hydration does provide some protection against heat stress since it helps delay dehydration, increases sweating, which cools the body and thereby minimizes rise in the core temperature of the body.

A technique called hyperhydration, i.e. consuming about 500 ml of cool water about 20 minutes before beginning the exercise in the heat, is practised. However, hyperhydration does not replace the need for continuous replacement of fluids during exercise.

The athlete must therefore not underestimate his requirements for fluids. Various factors influence fluid absorption, but how much fluid the athlete drinks, what solution he drinks and how hard he exercises depends upon the athlete himself.

It is believed that colder solutions are absorbed more rapidly than warmer ones. Hence, it is generally advised that the ideal temperature at which solutions must be consumed is 8°C to 13°C or 46°F to 55°F. However, some people believe that the colder fluids may clash with the high body temperature. It is, therefore, best left to an individual's experience and tolerance.

Large volumes (up to 600 ml) are absorbed more rapidly than smaller portions, but many athletes find it uncomfortable to exercise on a full stomach since, it tends to interfere with their breathing and hence, they prefer to sip the fluids at shorter intervals.

The duration of an exercise has little effect on the fluid absorption but its intensity is very important. Therefore, the harder you work the more difficult it is to replace the fluids lost in sweat in a short time.

As more fluid is lost than electrolytes, the concentration of electrolytes in the plasma increases or remains constant. This is because the body reduces the excretion of electrolytes in the urine and in sweat through the action of aldosterone.

Thirst is not a good indicator of the need to start taking fluids. The athlete should ensure that the body is fully- or over-hydrated prior to exercise, and never dehydrated. He should also accustom himself to take fluids at all exercise intensities, both during training and competition.

Monitoring the fluid intake of endurance athletes is more important since, their fluid loss is far in excess of fluid absorption from the stomach. About 1000 ml of fluid is absorbed by the body every hour while body losses of fluids may be almost double of this.

Adequacy of rehydration may be decided on the basis of change in body weight during and after exercise or athletic competition.

Flavoured drinks containing about six to eight percent carbohydrates and 1053 to 1170 mg per litre of sodium chloride have been found to significantly help voluntary rehydration. Addition of sodium to the fluid facilitates more complete rehydration, than plain water. In addition, a small amount of potassium (2 to 5 mmol/l) enhances the retention of water in the intercellular space and lowers the loss of potassium due to sodium retention by the kidneys. Under all circumstances, depletion of sodium in the body (hyponathremia) must be prevented. Ideally the oral rehydration fluid must taste good to be absorbed rapidly in the body, should cause no gastro-intestinal distress, maintain proper ECF volume as well as its osmolality and enhance exercise performance. Commercial preparations available in the market generally give the range of carbohydrates, sodium and potassium present in them.

For the Indian athlete, the above can be achieved by using coconut water, lemon *sherbet* or *kokam sherbet*. In the year 2000, FAO has declared that coconut water can be used as a sports drink. A coconut between six and nine months old contains about 750 ml of water. It is a natural isotonic beverage, with the same level of electrolytic balance as in our blood. Today, most coconut water is still consumed fresh in tropical coastal areas. Once exposed to air, the liquid rapidly loses most of its nutritional characteristics, and begins to ferment. A new cold sterilization process that retains its flavour and all its nutritional characteristics is being standardized.

The approximate composition of coconut water is given in Table 6.2.

Table 6.2 Composition of coconut water

Nutrient (mg /100 ml)	Sports beverage	Coconut water
Potassium	10–13	250–300
Sodium	36–45	22–28
Chloride	35–45	115–120
Magnesium	6–8	8–12
Sugar (g/100ml)	5–7	4–6

It is advisable to avoid salt tablets since our diet contains sufficient salt. Suitable clothing to cope with prevailing climatic conditions must be worn. Some amount of fluid about 250–500 ml water must be consumed 20 to 40 minutes prior to the exercise. Plain water is the best fluid.

6.11 SPORTS SUPPLEMENTS

Any fitness goal can be achieved first by a strong base in training. Only thereafter, the extra edge can be achieved by using:

1. Macronutrient supplements
2. Anti-catabolics
3. Ergogenics
4. Fat burners

□ Macronutrient Supplements

They can be obtained through food and supplements. They can be varying in proteins, carbohydrates and fats. They also supply vitamins and minerals. There are 3 major macronutrient or protein supplements, namely pure proteins, weight gainers and meal replacements. These can be used for

- minimizing catabolism
- boosting power and muscle growth
- stimulating greater fat loss

They are generally available in powder form but may also be the ready to drink type of liquids. These are protein pre-mixes in the liquid form which are convenient to use. They may be zero carb whey proteins, meal replacements or weight gainers.

Macronutrient supplements may also contain essential fatty acids, MCT's, fibre, digestive enzymes, colostrum, blood protein isolates, etc.

1. Pure proteins are 65 to 90% proteins obtained from a high biological value protein source such as whey, casein, egg albumin, soya or a blend of these. They do not contain added carbohydrates and fats except that which comes from the protein source. Other substances such as glutamine, enzymes, may also be present. This group of supplements is useful for people targeting weight loss, or as an addition to the diet of a person desiring weight gain. These pure proteins can also be used to meet the protein requirement of any exercising individual.

They are available as powders which can be made into a drink.

2. Weight gainers: They are calorie dense products and may range from 500 to 1000 kcals per serving. The ratio of carbohydrates to proteins in these products may be 2:1, 5:1, but the most optimum ratio is 3:1. The preferred protein in them is generally casein. They have high glycemic index sugars, starches, polymers, glucose, complex carbohydrates and dietary fibre. Most products contain 5 to 10 grams fat low in saturated fat, trans fat and cholesterol. Some may contain vitamins and minerals, n-3 fatty acids and finer micronutrients such as chromium, creatine and glutamine.

These are generally available as powders.

3. Meal replacements are alternative to a meal containing good quality carbohydrates, proteins, fats, vitamins and minerals and are convenient and practical. Generally, the carbohydrate to protein ratio is 1:2. Some may be 4:1. The protein source is generally casein and may be 40 to 50 grams per serving. The glycemic index is generally low supplied by starches, glucose polymers and sorbitol. This would enable slow absorption of glucose and maintain steady levels of insulin. A good dietary meal replacement contains adequate dietary fibre to maintain glucose levels in blood and contributes to the satiety value of the meal replacement. The lipids constitute omega fatty acids and less quantity of saturated fats. The vitamins and minerals in the meal replacement must satisfy at least half the day's requirement. Anticatabolics such as glutamine, glutamate and glutamine peptide may also be found.

Meal replacements are good for body builders as a pre-workout meal. They are available in the form of bars and ready to drink beverages.

Anti-Catabolics

They include anti-oxidants and amino acids such as glutamine and Branched Chain Amino Acids (BCAA). At a higher level ergogenic substances such as creatine will aid muscle growth.

They reduce muscle breakdown and indirectly contribute to anabolism. A fat loss program will not succeed without anticatabolics. They fight free radical attack and the use of amino acids for energy or other physiological functions. Anti-oxidants such as vitamins C, E, beta-carotene, selenium, zinc, manganese, copper are effective anti-catabolics.

Amino acids such as glutamine are important for maintaining or increasing immunity. A low level of this amino-acid is found to predispose the training individual to infections, slow wound healing and fever. Hence, it is necessary to be adequately replenished in the post-workout phase. It has a powerful anti-catabolic effect thereby, reducing muscle breakdown.

Glutamine has shown anabolic effectively enhancing protein synthesis and it also serves to regulate glucose. It also raises the level of glutathione which is also a strong anti-oxidant. By playing an active role in the recover and healing of tissues, it is a valuable addition in anticatabolic products.

The other anti-catabolics are BCAA's, namely leucine, isoleucine and valine. Their requirement is met adequately if high biological value proteins are consumed in the diet. They have an important role to play even in surgery, starvation, burns and other states of trauma. Therefore, both glutamine and BCAA's prevent catabolism, promote growth and recovery.

□ Ergogenic Substances

They help to increase the work capacity of which the most popular is creatine.

Creatine Phosphate (CP) is required for energy production for muscle contraction. Creatine is also known as methyl guanidoacetic acid. Since, it plays an important role in the formation of ATP from ADP, it is a powerful source of energy for intense training individuals. Food sources of CP are animal sources with fish such as herring, tuna and salmon containing the highest quantity. Beef and pork are also good sources.

□ Thermogenics or Fat Burners

They are also known as fat-loss supplements. They help in losing fat but only after all other factors have been optimized. Examples of this group are caffeine and aspirin.

6.12 NUTRITIONAL ALLOWANCES AS GIVEN BY NIN

The National Institute of Nutrition (NIN) has formulated allowances and menus for four basic groups of players and athletes, which are shown in Table 6.3. Also refer Appendix IX.

Table 6.3 General grouping of sports events for suggesting allowances

<i>Group</i>	<i>Average body weight (kg)</i>	<i>kcal/kg /day</i>	<i>Total kcal/day</i>	<i>Type of activity</i>
I	80–90 (80 and above)	70	6000	<i>Power events of higher weight category:</i> Heavyweight lifting, boxing, wrestling and judo and throwing events (hammer, shot-put and discus)
II	65 (60–70)	80	5200	<i>Endurance events:</i> Marathon, long-distance running, long-distance walking, road cycling, rowing, middle and long distance swimming (200 m and above).
III	65 (60–70)	70	4500	<i>Team events and Power events of middle-weight category:</i> Hockey, football, volleyball, basketball, tennis, track cycling, javelin, badminton, handball, jumpers, sprint running and swimming (below 200 m), water polo, middle-weight categories of Power events like boxing, wrestling, weightlifting and judo (60–80 kg).
IV	60	60	3600	<i>Events of lightweight category:</i> Gymnastics, table tennis and power events of lightweight category (60 kg and below and yachting)
V	60	50	3000	<i>Skill games:</i> Shooting, archery, and equestrian.

Group III (Power events of middle-weight categories) is considered the core group. Since, endurance events like marathon, long distance running, etc. require sustained energy supply, sportspersons are advised to consume a higher proportion of calories from carbohydrate sources. Table 6.4 gives the nutrients suggested by NIN for the four major categories of sportspersons.

Table 6.4 Suggested nutrient allowances for major categories of sports persons

Group	Protein (g)	Fat (g)	Calcium (g)	Iron (mg)	Retinol (ug)	B1 (mg)	B2 (mg)	Niacin (mg)	Vitamin (mg)
I	225	200	3.0	85	2500	6	6	60	150
II	195	144	2.5	75	2000	5	5	50	125
III	160	120	2.0	60	1500	4	4	40	100
IV	135	120	1.5	50	1000	3	3	35	80

In order to fulfil the nutrient requirements as specified in Table 6.4 NIN has given the details of consumption of food commodities by sports person of various categories, which are shown in Table 6.5.

Table 6.5 Food commodities to fulfil nutritional requirements of sports persons

Food commodity	Group III	Group II	Group I	Group IV
Cereals (g)	550	630	730	400
Pulses (g)	40	40	60	40
Green leafy Vegetables (g)	150	150	150	150
Other vegetables (g)	200	200	210	200
Roots and tubers (g)	150	150	160	150
Fruits (g)	150	300	450	150
Milk (ml)	750	750	750	750
Oil (ml)	50	50	60	50
Butter (g)	25	25	50	—
Sugar (g)	80	130	80	60
Jam (g)	20	40	40	20
Meat (g)	250	250	350	250
Eggs (g)	100	150	200	50
Calories	4560	5320	6155	3700
Protein (g)	170	186	230	148
Fat (g)	155	164	164	125
% energy from protein	15 (55% animal protein)	14 (54% animal protein)	15 (56% animal protein)	16 (58% animal protein)
% energy from fat	13 (42% vegetable fat)	28 (41% vegetable fat)	31 (38% vegetable fat)	30 (50% vegetable fat)
% energy from carbohydrates	54	58	54	54

Skim milk powder, whey protein isolate or concentrate, defatted soy flour and soy chunks or granules and various protein supplements available in the market may be used to fortify the protein requirements.

Table 6.6 Sample diet for a wrestler

Item	Exchange	Carbohydrates (No.)	Protein (g)	Fat (g)	Calories (g)
Milk	6	—	30	32	600
Legumes and pulse	4	90	24	—	400
Flesh food	3	—	20	26	140
Vegetable A	6	—	—	—	—
Vegetable B	6	60	—	—	300
Fruit	6	60	—	—	300
Cereals	18	360	36	—	1800
Fat	6	—	—	66	600
Sugar (g)	50	50	—	—	200
Total	—	620	110	124	4340

□ Menu Plan for the Day

Morning: Whole milk: 1 glass

Almonds: 5

Mid-morning: *Ragi* malt: 1 glass
Eggs: 2 or *Usal* (Sprouted legume): 1 cup
Bananas: 2

Lunch: *Jowar/Bajra/Ragi Bhakris*: 4
Colocasia vegetable: 2 cups
Paneer bhurji: 1 cup
Fish fry /curry: 3 big pieces
Brinjal vegetable (with soy chunks): 2 cups
Cucumber/Beet salad: 1 cup
Dal: 1 cup
Rice: 2 cups
Curd: 1 cup

Mid noon: Fruit milk-shake fortified with protein supplement (providing at least 20 g protein): 1 glass.

Evening: *Upma / Uttappa / Thalipith*: 2 servings
Egg: 1 Banana / Apple: 1

Dinner: *Jowar / Bajra / Ragi / Bhakris*: 4
Spinach *Paneer* vegetable: 2 cups
Potato vegetable (with soy chunks): 2 cups
Tomato/Beet salad: 1 cup
Dal: 2 cups
Rice: 2 cups
Curd: 1 cup

Bedtime: Fruit milk shake with protein supplement (providing at least 20 g protein): 1 glass.

6.13 BROAD GUIDELINES FOR SPORTS PERSONS

1. Follow the advice of your physician, nutritionist and coach.
2. Frequent meals rather than only two or three meals per day improve overall performance.
3. The last meal must be eaten at least three hours prior to competition. It should be high in carbohydrates having a high glycemic index but low in proteins and fats. It should not contain strong spices and oils. Preferably, it should be a beverage. Avoid eating simple sugars.
4. A high-carbohydrates diet gives better endurance and higher muscular effectiveness than a high fat diet.
5. Optimal amounts of proteins, vitamins and minerals are beneficial. However, excessive intake of these does not improve performance.
6. For long duration events, carbohydrate is a better fuel than fat or protein, while for short duration, high carbohydrate, low lipid is a better combination (4:1 ratio).
 - (a) Exercise tapering must be done 48 hours before the competition and resting 24 hours before the event.
 - (b) There must be a shift to a high carbohydrate diet in the meal immediately preceding the event. (Cereals, e.g. oatmeal, toast, jam or honey can be given). Carbohydrate loading may be done two to four days prior to the event.
7. Bulky foods and high-protein foods must be avoided. Proteins are a source of fixed acids, which can be eliminated mainly by urinary excretion. Protein intake is therefore best reduced to a minimum at the meal preceding the event. Similarly, bulk foods are best eliminated from the diet (lettuce, tomatoes, etc.) 48 hours preceding the contest. Highly spiced foods should also be avoided during the last 48 hours.
8. Alcohol is best avoided since even in small amounts it may have some effect on coordination. Coffee and tea, while stimulants, may have a depressing effect three or four hours after intake and thus impair performance if consumed at the meal preceding the exercise. They may also cause fluid depletion, which is detrimental.
9. Nutrition during contests—Some sugar feeding during a long and exhausting contest does improve performance. Feeding glucose pills, pieces of sugar or honey, however, tends to draw fluid for their digestion and absorption into the gastro-intestinal tract and further dehydrate the organ. Two to three glasses of fluid, except milk, with the pre-event meal ensures adequate hydration without producing a diuresis. The salt content of the fluid should be of the same tonicity as the total loss of fluid and electrolytes via the sweat, which is anticipated to occur.

6.14 PRE-COMPETITION, DURING COMPETITION AND POST-COMPETITION MEAL

An athlete, however fit and trained for a competition, will have an impaired performance if his liver and muscle glycogen stores are depleted due to lack of proper attention to his pre-competition meal. Pre-competition means the period of the few hours before competition.

□ Pre-event and Post-event Meals—A Prelude

Exercise performance can be affected by diet and, in order to maintain optimal training, the body must be properly refueled with appropriate nutrients. The pre-event and post-event meal is an integral part of the complete training plan. However, it must be a part of the routine of an athlete since a single pre-event meal will not compensate for a poor training diet. Hence, the active person should follow basic nutrition guidelines routinely. If the diet contains enough calories to cover the daily energy expenditure and is composed of a wide variety of foods, it will also ensure adequate intake of vitamins and minerals.

The training diet should be high in carbohydrate without compromising the needs for protein and fat.

A high-carbohydrate pre-event meal enhances performance as compared to a low-carbohydrate meal. Glycogen stores in the liver and muscles can be metabolized to provide energy for the working muscle more rapidly than fat, allowing a person to sustain a higher intensity level of exercise. Therefore, depletion of glycogen stores would inevitably result in reduced exercise intensity or discontinued exercise. Enough carbohydrate must be consumed to maximize glycogen stores (which are limited), particularly for those participating in endurance events.

□ Basic Goals of the Pre-event Meal

1. Prevent weakness and fatigue
2. Reduce feelings of hunger as well as minimize gastrointestinal distress
3. Ensure optimal hydration

It must be emphasized that the correct intake of nutrients can enhance and optimize performance. The psychological effect of consuming the food, with due consideration for individual preferences, may result in enhanced performance.

Some Guidelines

1. The meal should consist primarily of easily digested carbohydrates and fluids. In case of a small meal (400–500 calories), it can be consumed approximately 2–3 hours prior to an event. This allows enough time for digestion and absorption.
2. If the meal is high in fat, protein, or fibre, extra time must be allowed for digestion. A large meal containing appreciable amounts of protein or fat may need to be eaten 5–6 hours before competition.
3. If the amount of food consumed increases, the time needed for digestion will increase.

4. Fibre-rich carbohydrates and gas-forming foods (bran products, legumes, onion, cabbage and cauliflower) are not recommended as they may cause intestinal discomfort.
5. When the athlete's schedule does not permit time for meals or if there is much pre-competition anxiety, liquid meals like sports drinks, juices, low-fat smoothies and shakes may be consumed.
6. Carbonated drinks may cause stomach discomfort.
7. Caffeinated drinks should be sparingly used. For some caffeine may be ergogenic, while for others it may cause nausea and anxiousness. An excess of caffeine can contribute to dehydration due to its diuretic effect.
8. Plenty of liquids should also be consumed to ensure maximum hydration status.

□ Suggestions for Pre-event Food Choices

1. For Morning Events The night before, eat a high-carbohydrate meal. Early morning, eat a light breakfast or snack such as cereal and non-fat milk, fresh fruit or juice, toast, or English muffin, pancakes or waffles, non-fat or low-fat fruit yogurt.

2. For Afternoon Events Eat a high-carbohydrate meal the night before as well as for breakfast. Have a light lunch: salads with low-fat dressings, meat or chicken or vegetable sandwiches, fruits, juice, low-fat crackers, high-carbohydrate nutritional bars, etc.

3. For Evening Events Eat a high-carbohydrate breakfast and lunch. In the evening, take a light meal or snack such as pasta with tomato/marinara sauce, rice with vegetables, pohe, upma, idli, dosa, light-cheese pizza with vegetable toppings, noodle or rice soups with crackers, baked potato, frozen yogurt, etc.

The athlete should try out new foods to find out which foods optimize his performance on the field. However, it is important to experiment with new foods *during training* rather than *around competition*.

Great stress is laid on the pre-event meal, but rapid refueling is most important for people who do repeated bouts of intense, depleting exercise. The muscles are most receptive to refueling within an hour after a hard workout, so care must be taken to refuel after a workout or after competition. If he has had an easy workout and, hence, lower recovery needs, he may not need to refuel immediately after the workout. However, it is in the best interest of the sportsman to develop a habit of refueling soon after the workout. It will help him feel better, have more energy and will curb his appetite. It must be remembered that the training is not complete until the sports person has refueled !

□ Pre-competition

A good pre-competition meal must provide adequate carbohydrate energy and ensure optimal hydration. Since, the athlete may undergo psychological stress and tension, it is necessary to consider this factor.

Table 6.7 Balanced diets for men and women in sports camps

Item	Men		Women	
	Veg.	Non-veg.	Veg.	Non-veg.
Rice	150	150	100	100
Wheat flour	250	250	200	200
White bread	150	150	100	100
Biscuits	20	20	20	20
Cheese or <i>paneer</i>	50	—	30	—
Butter/jam	20/50	20/50	20/50	20/50
Whole gram	35	35	30	30
<i>Dal</i>	35	—	30	—
Milk	900	700	900	700
Banana/Apple	One	One	One	One
Sweet lime/Orange	200	200	200	200
Root vegetables	150	150	100	100
Green	175	175	150	150
Leafy vegetables				
Other vegetables	200	200	150	150
Onion	100	100	50	50
<i>Ghee</i>	20	20	20	20
Vegetable oil	40	40	40	40
Sugar	50	50	40	40
Mutton/Chicken/Fish	—	250	—	50
Eggs	—	100	—	200

Foods which digest slowly, i.e. those rich in lipids and proteins, must be avoided. About three hours prior to the competition is sufficient time to digest and absorb a carbohydrate-rich, pre-event meal. It should contain about 150 to 300 g of carbohydrate (3 to 5 g/kg of body weight). This is sufficient to maximize the muscle and liver glycogen stores.

Liquid and pre-packaged meals, if available, may also be used.

This is because the liquid meal digests rapidly, leaving very little residue in the gastro-intestinal tract. Events such as swimming and track meets, tennis, soccer and basketball tournaments demand good nutrition in a short time. Liquid nutrition fulfils this requirement very effectively.

Foods rich in fat, highly seasoned or gas-forming foods must be avoided since they hinder performance. Simple sugars just prior to the competition must be avoided since they are rapidly digested causing an increase in insulin, which clears the sugar from the blood stream resulting in a fall in blood sugar just when you need it the most. High levels of insulin also inhibits the release of free fatty acids and causes an increased use of glycogen during the initial stages of exercise.

□ During Competition

During competitions the intake of sugar solutions like the polyglucose drinks have beneficial effects since they maintain both energy as well as fluid balance during long-term events.

□ Post-competition

The post competition meal also comprises sufficient carbohydrates to replenish the glycogen stores in the body. It is a good idea to decrease the workload and maintain a fairly high level of carbohydrates having high glycemic index, after the competition (about 7 g to 10 g/kg body weight).

It must be remembered that a sportsperson is not an ordinary person. His nutritional requirements must be fulfilled every day even while he is training for an event. This will enable him to perform consistently and be successful in his endeavour to win medals in any competition.

The pre-event Meal

This meal is important physiologically but its psychological value must not be ignored. Some important aspects are as follows:

- It should be eaten 1 to 4 hours prior to the event
- It should provide 100 to 200 g of carbohydrates
- It should be moderate in fat
- It should be low in protein
- Fluid intake should be generous

Commercial formulas are available in the market which provide easily digested, high fluid, high carbohydrate meal.

Alternately, the athlete may have bread toast, slightly buttered bread with plenty of jam or jelly, a cereal with skim milk, low fat yogurt with fruit and sugar, etc.

The athlete must drink about 400 to 600 ml water about 15 minutes before the event. This prehydration is important and does not induce urination.

Nutrition During Performance

This depends entirely on the intensity and duration of the event and the ambient temperature. The feeling of "thirst" is not a reliable indicator of the fluid requirement by the body. The rehydration fluid must contain sodium for efficient rehydration.

Another important nutrient is the carbohydrate content. This should be about 25 to 30 g for every 30 minutes for an athlete participating in endurance games. This amounts to about 1 cup (about 200 ml) of 6% carbohydrate content. The concentration of carbohydrate must be maintained between 6 and 8%. Higher concentrations of carbohydrate must be avoided since they can induce abdominal cramps, nausea and diarrhoea. The preferred carbohydrate is glucose.

Fluid intake must be such that its absorption along with the nutrients in it is quick. Cold fluids are transported quickly and absorbed fast (earlier they were avoided since they were thought to cause abdominal cramps). Excessive fluid intake at one time should be avoided. About 250 ml fluid every 15 minutes is generally adequate. It is difficult to provide more than 800 to 1000 ml of fluid per hour during an event. However, certain endurance games cause fluid losses up to 2 L per hour. Hence, the process of rehydration must continue in the post-event meal.

Post-event Meal

The focus of a post-event meal is:

- Rehydration
- Repletion of glycogen stores
- Restoration of electrolyte balance especially sodium and potassium

Body losses during the event must be overcome by providing a diet rich in carbohydrates (especially starches), high in fluids, sodium and potassium. Hence, salted foods and plenty of fresh fruits and vegetables must be preferred in substantial amounts.



SUMMARY

It is not just sufficient to “catch ‘em young” but it is also important to train the athlete for proficiency of the highest level. Sports and the nourishment required to attain maximal output has always interested scientists. Today, scientific studies have given nutritionists a better insight into sports science. The energy giving nutrients (carbohydrates, fats and proteins) fed in the correct proportions along with those helping in the release of energy from them (vitamins and minerals) and the fluid required to adequately hydrate the body could optimize the athlete’s performance. Training and regular fitness programmes must accompany the dietary regimen. Nutrition must be equally emphasized before, during, as well as after competitions.



CASE STUDIES

- I A wrestler aged 26 years and about 5 feet 9 inches tall weighs about 92 kgs. He needs to know:
 1. Is his weight as per the norms?
 2. Which sports supplements are suitable for him and why?
- II A middle distance runner is practising for an event coming up in about one month. What will you advise her regarding:
 1. Pre-event meal management
 2. Nutritional supplements
 3. Nutrition during the event.



REVIEW QUESTIONS

1. What is fitness? How is it important for non-sports persons as well as sports persons?
2. How is the rate of energy metabolism measured?
3. What is VO_2 ? How can it be improved?
4. What are the advantages of obtaining energy from carbohydrates?

5. What are the two type of fibres in a man's body? Which fibres are mainly utilized in the following sports: heavyweight lifting, sprinting, table tennis?
6. Which factors dictate the utilization of fuel during exercise?
7. What precautions are necessary for sports persons when reducing weight?
8. What is carbohydrate loading?
9. Which points must be remembered during the pre-event period?
10. What is the importance of fluid in exercise?



Section 2

DIET THERAPY

- **Chapter 7** Therapeutic Diets and Effective Nutritional Counselling
- **Chapter 8** Diet during Energy Imbalance—High and Low Calorie Diet
- **Chapter 9** Diet for Diabetes Mellitus
- **Chapter 10** Diet for Cardio-Vascular Diseases
- **Chapter 11** Diet for Kidney Diseases
- **Chapter 12** Diet for Gastro-Intestinal Diseases (Stomach and Intestines)
- **Chapter 13** Diet for Liver Diseases
- **Chapter 14** Diet for Infections and Fevers
- **Chapter 15** Nutrition in HIV/AIDS
- **Chapter 16** Diet in Other Health Conditions

Chapter

7



Therapeutic Diets and Effective Nutritional Counselling

The nutritional needs of a normal person in his lifespan—from conception through infancy, childhood, adolescence, adulthood and old age—are modified according to the demands of growth and development at different stages of life. Balanced diet at these stages prevents precipitation of deficiency symptoms of any nutrient and protects the person from any nutritional disorder or disease as well as secondary diseases, mostly infections, caused by lowered resistance due to *undernourishment* or *malnutrition*.

The needs of every person at any stage of life are to be modified and deviated from the normal when attacked by illness. Diet therapy can then be considered as a shield, which if effectively used, can protect a person from further attack of the disease and help in restoring normal health. Thus, an understanding of nutrition is the basis of diet therapy. We have studied the normal requirements of a person. Modification of these nutrients can then be considered to be the core of diet therapy.

Use of medication alone is not always sufficient to cure any health disorder unless there is proper nutritional management. On the other hand, in the absence of good and proper nutrition the drug therapy, even though at its best, may become a total failure. On the contrary, it may be possible at least in some instances to avoid or limit the drug therapy with proper nutrition. Because of this awareness, the field of therapeutic diets in nutrition has become popular and is gaining wide acceptance in a major cross-section of our society.

Following are some of the cases where therapeutic diets may be required:

1. When food consumption is interfered with, as in impaired appetite, gastrointestinal disease, traumatic neurological disorders interfering with self-feeding, neuropsychiatric disorder, disease of soft or hard oral tissue, alcoholism, pregnancy anorexia and vomiting, food allergy, and disease requiring a restricted diet.
2. When absorption is interfered with as in the absence of normal digestive secretions, intestinal hypermotility reduction of effective absorbing surface, impairment of intrinsic mechanism of absorption, drug preventing absorption.
3. When utilization or storage is interfered with as in impaired liver function, hypothyroidism, neoplasm of gastro-intestinal tract, drugs or radiation therapy.
4. When the function is impaired or when tissues are destroyed as in achlorhydria in the gastro-intestinal tract, heavy metals and other metabolic antagonists.

5. When there is an increase in excretion or loss of nutrients from the body as in lactation, burns, glycosuria and albuminuria, acute or chronic blood loss.
6. When there is an increase in the nutrient requirements as when physical activity is increased or in period of rapid growth, pregnancy and lactation, hyper-thyroidism and drug therapy.

7.1 DRUG AND DIET INTERACTION

Knowledge of drug and diet interaction is very essential for physicians, nutritionists and dietitians. Some of the important highlights of this topic are briefly outlined here.

It is a routine experience that medication is dispensed along with some dietary instructions. This is true in allopathy, homeopathy, ayurveda and other schools of medicine. While you are on homeopathic medicines you are asked not to consume coffee since it is detrimental to the benefit of the medicine.

Similarly, we are asked to take the medicine on empty stomach, sometimes after the meals or with milk, because of the interaction between dietary factors and medicines. Our knowledge in this regard is increasing everyday with new observations and experience. The drug and food interactions fall into four categories. These are as follows:

1. The dietary factors help promote drug action and, thus, faster recovery.
2. The dietary factors may reduce the potential of the drug to deliver the expected results.
3. The dietary factors and drug may interact to produce harmful or at times toxic effects resulting in unexpected complications.
4. The drug in certain cases influences the metabolic processes in such a way that the availability of the nutrient to the body is adversely affected.

Drugs with diuretic effects drain-off important electrolytes and cause their insufficiency (deficiency) in the body.

Some of the major known drugs and nutrient interaction are listed in Table 7.1

7.2 DIET THERAPY AND TYPES OF THERAPEUTIC DIETS

Diet therapy is the use of food in the treatment of a disease. This is accomplished by changing the patient's normal diet in order to meet the altered requirements resulting from disease or injury.

Therapeutic diets are normally prescribed, by the doctor attending the patient in a hospital.

In a hospital, the interaction between the doctor, the dietitian and the patient is very important. The doctor would normally advise the dietitian to alter the diet in three respects. These are the following:

1. The Nutrient Content of the Diet In this respect, the amount or quantity of the basic nutrient content is varied like increasing or decreasing the proportion of fat, carbohydrate or protein, etc. in the diet as the situation demands. Such a diet may then be referred to as a low-fat diet, or a high-protein diet, etc. according to decrease or increase in the quantum of the basic nutrient.

Table 7.1 Potential drug-nutrient interactions for some commonly used drugs

<i>Drug</i>	<i>Nutrient</i>	<i>Potential side-effect</i>
Alcohol	Thiamine Vitamin B ₆ Folate Zinc Calcium Magnesium	Deficiency
Alumunium hydroxide	Phosphorus Calcium	Binding Deficiency
Antacids	Thiamine Calcium Iron	Decreased absorption due to altered gastro-intestinal pH
Anticoagulants	Vitamin K	Deficiency
Antihistamines	—	Weight gain
Amphetamines	—	Appetite suppression Weight loss
Aspirin	Iron	Anaemia
Cathartics	Calcium	Impaired gastro-intestinal motility
Cholestyramine	Vitamin A, D, E, K	Deficiencies
Cimetidine	Vitamin B ₁₂	Deficiency
Clofibrate	Carbohydrate Vitamin B ₁₂ Carotene Iron	Enzyme inactivation Decreased absorption
Colchicine	Vitamin B ₁₂ Carotene Magnesium	Decreased absorption due to damaged intestinal mucosa
Corticosteroids	Zinc Calcium Potassium	Damage to intestinal mucosa Gastro-intestinal loss
Ethocrynic acid	Sodium	Depletion
Euressemide	Calcium Potassium Sodium	Diuretic effect Depletion
Gentamicin	Potassium Sodium	Depletion
Levodopa	Protein	Competition for absorption
Neomycin	Fat Protein Sodium Potassium Calcium Iron Vitamin B ₁₂	Decreases pancreatic lipase and binds bile salts and interferes with absorption

(contd.)

(contd.)

<i>Drug</i>	<i>Nutrient</i>	<i>Potential side-effect</i>
Penicillamine	Zinc Vitamin B ₆ Sodium	Altered nutrient excretion
Phenobarbital	Vitamin D Folate	Impaired metabolism and utilization
Tetracycline	Vitamin D Folate Protein Iron	Impaired metabolism and utilization
Tricyclic antidepressants	—	General malabsorption, weight gain due to appetite stimulation

2. The Consistency of the Diet In this the normal or modified diet may be given as a liquid diet or a soft diet depending on the condition of the patient.

3. The Amount or Quantity of the Diet This may be restricted. Simultaneously, the proportion of some components may also be changed such as prescribing a 1000 mg sodium with 1200 calories diet.

Common terms that are used in a therapeutic diet are high and low. This means whether the nutrient that is to be fed should be in greater or lower quantities than the number of servings recommended in that food group, e.g. if a low-protein diet is advised then the normal requirement of six servings of protein foods is reduced to two to three, servings.

The modified diet is different from the normal diet. Many a times, restriction of certain foods from being included in the therapeutic diet may result in lack of certain nutrients. In such cases, nutritional supplementation with tonics, tablets, syrups or injections may be necessary during the course of administration of a therapeutic diet.

In order to be effective, the prescribed diet must be followed to the very last detail. This depends on the patient. Quite often the modified diet may be resented by the patient himself as in the case of a patient who has been diagnosed as diabetic. This person may develop an aversion to his diet due to prejudices about therapeutic diets or his mental state. It is here that the dietitian plays an important role. She can develop an understanding in the patient and change his mental attitude towards the diet and try to make the food as interesting as possible.

7.3 THE HEALTHCARE TEAM

A patient enters the hospital in a state of anxiety. The hospital and members of the healthcare team have to work in a partnership with the patient and his family, with a goal to help him recover from illness and return home in a fit physical and mental condition to become a productive part of the society he lives in.

Every patient has his own individuality and personality, and knows his body. The hospital has the medical expertise, the ability to use education, science and

technology to improve the patient's health. Thus, the healthcare team, in keeping with their guiding principles, must completely focus on healing and restoring the quality of life of the patient for his needs, along with the needs of his family through respect and compassionate care.

The members of the healthcare team are the following:

1. Attending Physician The attending physician has the responsibility for all decisions made that affect the care of the patient. Based on the diagnosis, the attending physician may be a hospitalist or a specialist such as a cardiologist or surgeon. The attending physician will play an important role on the length of stay of the patient.

2. Resident A resident is a fully licensed physician who is training to be a specialist. A resident is not an attending physician but will often be an active member of the healthcare team.

3. Nurse During the patient's stay in the hospital, nurses provide 24-hour bedside care and assistance. At any time, if the patient has any questions, needs or concerns, he should bring it to the nurse's attention.

4. Social Worker As part of the medical team, a social worker's role is supportive, informational and educational. He helps assess the needs of the patient, provides counselling and assists the patient to take help from community and hospital resources.

5. Dietitian A registered dietitian helps in planning meals and dietary needs as advised by the patient's attending physician. It is important to the dietitian that the patient's food choices are met with minimum variations from his normal dietary likes and dislikes. The dietitian has to take into account the patient's personal, cultural or religious food preferences (e.g., Jain, vegetarian, lactose-free, etc.).

6. Therapists Every hospital has many therapists who specialize in various aspects of the patient's recovery. Physical, occupational, speech and respiratory therapists are a few examples of those who may be part of the patient's extended healthcare team.

7. Home-Care Liaison Nurse/Ayah After the patient is discharged from the hospital, it may be necessary to coordinate any home healthcare needs, like a visiting nurse or if any special equipment is needed to be used at home by the patient.

8. Other Team Members Other members who may interact with the patient are a wide range of individuals such as radiologist, intensivist, pharmacists, volunteers and such people who are dedicated to the patient's healthcare.

9. Family and Friends Family and friends play an important role for many patients during their stay at the hospital as well as after being discharged from the hospital. Within this group, there are often one or two individuals with whom a patient feels especially connected and comfortable. These individuals are the support persons.

The hospital may need to know the primary support person for the patient and may need to have 24-hour access for him to be with the patient. He/She will be

the main contact for the patient's providers. The providers will update the primary-support person who will communicate the patient's wishes to others.

However, given that every patient is an individual with different needs and relationships, it is up to the patient to decide the extent to which he would like the primary-support person's involvement in his care during the hospital stay. The hospital may need to discuss aspects such as patient advocacy, medications, the current condition and healthcare history with the support person.

7.4 ROLE OF A DIETITIAN

A clinical registered dietitian may work in a hospital, medical office, or health agency whereas the administrative registered dietitian manages a food service and or a dietary department.

Many dietitians are employed in hospitals, public health nutrition programmes, long-term care facilities, child feeding programmes and food service management firms.

The dietitian has certain responsibilities, which could be listed as follows:

1. To assess the nutritional status of patients in health and disease.
2. To devise and coordinate all aspects of nutrition care plan, which should include long-term and short-term plans, newer treatment modalities and nutrition education plans.
3. To communicate with the doctor and monitor implementation of nutrition care plan.
4. To document all aspects of nutrition care.
5. To arrange patient follow-up as needed.
6. To participate in applied research as well as diet related professional activities. She must apply research findings and current knowledge in nutritional care of patients.
7. To communicate effectively and share knowledge with other members of the health team.

She has to perform the nutritional care program on five levels. These are as follows:

1. Patient level
2. Intra-professional level
3. Inter-professional level
4. Intra-organizational level
5. Inter-organizational level

The dietitian may collect relevant data from the patient as a 24-hour recall. In this method, she is required to record on a form, the oral intake of the patient during the previous 24 hours. She is required to collect data from the medical history of the patient. She has to develop a nutrition care plan as well as write the menu in accordance to the diet plan. She must monitor and document individual patient's adherence to the diet plan. In short, at the patient's level she must assess, plan, implement, evaluate and educate the patient's nutrition care programme.

At the professional level she must directly communicate with the doctors, the other members of the health team (nurses, pharmacists) and the social worker, about the patient's health status.

She must constantly be in touch with the current scientific advancements in the fields of medicine and nutrition. A continuing education programme such as attending conferences, seminars, meetings in related fields of nutrition and health care will go a long way in rejuvenating her role.

A dietitian has an important role, especially in planning the diet of a convalescing patient. Following are some of the functions of a dietitian:

1. Plan and prescribe a diet conforming to the dietary principles for the medical condition for which the case has been referred by the physician.
2. Prepare the patient mentally to accept the modified diet.
3. Plan the diet and make it more appetizing and appealing.
4. Enlighten and motivate the patient as per the needs regarding the technical and scientific aspects governing the diet.

It is often difficult to get the patient to eat meals based on a therapeutic diet. This is because many people are often reluctant to eat a new food or even a familiar food prepared in an unfamiliar way. This is more so when people are ill. Parents must have often experienced that when the child is ill, he refuses even a normal meal. If, in such an instance an unfamiliar food is offered to the child, his refusal will be even more emphatic. Appetites are depressed during illness, weakness and exhaustion. Hence, change in diet may be gradually brought about; if it has to be done suddenly then the changes may be such that the deviation from the patient's normal diet is minimal.

The surroundings in which the food is served influences the appetite. Thus, it must be served as attractively as possible. One should ensure cleanliness, colour, flavour and appetizing aroma around the patient. Large portions or servings may discourage a patient with a poor appetite. It is also essential for the person serving the food to be cheerful and encouraging.

Technical aspects about the diet should never be explained when the patient is eating his food. The explanation about basic facts of nutrition should be done only when the patient is completely relaxed and in a receptive mood. It is necessary to stress that the intake of a nutritious and balanced diet will result in a healthy living.

It is most important to see that the patient eats the prescribed diet. Unless a diet is meticulously followed, it is of no use.

□ Tools for Effective Nutritional Counselling

Behavioural and dietary changes can be helpful in preventing or treating a variety of prevalent health problems. Dietitians can be helpful in motivating patients to make positive dietary changes, be physically active and all this can be achieved to a very great extent with effective nutrition counselling.

There are some user-friendly tools which can enable dietitians to rapidly and accurately assess patient's diet and exercise habits as well as provide information important for effective nutrition counselling. The Nutrition Academic Award has developed two new tools, WAVE and REAP, that can help health care providers

conduct nutrition assessment and counselling with their patients in a practical and effective manner.

The WAVE acronym and tool is designed to encourage provider/patient dialogue about the pros and cons of the patients' current status related to Weight, Activity, Variety and Excess.

The Rapid Eating and Activity Assessment for Patients (REAP) is a brief validated questionnaire that is designed to aid providers in performing a brief assessment of diet and physical activity.

An accompanying Physician Key helps the provider in discussing the patient's answers and counselling them appropriately. REAP and WAVE can be helpful tools to facilitate nutrition assessment and counselling. Depending on the patient's health priorities and how much time is available, these tools can be used in a variety of ways to discuss nutrition with patients during a clinical encounter in 1–9 min.

For more information, refer American Society for Nutritional Sciences *J. Nutr.* 133, 556S–562S, Feb. 2003

7.5 HOSPITAL DIETS AND PROGRESSIVE MODIFICATIONS

A general, basic hospital diet is a necessity in all the hospitals as it is economical, improves efficiency, is convenient and affords uniform service.

Such a general or routine diet must be nutritionally adequate either to maintain adequate nutrition or to improve the nutritional status. The basic principles outlined earlier in this book for a normal, nutritionally adequate diet pertaining to the RDI based on the Basic Five Food Groups also hold true in respect of the general hospital diet. This general diet which in many hospitals may be known as House, Regular, Standard or Full Diet is served to ambulatory patients and those patients who do not require a therapeutic diet. However, this diet should contain a minimum number of rich foods and foods that require longer time for digestion, since, hospital patients are physically less active than average, normal persons.

Patients who need adaptations or modifications in their diet, due to illness, accident or injury, are served a modified diet until they become ambulatory patients who can be served the general diet. A typical general diet is shown in Table 7.2.

The progressive therapeutic diets in a hospital may be classified as follows:

1. Liquid diets (i) clear liquid, and (ii) full liquid
2. Soft diets
3. Light diets

Let us now examine the foods that are to be included and excluded in these diets. Some salient features of these diets are as follows:

□ Liquid Diet

As given above, the liquid diet is of two types, the clear liquid and the full liquid diet.

1. Clear Liquid Diet The clear liquid diet is usually prescribed for patients in the pre- or post-operative stage for one or two days. This diet is completely free of any solids, even those found in milk. Only clear liquids such as tea or coffee without

cream or milk, clear soups, etc. are given. This diet is nutritionally inadequate but is used for a very short period of time.

Table 7.2 A general hospital diet

Food Exchange List				
Full Vegetarian Diet (Adult Man—Sedentary Worker)				
	<i>Food group</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Calories</i>
1.	Milk	4	20.0	400
2.	Legumes and Pulses	2	12.0	200
3.	Flesh foods	—	—	—
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	2	—	100
7.	Cereals	12	24.0	1200
8.	Fat	2	—	200
9.	Sugar	25 g	—	100
			56.0	2300

Menu for the Day				
<i>Tea</i>	—	1 cup	<i>Tea</i>	1 cup tea and 4 biscuits
<i>Breakfast</i>	—	1 cup milk with sugar 2 slices bread with 5 g butter and 10 g cheese /1 boiled egg 1 banana (small)	<i>Dinner</i>	2 <i>chapatis</i> 1 cup rice 1 cup cauliflower and peas curry
<i>Lunch</i>	—	2 <i>chapatis</i> 1 cup rice 1 cup medium thick <i>dal</i> 1 cup spinach + potato curry 1 cup curds	<i>Bedtime</i>	2 small tomatoes 1 cup medium thick <i>dal</i> 1 cup milk with sugar

Table 7.3 Sample menus of clear liquid diet

<i>Tea</i>	—	Tea without milk	<i>Midafternoon</i>	—	Ginger ale
<i>Breakfast</i>	—	Coffee without milk	<i>Tea</i>	—	1 cup tea
<i>Midmorning</i>	—	Aerated beverage	<i>Evening</i>	—	Fruit juice
<i>Lunch</i>	—	Clear vegetable soup, <i>Ragi</i> , <i>kanji</i> plain jelly (using gelatin) using aspartame or saccharin	<i>Dinner</i>	—	Clear vegetable soup, <i>sago kanji</i> . plain gelatin jelly (using aspartame or saccharin)
			<i>Bedtime</i>	—	1 glass protinules

2. Full Liquid Diet The full liquid diet is used for patients who are acutely ill or who are unable to chew or swallow solid food. This diet includes liquid foods containing solids which are not very difficult to digest. The iron content of this diet is often inadequate (Table 7.4).

Table 7.4 Full liquid diet

Tea	—	1 cup milk	Tea	—	1 cup tea
Breakfast	—	1 glass egg-nog	Dinner	—	1 cup strained vegetable
Midmorning	—	1 glass fruit juice			soup with butter
Lunch	—	1 cup strained			1 cup rice <i>kheer</i>
		vegetable soup			1 cup custard
		with butter	Bedtime	—	1 glass milk with cream
Midafternoon	—	1 cup ice-cream			and protinules

□ Soft Diet

This diet is intermediate between a full liquid and a light diet. It is served to patients who are convalescing from surgery, gastro-intestinal disturbances and acute infections. This diet can be nutritionally adequate when planned on the basis of a normal diet. The foods should be soft in texture and consistency, easy to chew and contain low roughage (Table 7.5). The diet is made of simple, easily digestible foods and should contain no harsh fibre, and no rich or highly flavoured foods. It should be a high calorie-high protein diet.

A slight modification of this diet may be mechanically softened or dental soft diet which requires little or no chewing. Inclusion of a moderate amount of soft fibre is more helpful than harmful in most cases.

Table 7.5 Soft diet

<i>Tea</i>	—	1 cup	<i>Tea</i>	—	1 cup tea
<i>Breakfast</i>	—	2 slices bread with			2 biscuits
		butter	<i>Dinner</i>	—	4 <i>phulkas</i> /2 <i>chapatis</i>
		1 soft cooked egg			1 cup potato and palak
		1 banana (small)			curry
<i>Lunch</i>	—	4 <i>phulkas</i> /2 <i>chapatis</i>			1 cup <i>mung dal</i>
		1 cup <i>dudhi</i> vegetable			1/2 cup rice
		1 cup <i>mung dal</i> with			1 cup curds
		<i>ghee</i>			1 peeled <i>chiku</i>
		1/2 cup rice	<i>Bedtime</i>	—	1 cup rice <i>kheer</i>

□ Light Diet

This diet is very similar to a soft diet and, therefore, this classification is sometimes omitted by some hospitals. The light diet includes all foods mentioned in the soft diet in addition to simple salads such as fruits and cottage cheese or sliced tomato (Table 7.6).

Table 7.6 Light diet

<i>Tea</i>	—	1 cup	<i>Tea</i>	—	1 cup tea
<i>Breakfast</i>	—	1 cup <i>rava kheer</i>			2 slices bread with
		1 banana			butter
<i>Lunch</i>	—	4 <i>phulkas/2 chapatis</i>	<i>Dinner</i>	—	4 <i>phulkas/2 chapatis</i>
		1 cup red pumpkin			1 cup <i>chowli</i> with potato
		curry			curry
		1 cup <i>mung dal</i> with			1 cup <i>mung usal</i>
		<i>ghee</i>			1/2 cup rice
		1/2 cup rice			1 cup rice <i>kheer</i>
		1 sliced tomato	<i>Bedtime</i>	—	1 cup milk with
		1 cup curds			Protinules

Table 7.7 gives a comprehensive understanding about the various hospital diets.

7.6 ADDITIONAL MODIFICATIONS IN TEXTURE AND CONSISTENCY

As seen earlier, therapeutic diets are modified as liquid, soft, light and regular in terms of consistency and texture of the food, but besides these, additional modifications in consistency may have to be made and the same are listed out as follows:

1. Mechanical Diet (Edentulous) This diet is prescribed for the individual who has difficulty in chewing either because of lack of teeth or dentures or because of swelling of the oral cavity.

2. Tube Feeding This is used in cases of extreme emergencies when swallowing is difficult either due to oesophageal obstruction, severe burns, gastric surgery or similar conditions. Tube feeding is also required for patients who are suffering from *anorexia nervosa*.

3. Bland Diet This diet is used for patients with ulcerative colitis, gastritis, or diarrhoea. A progressive bland diet can be successfully used in treating gastric and duodenal ulcers.

4. Restricted Residue Diets This diet is used for patients suffering from severe diarrhoea, ulcerative colitis, diverticulitis, typhoid fever or partial obstruction in intestines as well as after a gastro-intestinal tract surgery.

5. High Residue or High-Fibre Diet This is prescribed either in atonic constipation or for diverticulosis.

Table 7.7 Summary of hospital diets

Type of hospital diets	Foods allowed	Foods omitted
Liquid Diet Clear liquid	Mild tea or coffee without cream or milk, fat-free broth Carbonated beverages, strained vegetables or fruit juice and gruels (<i>lapsi</i>) Plain gelatin, ginger ale protein supplements like protinules, protinex.	Milk, cream, egg, pureed vegetables or fruit; sugar, butter, margarine, oil or <i>ghee</i> , whole-grain cereals, legumes and pulses, fish, meat, poultry and sweetmeats.
Full liquid	Any food liquid at body or room temperature, milk, cream, icecream, gruels, <i>kheer</i> , vegetables and fruit juices, egg-nog, plain gelatin desserts, custard, curds, sugar, butter or margarine, <i>ghee</i> , oil, strained soups, strained meat in broth, tea, coffee and carbonated beverages, soft-cooked pulses like <i>mung dal</i> in soup form can be given.	Whole-grain cereals and pulses, vegetables such as cauliflower, onions, etc; sweetmeats, fish, etc.
Soft Diet	Soups-broth, cream or strained vegetables	Salads are not to be given
	Eggs—all types except fried eggs, soft-boiled and poached are preferably given.	Fried eggs
	All milk and milk products	Sweetmeats
	Cooked vegetables with simple preparation methods using minimum quantity of oil or <i>ghee</i> .	Strongly flavoured vegetables such as cauliflower, cabbage, onions and fibrous ones such as corn.
	Butter in limited amounts Fruits—cooked and canned ones which are without seeds, coarse skins or rough fibres and bananas, All fruit juices.	Spices and all ground <i>masalas</i> , green chillies, fried foods, nuts, coarse cereals, fibrous vegetable, tough meats, pastries and pickles.
	Cereals—All should be well-cooked, enriched, or finely ground, Rice, spaghetti, vermicelli, <i>khakra</i> , <i>phulka</i> , <i>rotla</i> , bread. All types of porridge or <i>kheer</i> .	Pulses like <i>chana</i> , <i>chana dal</i> , cowpeas, mothbeans, peas, etc.
	Pulses— <i>Mung</i> and <i>mung dal</i>	Fruits with seeds, coarse skins and rough fibre foods
	Meat—ground or minced, baked, boiled, broiled or creamed, sweet breads, liver, poultry, tender chicken and fish may be used. Ground beef and lamb can be given	

(Contd.)

Table 7.7 (Contd.)

Type of hospital diets	Foods allowed	Foods omitted
	Beverages—all may be given	
	Desserts—ice-cream, <i>sherbet</i> , plain <i>cakes</i> , and biscuits, simple puddings such as custard, tapioca and <i>blancmange</i> .	
Mechanically softened	All soups	Pineapple, skin from apples
	All egg preparations	and <i>chiku</i> may be removed
	All milk products	before serving.
	All vegetables especially in the pureed, chopped or diced form Corn cut from the cob, finely chopped lettuce, raw tomatoes, fried onion rings, etc.	
	All fruits	
	Meat, fish and poultry may be minced or finely ground, served with gravy to ease swallowing.	
	Desserts—all may be given including pastries.	
	All beverages	
Light Diet	All as in soft diet + simple salads such as fruit and cottage cheese (<i>paneer</i>) or sliced tomato.	Fried foods, pastries, fibrous vegetables and nuts.

7.7 MODIFICATIONS OF A NORMAL DIET DURING ILLNESS AND CONVALESCENCE

In addition to modifications in texture and consistency, other modifications in relative proportion of nutrients and restriction of certain nutrients are necessary with respect to the following:

1. Carbohydrate: type and content
2. Protein: type and content
3. Fat: type and content
4. Electrolytes and mineral: content
5. Vitamins: content

Modification in the proportions of carbohydrates, fat and protein in the diet are necessary, as listed below.

(a) Diabetic Diet is carefully calculated for each diabetic patient to minimize hyperglycaemia and glycosuria, to attain ideal body weight and to prevent ketosis, hypoglycaemia and coma. In this diet, proportion of carbohydrates is reduced, that of proteins is increased whereas fat is restricted.

(b) Low Calorie Diet is prescribed in order to achieve weight loss especially for those suffering from cardio-vascular and renal diseases, gout or hyperthyroidism and for severely ill patients with low food tolerance. In this diet, all the three energy-yielding nutrients are restricted.

(c) High-protein, High-fat, High Carbohydrate Diet is used for patients with hypoglycaemia.

(d) Ketogenic Diet is used to control epilepsy. It is a low-carbohydrate, low-protein, high-fat diet.

(e) Calorie-dense Diet is used in weight-increasing regimes.

1. Modification in Carbohydrates

(a) Lactose-free Diet is prescribed for patients suffering from total or partial inability to metabolize lactose (milk sugar).

(b) Dumping Syndrome Diet is prescribed for patient who have undergone gastrectomy or gastric bypass surgery.

2. Modifications in Fat

(a) Restricted Fat Diets are prescribed for patient with disease of liver, gall bladder or pancreas in which disturbances of digestion and absorption of fat may occur.

(b) Fat-controlled, Low-cholesterol Diet is used for patients with increased levels of blood cholesterol and for those with atherosclerosis.

(c) Dietary Management in Hyperlipoproteinaemia is required for patients suffering from elevation of blood lipoproteins.

3. Modifications in Protein

(a) Restricted Protein Diet is used for patients in hepatic coma or with chronic uraemia, renal disease or liver disease.

(b) Gluten-free Diet is prescribed for patients with celiac disease or nontropical sprue having gluten intolerance.

(c) Restricted Phenylalanine Diet is given to confirmed cases of phenylketonuria.

(d) Restricted Purine Diet is useful in order to decrease the blood uric acid level as in gout.

(e) High Protein Diet is required to be prescribed in several cases. They are pre- and post-operative period, high fever, burns, injuries, increased metabolism, nephrosis in children, chronic nephritis (unless there is nitrogen retention), pernicious anaemia, ulcerative colitis, hepatitis, celiac and cystic fibrosis, tuberculosis and other wasting illnesses, wounds and nutritional anaemia.

4. Modifications in Electrolytes and Minerals This may be required in the following cases:

- (a) **Increased Sodium Diet** is useful in Addison's disease.
- (b) **Restricted Sodium Diet** is more common and advised for patients with cardio-vascular disease, hypertension, renal disease with swelling, cirrhosis of liver with ascites, pre-eclampsia and eclampsia (toxaemia) and ACTH therapy.
- (c) **Restricted Potassium Diet** is used in cases where potassium is not excreted properly from the body.
- (d) **Restricted Copper Diet** is given in Wilson's disease, oliguria or anuria.
- (e) **High Calcium and Phosphorus Diet** is advised in rickets, osteomalacia, tetany, dental caries and acute lead poisoning.
- (f) **High Iron Diet** is advised in nutritional or haemorrhagic anaemia.
- (g) **Acid-ash or Alkaline-ash Diet** is responsible for producing acidity or alkalinity in the body. It is prescribed according to the type of kidney stone depending on its solubility in acidic or alkaline urine.

5. Modifications in Vitamins High *vitamin diet*—Vitamin A content of the diet may be increased to combat night blindness and xerophthalmia; increased vitamin D content to combat rickets and osteomalacia; increased vitamin K content to combat liver and gall-bladder disease; increased thiamine to prevent beriberi and polyneuritis; increased niacin to prevent pellagra; increased ascorbic acid (vitamin C) to prevent scurvy, and to improve wound-healing and overall defence mechanism of the body.

7.8 TYPES OF FEEDINGS

There are various types of feedings:

1. Oral or Enteral Enteral feeding is a method of providing nutrient solutions in the GI tract through a tube. This method is used for nutritional support in patients who are unable to ingest or digest sufficient amounts of food, but have adequate intestinal capacity. It may include the use of formulas as oral supplements or meal replacement.

Enteral nutrition may be required if the patient is

- (a) Unable to consume oral nutrition as in comatose states, spinal cord injury, burns, COPD, oro-facial surgery, etc.
- (b) Has impaired digestion, absorption, and metabolism as in severe gastroparesis, Crohn's disease or even inborn errors of metabolism.
- (c) Has undergone severe wasting as in cancer, cerebral palsy or sepsis.
- (d) Has difficulty in orally consuming nutrients such as in facial trauma, neurological disorders, HIV/AIDS, respiratory failure, traumatic brain injury, etc.

The decision of using enteral feeding depends upon the period for which it may be required, whether the patient has the ability of normal digestion and absorption, the degree of tract for aspiration (tube displacement) and the formula viscosity and volume that will be used.

Today, enteral feeding has come a long way from the times it was practised by the Egyptians in the early XVI century. Enteral feeding can be used today due to a number of factors. These are:

- (a) Development of simple, low risk procedures for placement of tubes in the GI tract, especially percutaneous endoscopic gastrotomies and jejunostomies.
- (b) Availability of a wide variety of commercial enteral feeding formulae.
- (c) Advantages of enteral feeding over parenteral nutrition (PN) like preservation of structure and function of the GI tract, more efficient use, fewer infections and metabolic complications, greater ease of administration and lower cost.

Feeding tubes are inserted either through the nose (naso-gastric or naso-enteral tubes) or through the abdominal wall (gastrostomies, jejunostomies and duodenostomies). Occasional feedings may be given through a pharyngostomy or an esophagostomy. One method may serve as a transition to another method of administration subject to change in patient's status.

A number of commercial products are available which are designed for general nutrition and others are designed for specific metabolic or clinical conditions. They are as follows:

- (a) Defined formula diets, i.e. they contain ingredients including nutrients processed from foods and/or relatively purified compounds, simple or complex, which are prepared commercially. Generally, they provide 1.0 kcal/ml. Those which provide 1.5 to 2.0 kcal/ml are used when fluid intake is restricted for patients with cardiopulmonary, renal and hepatic failure. Patients of burns, fistulas, sepsis or trauma may require high-nitrogen formulas.

Table 7.8 General composition of formulas in enteral feeding

<i>Nutrient</i>	<i>General recommendation</i>	<i>Components used</i>
Protein	4% to 32% of total kcals	Lactalbumin, beef, soya protein isolate. High osmolalose products such as hydrolysed casein, whey, lacalbumin or soy (dipeptides, polypeptides, oligopeptides)
Carbohydrate	40% to 90% of total kcals	Pureed fruits and vegetables, corn syrup solids, corn and tapioca starch hydrolysates, maltodextrins, sucrose, fructose and glucose. Lactose is avoided.
Vitamins, minerals,	Moderate amounts	Patients with normal cardio, renal and hepatic function
Electrolytes	Electrolyte restriction	Compromised cardio-pulmonary, renal or hepatic function.
Fluid	1 ml/kcal or 30 to 35/kg of ideal body weight	Standard formulas contain 80 to 85% free water. All fluids given should be considered.
Osmolality	300–500 mOsm	General purpose formulas
	400–700 mOsm	Nutrient dense formulas
	900 mOsm	Hydrolysed formulas

- (b) Elemental, i.e. those that contain pre-digested proteins. Other solutions used in enteral nutrition are:
- (i) Polymeric solutions containing macro-nutrients in the form of protein isolates, triglycerides and carbohydrate polymers.
 - (ii) Monomeric solutions containing proteins as peptides and/or amino acids, fat as long chain triglycerides, or a mix of long chain triglycerides and medium chain triglycerides, and carbohydrates as partially hydrolyzed starch maltodextrins and glucose oligosaccharides.
 - (iii) Solutions for specific needs as in inborn errors of metabolism, renal failure, hepatic failure, etc.
 - (iv) Modular solutions—the nutrient components are mixed with other enteral products to meet special nutritional or metabolic needs of a given patient, e.g. increased calories, minerals, etc.
 - (v) Hydration solutions, which provide minerals, water and small amounts of carbohydrates.
- (c) *Home Enteral Nutrition (HEN)*—This is being used increasingly, especially for cancer patients and patients with swallowing disorders. The latter generally occur in those who had suffered strokes. The patient is fed regular homemade food after blenderising it. HEN has been used for periods exceeding seven years, providing good nutrition and rehabilitation with minimal impact on the quality of life. However, it is necessary that the patient undergoes a regular follow-up to ensure appropriate functioning of the feeding tube as well as optimization of the nutritional regime.



2. IVH/Intravenous Hyperalimentation The term *hyperalimentation* implies a high caloric formulation. Since, it also applies to tube feeding, it was differentiated as intravenous hyperalimentation and enteral hyperalimentation. Recently, these terms have been replaced by total parenteral nutrition and enteral hyperalimentation.

□ Problems of Enteral Nutrition

Since, enteral feeding may be for short or long periods of time, the patient may experience problems such as tube displacement, ulceration, regurgitation, aspiration. There may be GI complications such as nausea, vomiting, constipation, diarrhoea or even metabolic complications such as micronutrient deficiencies, glucose intolerance, etc.

□ Primary Objectives of Parenteral Nutrition (PN)

Patients who for a critical period cannot be adequately nourished by oral or tube feeding require PN. It is useful in problems of gastro-intestinal incompetency like short bowel syndromes, other types of bowel dysfunction, paediatric disorders, cancer, obstetric problems, neurologic injuries, multi-organ system failure and other hypermetabolic states, surgery, sepsis, and AIDS.

Peripheral and central venous access are used as routes of PN. Some examples of vascular access routes are the peripheral vein, jugular vein, subclavian vein, portal vein, arteriovenous fistulas, femoral or iliac vein, etc. Central access refers to the catheter tip placed in large, high blood flow vein such as the superior vena cava.

Components of PN fluid include water, an energy source (generally glucose), all essential and sufficient non-essential amino acids, essential fatty acids, macro minerals, trace elements and vitamins to meet the individual requirements. Adequate care must be taken to prevent a deficiency of any essential nutrient.

Commercial standard PN solutions are available generally having the following composition:

1. *Protein*: Concentration of essential and non-essential amino-acids ranges from 3 to 15%.
2. *Carbohydrate*: Concentration of dextrose monohydrate ranges from 5 to 70%. The calorific value of dextrose monohydrate is 3.4 kcal/g
3. *Lipid*: Emulsions of aqueous suspensions of soyabean or safflower oil with an emulsifier are available at concentrations of 10 to 20%. Glycerol is added to this emulsion and provides osmolarity. Glycerol gives about 4.3 kcal/g
4. *Electrolytes, vitamins, trace elements* must be present in a PN solution but lower than normal intakes.
5. *Fluids*: As calculated for enteral nutrition.

To calculate osmolarity of a PN solution:

Total Osmolarity = (grams of dextrose/L × 5) + (grams protein/L × 10) + (mOsm of electrolytes)

□ The Indian Society for Parenteral and Enteral Nutrition (ISPEN)

Since its inception, the major features of ISPEN's activities have been:

1. Six annual conferences have been conducted in Delhi (1994) Mumbai (Bombay) (1996), Chennai (Madras) (1997), Hyderabad (1998), Pune (1999) and New Delhi (2000).

2. Several 1–2 day workshops, all over India, notably at Chennai, Thrissur (Kerala), Bangalore, Thiruvananthapuram.
3. Information Access Service to members through website links.

The objectives of ISPEN are:

1. To promote awareness of nutrition amongst medical and allied medical professionals.
2. To support research.
3. To advise educational and governmental authorities in training, certification and licensing.
4. To assess nutritional products.

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ISPEN was formed and registered as a society in 1994 at Chennai and is the additional link to the already existing chain consisting of American Society for Parenteral and Enteral Nutrition (ASPEN), European (ESPEN), Australian (AusPEN), Parenteral and Enteral Nutrition Society of Asia (PENSA) and South African (SASPEN) societies. ISPEN is represented in the International Confederation of Nutrition Support Organisations (ICNSO) organised by ASPEN, as well as Nutrition Science Educational and Research Fund (NSERF). Members of ISPEN automatically become members of PENSA.

7.9 INDIAN DIETETIC ASSOCIATION (IDA)

In 1963, a band of nutritionists, dietitians and workers in the allied health fields resolved to form a scientific body to highlight the importance of dietetics and nutrition in the maintenance of health and in the prevention and treatment of diseases. Thus, the Indian Dietetics Association was founded, with Prof. Kalyan Bagchi as Secretary and Dr. C. Gopalan as President. The association was affiliated to the International Congress of Dietetics in 1975.

The objectives for which the IDA was established are:

1. To promote the cause of science, particularly the branch of Nutrition and Dietetics, including related areas and to encourage the spirit of active pursuit of knowledge and original scientific research.
2. To facilitate social, scientific and cultural fellowship and cultivation of goodwill among the members.
3. To establish close contact among persons following different branches of pure and applied sciences and technologies with a view to develop a wider outlook and stimulate an intellectual pursuit towards a possible practical integration of available scientific knowledge in society.
4. To safeguard the interests of scientists, particularly those of its members, and work for their general welfare.

Registration Board

The suggestion regarding the institution of a registration board for dietitians was mooted in 1977, during the 12th Annual Convention of the Association, and started functioning from January 1981. The main objective of forming the Board was to ensure minimum standards of teaching and training in dietetics and to maintain a register of professional dietitians.

The Registration Board consists of the current president of IDA and six members nominated by the executive. Each member is to serve a term of five years. The Board is responsible for all activities related to the registration of dietitians.

Registration The registration is awarded to applicants successfully qualifying in the Registration Exam.

Eligibility Requirements for Registered Dietitian Examination

The eligibility requirements for Registered Dietitian Examination are as follows:

1. Life membership in IDA.
2. Graduate in Nutrition and Dietetics/PG Diploma or Master's degree in Nutrition and Dietetics.
3. Six months internship after completion of qualifying exam, in a hospital recognized by the IDA for internship and supervised by a registered dietitian. The internship should be done continuously or in two instalments.

Or

Two years of experience as full-time dietitian in a teaching hospital or under a registered dietitian.

Syllabus The syllabus for the examination comprises two test papers, which include subjects like physiology, microbiology, biochemistry, nutrition, dietetics and food service management. Some sample question papers are given in Appendix I.



SUMMARY

A normal diet which has been modified to suit the altered needs of a person in disease is a therapeutic diet. The diet may be modified in its physical form such as its texture, consistency, etc. along with its nutritive value as in a high-protein diet, high-calorie diet, or a sodium restricted diet. It plays a key role in supporting the vital systems so as to fight illness and recoup vitality.

The therapeutic diet also goes a long way in supplementing the drug therapy and counteracting the untoward side-effects of the drug. This leads the patient to near-normal health as far as possible.



CASE STUDIES

- I** A 32-year-old patient has undergone surgery for gallstones. Prescribe a post-surgery diet. How will you allow progression of the diet?
- II** A 6-year-old boy is admitted due to severe dehydration and high fever. He is being given fluids intravenously. What will be your role as a dietitian?
- III** An 82-year-old woman has been diagnosed with Hepatitis B and is showing signs of severe jaundice. What kind of a diet plan will you adopt? Explain the dietary principles involved.



REVIEW QUESTIONS

1. List five cases in which therapeutic diet is prescribed.
2. Give five examples of drug-nutrient interaction.
3. What is the role of a registered dietitian in a hospital?
4. Write short notes on: liquid diet, soft diet, light diet.
5. Plan a diet for an old woman who is 65 years old and using dentures.
6. In which cases are modifications done to a normal diet? List them out.
7. When was the IDA founded ? What are its objectives?

Chapter

8



Diet During Energy Imbalance—High- and Low-Calorie Diets

One often hears some people saying 'I eat so little, yet I put on so much weight!' It is puzzling as to how a person eats less and still puts on weight. What has gone wrong?

8.1 ENERGY BALANCE

In order to understand the concept of weight regulation, it is necessary to understand the meaning of *energy balance*.

In Fig. 8.1, you will see that the terms *fuel foods* (energy-giving foods) and *physical activity* are at opposite scales. This means that if there is balance between energy intake and energy output, the scales of energy balance will be equal. Hence, a person who is in energy balance will maintain his weight.

Energy balance, therefore, is a condition in which calorific value of food intake is practically equal to the total energy expenditure (Fig. 8.1 (A)) and the body weight remains stationary.

If the amount of caloric (energy) intake through fuel foods remains constant but the energy output is either in excess or less than the energy intake, then the energy balance is not maintained, as shown in Figs 8.1 (B) and (C). In the former case, the person loses weight while in the latter the person gains weight.

□ Energy Intake Versus Energy Expenditure

If a person has increased his physical activities which call for more energy than what is provided by the food that he eats, then the person loses weight.

If, on the contrary, the physical activity of the person is reduced to such an extent that there is an excess of energy intake over his body's needs, then the person gains weight. An imbalance between fuel intake and energy output would result if the amount of fuel foods that a person eats every day over a long period of time is increased or decreased while his energy needs remain constant.

You may now understand that a stout person who says he is eating less is telling the truth but not the whole truth because he has not realized the fact that in proportion to the energy output his body is expending, he is eating more.

Another factor that has been realized is the *assimilation capacity* of persons. This factor varies from person to person. The ability of the body to convert available excess food energy into fat is found to be more in case of obese individuals. This factor is governed by heredity.

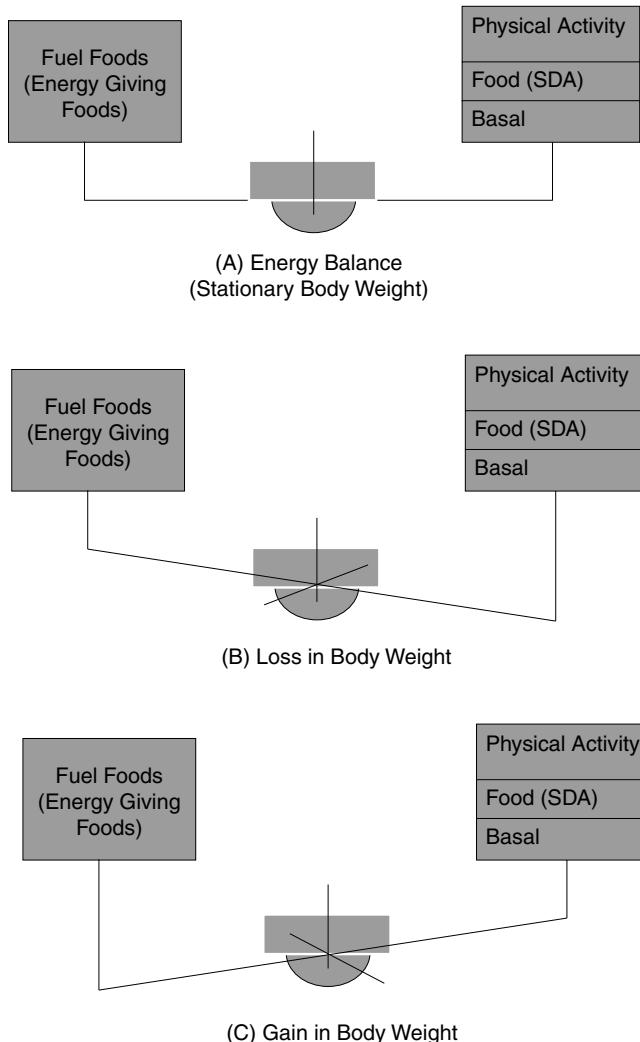


Fig. 8.1 Energy intake v. energy expenditure

8.2 DEFINITIONS, TYPES AND CAUSES OF OBESITY

According to the ideal height and weight tables for Indian males and females, given in Appendix IV, the percentage deviation for overweight and obese will be clear. However, these may be defined as:

- **Overweight** — A person who is 10 to 20 percent above the normal ideal weight for his sex, age and height.

- *Obese*—A person who is more than 20 percent above the normal ideal weight for his sex, age and height.
- *Underweight*—A person who is 10 percent or more below the normal ideal weight for his sex, age and height.

Obesity and overweight have to be reviewed in terms of the lean body mass or muscle to body fat. An athlete for example will have highly developed muscle mass and therefore may be overweight according to the layman but his body has more muscle than fat in proportion. It is therefore, not a mere matter of total weight, one must be able to distinguish between weight due to well developed muscle mass and due to excessive flap or fat deposition. There are two types of obesity:

1. Developmental Obesity This category of obesity begins in the early years of a child's life and continues steadily over the adult years. Hence, the foundation has already set in by the time the child is about four years old. The cells become saturated with fat and as the child grows older, more and more fat accumulates in the body. Muscle and bone mass also increases since, the body has to carry the additional weight. Such children usually grow tall, look older for their age and are obese right through infancy even up to their adult years. This type of obesity results in a higher lean body mass along with the fat.

2. Reactive Obesity This type develops due to periods of emotional stress in a child's life. During such stress periods the child may overeat resulting in increase of weight. However, since these periods are intermittent, the weight also reflects ups and downs.

Such a type of obesity results in a child having more lean mass as compared to the fat content.

Difference in sexes have shown that women generally gain weight after the first pregnancy and after menopause. Men gain weight generally after the age of 50 since their basal metabolic rate is lowered and the physical activities are decreased, while the food intake in terms of calories is not reduced.

Several factors are responsible for obesity. Of these, four causes are recognized. They are as follows:

□ Factors Responsible for Obesity

1. Hereditary Factor Although genetically the child is not determined to be obese yet obesity in parents influences obesity in children since the food habits of parents mould those of the child.

Other genetically associated factors are the activities of the child such as *fidgeting* which is an important way of burning up calories. Some people who squirm and wriggle use up calories which equal to those burnt on jogging several miles every day.

Scientists have also found that a tendency to fidget or *spontaneous physical activity* varies from person to person but seems to run in families, just as obesity does. So also, significant differences are found in people's metabolism, that is, the rate at which they burn up calories while lying still, are passed from generation to generation. This also applies to food assimilation capacity.

2. Social and Cultural Factors People in the upper socioeconomic strata tend to be more obese mainly due to their rich food intake and luxurious lifestyle which involves minimum physical activity. Cultural factors which influence our food habits and thus, predispose us towards obesity have been elaborated in Chapter 5.

3. Emotional Factors The correlation between obesity and emotional factors has been well established. Overeating may result from boredom, loneliness or a sense of social rejection. Today, while watching television, one finds many teenagers and adults eating crisp, oily snacks with soft drinks as a means of passing time.

4. Abnormalities of Glandular Functioning or Metabolism A minor group of people suffer from obesity due to malfunctioning of some, one, or more of the endocrine glands, i.e. thyroid, pituitary or sex glands.

8.3 MEASUREMENT OF OBESITY

The methods employed to assess the amount of body fat and diagnose obesity can be listed out as below:

1. Lean body mass (muscle tissue) can be derived from the measurement of percent body water. The latter is estimated by using tritiated water or antipyrine. It is known that the average water content of lean body mass is 73.2 percent. Hence, the following equation:

$$\text{Percent body fat} = 100 - \left[\frac{\text{Percent body water}}{0.732} \right]$$

2. Body density measurement can be assessed by under-water weighing. The density of normal weight subject is known to be 1.0629 g/ml at 37°C and the density of obese tissue is 0.947 g/ml at 37°C. It is possible to determine the proportion of adipose tissue on this basis.
3. Measurement of body cell mass or total body potassium can be made by using various isotopes of potassium. Further, lean body weight can be derived from these data and body fat can be calculated.
4. A relatively simple method of assessing obesity is done by weighing the patient. By simple weighing, obesity is diagnosed if the weight is in excess of the average desirable weight for men and women at a given height. It is also important to measure the height accurately.
5. Body mass index (BMI) is the most commonly used criterion to diagnose obesity. It was described by Quetelet and is also called *Quetelet Index*. It is calculated as:

$$\text{Body mass index (BMI)} = \frac{\text{Weight (kg)}}{\text{Height (metre)}^2}$$

BMI Classification Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m^2). For example, an adult who weighs 70 kg and whose height is 1.75 m will have a BMI of 22.9.

$$\text{BMI} = 70 \text{ kg} / (1.75 \text{ m}^2) = 70 / 3.06 = 22.9$$

Table 8.1 International classification of adult underweight, overweight and obesity according to BMI

Classification	BMI(kg/m^2)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00–16.99	16.00–16.99
Mild thinness	17.00–18.49	17.00–18.49
Normal range	18.50–24.99	18.50–22.99 23.00–24.99
Overweight	≥ 25.00	≥ 25.00
Pre-obese	25.00–29.99	25.00–27.49 27.50–29.99
Obese	≥ 30.00	≥ 30.00
Obese class I	30.00–34.99	30.00–32.49 32.50–34.99
Obese class II	35.00–39.99	35.00–37.49 37.50–39.99
Obese class III	≥ 40.00	≥ 40.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004.

With advancing age BMI increase to the extent that Grade I obesity may be acceptable in people aged 65 years or above.

6. Skin-fold thickness (SFT) is the most commonly used technique that determines subcutaneous fat by measuring skin-fold thickness (SFT) using calipers. Since, subcutaneous tissue constitutes approximately 50 percent of adipose tissue stores, skin-fold measurements are useful in judging the total body fat of an individual. Measurements may be made at the triceps, biceps, subscapular and suprailiac skin-folds. SFT of (triceps plus subscapular area) greater than 45 mm for males and 69 mm for females signifies obesity.
7. A variety of other anthropometric measurements have been employed in the diagnosis of obesity. The waist-hip ratio is a simple and fairly useful parameter. In men, fat tends to be deposited more on the chest and the abdomen, while in women the tendency for fat deposition is more on the buttocks and thighs. For men a waist-to-hip ratio above 1.0, and for women a waist-to-hip ratio above 0.9 indicates obesity.

8.4 IMPORTANCE OF WEIGHT REGULATION

One has often heard the phrase ‘the longer the belt, the shorter the lifespan’. Excess weight can be dangerous. It involves inconvenience and also decreases the efficiency of the person, besides subjecting the heart to undue stress.

Obesity is indicated as a health hazard since statistical data shows that obese persons risk a number of diseases such as coronary atherosclerosis and hypertension. It also complicates other diseases such as respiratory difficulties in emphysema, chronic bronchitis and asthma. It increases risk during surgery. Heart attacks are more commonly found among the obese as is diabetes. Obesity, in short, places the body under undue strain, lowering resistance to infection causing general physical weakness and predisposing the obese persons to a number of diseases which can shorten the lifespan.

8.5 DIET DURING OBESITY

The first step towards a dietary treatment of obesity is to determine the amount of weight that is to be reduced. This can be easily done by referring to the height-weight tables given in Appendix IV for different ages and sexes. The desirable weight subtracted from the present weight will give the excess weight that must be reduced either in terms of pound or kilograms.

□ Calorie Adjustment Required for Weight Loss

In order to lose one pound per week or about four pounds per month, it is necessary to decrease the *daily* calorific intake by 500 kcals. This could be further aided by increasing the appropriate physical activities.

This calorie adjustment is outlined here.

Basis of estimation :

1 lb of body fat	= 454 g
1 g of pure fat	= 9 calories
1 g of body fat	= 7.7 calories (due to some water in fat cells)
454×7.7 cals/g fat	= 3495.8 cals/lb of body fat (rounded off to 3500 cals)
3500 cals/7 days	= 500 cals/day.

Before beginning the regime, it is necessary to *make up your mind*. The most important part of reducing diet is not its planning but its maintenance over a period of time by which it becomes effective. The food habits developed during this period will automatically maintain the desirable weight attained. A calorie-restricted diet works best for people whose eating habits are good but who only require to reduce the amount of food eaten.

Calories are restricted after determining the total energy needs by calculating the Basal Metabolic Rate energy needs, the Specific Dynamic Action and the caloric requirement of physical activities normally engaged by the person daily. The calculation is outlined in detail in Chapter 2.

The calculation given below shows a shorter and quicker method of computing the energy requirement and to calculate kilocalories for weight loss and weight gain.

Determine Energy Needs

1. Compute basal energy expenditure (BEE). This gives the number of calories required by the person in a resting state.
2. Multiply BEE by 1.2 to determine the number of calories used during daily activity.

3. Subtract 500 to determine kilocalorie requirement for *weight loss*.
4. Add 500 to determine kilocalorie requirement for *weight gain*.

Example: A woman who is 5 feet, 1 inch tall, 31 years old, with a weight of 112 pounds ($W = 112 \times 0.45 = 50.4 \text{ kg}$) ($H = 61 \times 2.54 = 154.94 \text{ cm}$).

How many calories per day will promote weight loss?

1. BEE woman = $655 + (9.6 \times 50.4) + (1.8 \times 154.9) - (4.7 \times 31) = 1272$
2. $1272 \times 1.2 = 1526$ kilocalories expended with daily activity
3. $1526 - 500 = 1026$ kilocalories to promote weight loss of one pound per week

BEE Formula

$$\text{BEE men} = 66 + (13.7 \times W) + (5 \times H) - (6.8 \times A)$$

$$\text{BEE women} = 655 + (9.6 \times W) + (1.7 \times H) - (4.7 \times A)$$

Note : W = Ideal body weight in kilograms (pounds $\times 0.45 = \text{kg}$)

H = Height in centimetres (inches $\times 2.54 = \text{cm}$)

A = Age in years.

8.6 FAD DIETS

Before proceeding with dietary management of obesity, it is essential to know about fad diets most of which are commonly called crash diets.

There are several of them such as *rice diet*, *banana diet*, *ice-cream diet*, *liquid-protein diet*, *fasting diet* or *no-carbohydrate or ketogenic diet*. The main drawback which can prove hazardous in the long run is manipulation of the components of a normal balanced diet into an unbalanced one to achieve weight loss. Such diets which are potential health risks are not recommended.

To cite an example, *protein sparing modified fasting* (PSMF) diet containing approximately 50 g protein and 500 kcal/day are recommended for extremely obese patients who are 30–50 percent over the ideal weight, *under strict medical supervision* for a maximum of 12 weeks. After one month of balanced, moderate, calorie-restricted diet, they may go back to PSMF diets for another 12 weeks until ideal weight is achieved. Such a regime if not followed under medical supervision can be dangerous since it causes ventricular arrhythmias resulting in death.

Once weight loss is achieved and the ideal weight is reached, it is necessary to maintain the ideal weight permanently. Only then the diet is deemed successful. It is achieved by the dieting person only through control over the quality and quantity of food intake.

Other types of diets that have come into vogue are as follows:

1. Restricted-Energy Diets Since, weight gain is associated with the calorific value of the diet, these types of diets prescribe the intake of restricted (limited) calories. These diets must be high in carbohydrates (50% to 55% of total kilocalories) using sources such as vegetables, fruits, legume sprouts and whole grains. The diet should also contain adequate amount of protein, (about 15% to 25% of the calories). This is a must for the protein-sparing action of carbohydrates. The fat content should not be more than 20 to 25% of the caloric intake. The intake of fibre (about 40 g) is

recommended to reduce calorie density of the diet and to delay the time required for the stomach to empty. However, over intake of fibre should be avoided.

It is also essential to give the dieter the freedom to decide the distribution of fat as desired throughout the day, since, it makes the approach more appealing and, involves the person in the dieting process.

It is necessary to avoid the intake of alcohol and foods rich in sugar, as we all know that they are empty sources of energy. However, this should not affect the palatability of the diet. Alcohol gives 7 kcal per gram. It behaves like a fat because it spares fat from being oxidised. When used in the diet it may substitute other healthy foods. Alcohol depresses appetite leading to weight loss, emaciation, and even malnutrition. Moderate users tend to gain weight due to alcohol calories added to their usual diet. Hence, use of alcoholic beverages in excess of energy requirements should be considered a risk factor for obesity.

Artificial sweeteners and fat substitutes can be used to improve the acceptability of food, but it may not be successful in reducing the food intake (rather otherwise!).

Vitamin and mineral supplements are usually recommended for diets that provide less than 1200 kcal for women or 1800 kcal for men.

2. Exchange System Diets This system of dieting is programmed to meet the individual needs by including snacks (mid-morning, mid-noon, or evening). The dieter can also use small amounts of sweets, alcohol, balancing them against some foods from the five food groups.

3. Formula Diet and Meal Replacement Programs These type of diets have begun flooding the market. Generally, they contain high quality protein, fructose and a moderate amount of monosaturated fat. The calorific value may be between 1000 to 1600 calories per day. These type of formula diets may be used for reducing programs as well as for weight maintenance. Generally, they supply approximately 900 to 1000 kcal. (20% from protein, 25% from fat, and 55% from carbohydrates.) At these energy levels, and supplementation with vitamins and minerals these formulae may be considered safe.

4. Commercial Programs Commercial weight-loss programs are also in fashion with new programs coming into the market regularly. Most of them offer balanced diets. It must be always borne in mind that any program must be based on sound nutritional practices. Some programs collect data on the effects of treatment, number of people who drop out of the program.

Some programs require the use of proprietary pre-packaged low-fat meals. To improve adherence to the diet regime, the members are taught self-introspection, behaviour modification, and basics of good nutrition. Some people prefer pre-packaged diets because they avoid making choices about food. Internet has pervaded our life in every way including dieting. The Internet can be used for weight loss programs provided it includes behavioural therapy and the individual's feedback. Qualified help must always be sought by the individual to make any dieting program safe and successful.

5. Fasting In India fasting is frequently done as a part of religious sentiment. Sometimes it may be used as an extreme effort to lose weight. Therefore, it is rarely

continued for long periods of time. The reader may be cautioned here that it may produce serious neurological, hormonal, and other side effects. More than 50% of the body weight loss is due to body fluids which can lead to serious low blood pressure (hypotension) problems. Concentration of the body fluids can cause gout and gallstones.

6. Extreme Energy Restriction These diets supply less than 800 kcals per day. Starvation or fasting diets provide fewer than 200 kcal per day. Such reducing methods are drastic and may not be safe.

7. Very-Low-Calorie Diets (VLCD) These diets supply between 200 and 800 kcal per day. Diets providing lesser than 800 kcal per day do not have any advantage and may not be safe.

The characteristics of VLCD's are that they are hypo caloric but provide protein in the range of 0.8–1.5 g/kg IBW per day. They contain adequate amount of vitamins, minerals, electrolytes, and essential fatty acids. They replace the person's usual food intake and should be used for 12 to 16 weeks. The results in the form of rapid weight loss is evident. However, such dieting may have side effects, hence, these diets may be advised for persons with a BMI above 30.

Most VLCDs are of two types. The PSMF (mentioned in fad diets) contains 1.5 g of protein per kilogram of IBW in the form of lean meat, fish, and poultry; no carbohydrates; and fat present in the protein sources consumed.

The second type of VLCD uses commercially formulated liquid diets. These may be based on milk or egg protein and contain 35 to 70 g of protein, 30 to 45 g of carbohydrate, and a very small amount of fat. Patients who follow a VLCD(400–800 kcal daily) can lose about 20 kg in 12 to 16 weeks and maintain about half of this loss.

□ Psychological Disorders of Dieting

1. Anorexia Nervosa This disorder is associated with an intense fear of gaining weight or becoming fat, even though the person is underweight. He prefers that his weight should be less than 85% of the expected normal weight. The person is constantly disturbed by his body weight or shape. Such persons have low self-evaluation and are in constant denial of the seriousness of the current low body weight. In young girls it may cause amenorrhea, i.e. the absence of three consecutive menstrual cycles.

A person suffering from Anorexia nervosa may severely restrict his intake of food or the person may be regularly engaged in binge eating and purging behaviour.

2. Bulimia Nervosa As in case of Anorexia nervosa, in this disease too, self-evaluation by the person is unduly influenced by body shape and weight.

This disorder is characterised by recurrent episodes of binge eating. The person consumes food indiscretely in an amount that is definitely larger than what most normal people would eat. Also the period of time between the two meals is short and fixed.

The person shows complete loss of control over eating during the period he is suffering from the nervous disorder. This episode of binge eating may occur on an average at least twice a week for three months.

After the episode of binge eating, the person undertakes compensatory behaviour in order to overcome his guilt and to prevent weight gain. He may do this by self induced vomiting, misusing laxatives, diuretics, enemas, or other medications. He may also undertake severe fasting or excessive exercise.

□ Dietary Management

1. Calories The basic principle of all reducing diets is to provide lesser calories than what the person requires. About 1200 calorie diet for men is found to suffice.

2. Protein A normal intake is essential. This means about 1 g/kg of ideal body weight should be supplied through the diet.

3. Fat It is essential to give taste and satiety to the diet. So also it supplies essential fatty acids and fat-soluble vitamins. About four teaspoons per day is recommended.

4. Carbohydrates These should be supplied so that they contribute not more than 70 percent of the total caloric intake. However, all simple carbohydrates such as those present in table sugar, jams, squashes, syrups, and fruit juices are to be avoided, since, they are a quick source of carbohydrates and, also, don't contribute bulk to the diet. A diet with a good amount of fibre helps to achieve a feeling of fullness with lesser amount of calories.

5. Vitamins and Minerals Including vitamin rich foods like green leafy vegetables, fresh fruits and whole grain cereals and sprouted legumes in the diet will provide the vitamins and minerals essential for our body.

6. Exercise It is as important in a reducing regime as the diet itself. This is important to decrease weight, to tone up the muscles and maintain the decreased weight. Regularity in exercise needs to be established. Besides vigorous exercises such as skipping, jogging, swimming, which expend many calories, there are *yogasanas* which help reduce fat from specific areas of the body. Such exercises mainly help one to burn calories, which has a synergistic effect on the reducing diet regime and makes it more effective.

The importance of exercise in weight control has not been fully understood. One reason is the misconception that additional exercise always causes an increase in appetite and food intake. This theory is without any basis. It appears that physical activity is necessary for normal functioning of the brain's feeding control mechanism. A fine balance between energy expenditure and food intake is not maintained by sedentary people. For most of them, the daily caloric intake generally exceeds energy requirement, resulting in *creeping obesity*. On the other hand, individuals who exercise regularly have an appetite control which matches their daily level of energy expenditure. This is borne out by labourers who regularly perform hard physical labour such as farm labourers and certain athletes whose daily caloric intake ranges between 3000–4000 kcals and yet are lean.

Another misconception is that the amount of energy expended during physical activity is so small that a person would have to spend an inordinate time exercising before achieving a substantial caloric deficit. It must be remembered here that increase in weight and accumulation of fat is the result of consistent surplus intake of energy

exceeding the requirement. Hence, it is also imperative that the calorie-expending effects of exercise should be cumulative. A calorie deficit of 3500 kcal is equivalent to one pound loss of fat, whether the deficit occurs rapidly or systematically over a long time.

The calorific cost of various physical activities varies with the body size. Activities which can be considered as being aerobic are brisk or uphill walking, jogging, running, swimming, cycling, ice-skating, roller skating and exercising to music. The first 12 minutes of these vigorous exercises are more effective in burning up body fat. Table 8.2 gives the value of energy expenditure of some exercises.

Table 8.2 Value of energy expenditure of some exercises*

	Exercises	Cals/min	Cals Burnt/Hour**
1.	Brisk walking, level ground		
	Weight 100 lb	3.6	216
	140 lb	4.6	276
	180 lb	5.4	324
2.	Brisk walking, uphill		
	Weight 155 lb	8.9	534
3.	Cycling 5.5 mph	4.5	270
	9.4 mph	7.0	420
4.	Climbing stairs		
	weight 140 lb	6.2	372
	180 lb	8.6	516
5.	Gardening, weeding, digging	4.4–5.6 8.6	264–336 516
6.	Swimming	5.0–11.0	330–660
7.	Cross-country running	10.6	636
8.	Climbing (light load and slope)	10.7	642
9.	Jogging	5.0–5.8	300–350
10.	Tennis	4.5–6.6	270–400

* Adapted from Passmore, R and Durnin, J VGA: 'Human Energy Expenditure', *Physiol. /Rev.*, 35,801, 1955.

** Figures computed from cals/min.

Hence, diet plus exercise is the ideal combination. A deficit in the caloric balance produced either by dietary restriction or by exercise can result in desirable modification in body composition, i.e. decrease in the body weight and body fat percent. A combination of exercise and diet offers considerably more flexibility for achieving a negative caloric balance and accompanying fat loss than either exercise or diet alone.

A decrease in intake along with increase in the energy output will be much more effective in the long run than by decreasing the caloric intake or increasing the caloric output alone.

To illustrate this point we take the same example of reducing 500 kcal from the daily energy intake (i.e. 3500 kcal per week) to reduce one pound per week. If in such a case, the dieting person performed half an hour of moderate exercise—the easiest being walking briskly—it will expend about 140 to 150 kcals per day (i.e. about 1000

calories per week), with this exercise, the weekly calorie restriction necessary to lose one pound fat each week would now only have to be 2500 kcal instead of 3500 kcal.

If the duration of the same exercise is doubled (about 1 hour) to expend 300 kcal per day, a calorie restriction of the diet would be only about 200 kcal per day or 1400 kcal per week, which is quite marginal.

If the intensity of the exercise is increased or if two exercises are combined, say walking briskly for one hour and climbing stairs (climbing about 70 steps expends 28 kcal which means it is necessary to walk up 5000 steps a week or 714 steps per day to get rid of 2000 kcal) or skipping rope or jogging for 30 minutes, there will be no need to restrict the calorie intake through diet and yet the person will lose one pound fat per week.

This clearly shows that physical activity can be used effectively, by itself or in combination with mild dietary restriction, to bring about an effective loss of body fat. Besides this advantage, it is seen that feeling of intense hunger and other psychological stresses are minimal compared with a similar programme of weight reduction solely achieved by diet. In addition to these two advantages, exercise enhances the mobilization and breakdown of fat from the body's adipose deposits. This helps to protect the lean tissue from breakdown, which is lost first when the weight loss is achieved by diet alone.

One should, however, be careful not to overexercise. One may exercise longer but not harder as it may unduly strain the heart.

In general, exercise benefits everyone by:

(a) Improving Fitness The basic components of fitness are flexibility, muscle strength, and cardio-respiratory endurance.

(b) Improving Psychological State Exercise assists individuals in coping with stress as well as building self-confidence and improving self-image.

(c) Changing the Body Composition Vigorous exercises significantly decrease body fat while proportionately increasing lean body tissue.

(d) Controlling Weight *Exercise can help individuals maintain weight if lean, lose weight if obese.* Exercise up to a certain level appears to influence energy balance by exerting an appetite-suppressing effect.

(e) Improving Physical Work Capacity or Stamina This is a result of the increase in maximum cardiac output during exercise. There is also an increase in the ability of the muscle to extract oxygen from the blood since the rate of blood flow increases through the tissues under exercise.

During the first few days of weight reduction the rapid weight loss is due to loss in body water and carbohydrates. At least two months of weight reduction is associated with a substantially greater loss of fat per unit of weight loss.

A weight loss programme which guarantees weight loss instantly should be judged with a lot of care since the caloric equivalent of each kilogram of weight loss increases substantially as the duration of caloric restriction increases. *This is the reason why it is so important to maintain a caloric deficit for extended periods of time: Shorter period of caloric restriction result in a larger percentage of water and carbohydrate loss per unit of weight reduction with only a minimal decrease in body fat.* Refer to Fig. 8.2.

□ Use of Artificial Sweeteners and Ready-to-Use Diets

Synthetic sweeteners such as drops or tablets of saccharin or aspartame may be used by the dieting person. Overuse of saccharin, however may cause some undesirable effects. It is, therefore, best to drink a beverage without any added sweetener, natural or artificial, if the need to control calories through sugar is found. More details on artificial sweeteners may be found in Chapter 9 on diabetes mellitus.

One should also be careful in evaluating the nutritional value of ready-to-use diets which have entered our market recently. Sufficient background of good nutrition has been given in these chapters for the discerning weight-loser to judge for himself the comparative benefits of a well-planned balanced diet prepared at home and slimming diets readily available in the market, which exaggerate the claims through blaring advertisements. These are more for commercial gains rather than public health benefit. More details about natural and artificial sweeteners are given in Chapter 9.

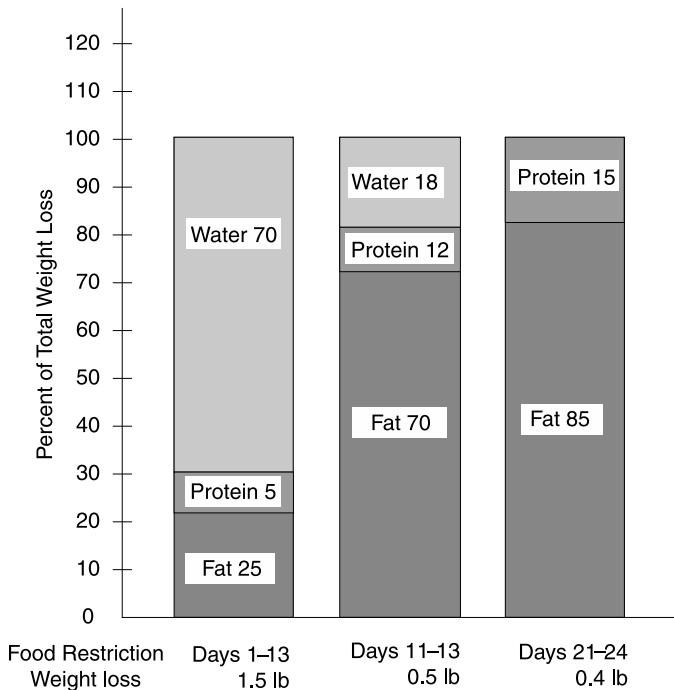


Fig. 8.2 Pattern of weight loss in a weight reduction regime

□ Practical Suggestions for Reducing Weight

1. Set the goal which is realistic.
2. Adjust the rate of weight loss to one pound per week.
3. Take the help of visible tools (weighing machine) and motivation techniques.
4. Learn the caloric values of your home dishes and control their consumption or exercise substitute. Do not be obsessed by calorie counter. Do not be finicky.

5. Anticipate plateaus. They are common to all. They occur due to accumulation of water as fat is used up. Increase exercise in this period to help get rid of this water and restart weight reduction.
6. Avoid commercially available low calorie foods. They are no better than low calorie home-made meals, besides being exorbitantly priced.
7. Avoid dietary binges. Your self-determination and mental control will see you through.
8. Avoid a separate menu for yourself. Instead adapt your dietary needs from the regularly prepared family dishes.
9. When eating away from home or in the company of guests take care and avoid excesses but do not get upset if you miss your planning. Adjust the following day's menu or the remaining part of the day's diet to compensate for the occasional excess calorie intake.
10. Avoid use of appetite depressants and such type of medication. The unnatural practices may do more harm than good; rather try out some natural methods. Some maintenance tips are given in the latter part of this chapter.
11. Do not change your meal or snack pattern. This is because you should not take all your calories at one sitting.
12. Do not think of any surgical methods. They may be harmful. However, liposuction may be tried in extreme obesity.

Table 8.3 gives a list of foods to be avoided, those which should be eaten in limited amounts and those that can be consumed liberally.

In addition an important tip is to boil, broil, steam or bake foods instead of frying them. Preferably, one must use the non-stick pans.

Foods which are high in calories usually are those which are greasy-crisp, oily, sweet, syrupy, sticky or concentrated or alcoholic.

Foods low in calories usually tend to be watery-crisp, clear, dilute or thin or raw.

Table 8.4 A and B shows sample menus for 1200 kcal diet for a sedentary woman and 1500 kcal diet for a sedentary man. Variety in the diet may be achieved by exchanging foods given in the exchange list in Appendix V.

8.7 MAINTENANCE DIET

The reducing diet has to be maintained until the desirable weight is obtained. Once it is attained a maintenance diet has to be formulated. This is the hardest part of the weight loss programme. The sensible maintenance diet teaches you healthy eating habits (which you must have already developed with the reducing diet) and protects you from hunger pangs.

A maintenance diet should begin with a good breakfast. A wide choice of low calorie foods to keep boredom (of the diet) at bay and plenty of raw foods at hand to keep hunger away.

Some maintenance tips are as follows:

1. After the gradual loss in weight to attain desirable weight is complete, increase the intake of low calorie foods gradually. These are listed in Table 8.3 under the subhead: Foods to be Allowed in Prescribed Amounts.

Table 8.3 Foods to be avoided, limited and consumed liberally

	<i>Foods to be Avoided</i>	<i>Foods to be Allowed in Prescribed Amounts</i>	<i>Foods to be Allowed Liberally</i>
1.	Sugar, jaggery, sweets, candies, jams, jellies, chocolates	Cereals such as wheat rice, <i>jowar</i> , <i>bajra</i> , <i>ragi</i> , etc.	Raw and green vegetables, especially the group A vegetables which contain very low amounts of carbohydrates.
2.	Bakery products such as cakes, sweet and cream biscuits, pastries, etc.	Dals and pulses	
3.	Concentrated milk and <i>mawa</i> preparations such as <i>pedha</i> , <i>burfee</i> , Bengali sweets, <i>basundi</i> , <i>shirkhand</i> , ice-cream, etc.	Milk without cream	Thin buttermilk
4.	All fried preparations including <i>farsan</i>		Spice to taste
5.	Fatty meat cuts, processed meat, ham, bacon, etc. All organ meats such as liver, kidney, brain, shell-fish and fatty fish	Fish, lean meat, egg, root vegetables such as potato, sweet potato, yam, colocasia, carrot and beetroot.	Clear soups
6.	Alcohol, alcoholic beverages and all synthetic soft drinks		
7.	Vanaspati, <i>ghee</i> , cream, oil dressings	Nuts and oil seeds Vegetable oils	
		Fruits—one serving of the following: orange, sweet lime, guava, pear, <i>chiku</i> —one medium size	
		Banana, mango—one small size or half big size	
		Apple—one small or one fourth big size	
		Grapes—20–25, small papaya, pineapple, watermelon, <i>chibood</i> (muskmelon) two to three slices.	

2. Whenever you desire to have a snack, prepare one with fresh, raw vegetables and fruits which are in season. These supply bulk, large amounts of fibre and good amounts of B complex vitamins and minerals.

Table 8.4 A 1200 kcal diet for an obese woman (vegetarian)

Food Exchange List				
	Item	No. of Exchanges	Protein (g)	Calories
1.	Milk	3	15.0	300
2.	Legume and Pulse	3	18.0	300
3.	Vegetable A	3	—	—
4.	Vegetable B	1	—	50
5.	Fruit	2	—	100
6.	Cereals	4	8.0	400
7.	Fat	1*	—	100
8.	Sugar	10 g	—	40
			41.0	1290

Menu Plan				
<i>Tea</i>	:	1 cup with 1 tsp sugar	<i>Tea</i>	: 1 cup tea with 1 tsp sugar
<i>Breakfast</i>	:	1 glass skimmed milk without sugar (about 200 ml)	<i>Dinner</i>	: 1 cup capsicum soup
		1 slice bread without butter		1 cup cabbage vegetable
		1 orange		1 cup <i>usal</i> (sprouts)
<i>Lunch</i>	:	1 cup tomato soup		1 <i>chapati</i> or 2 <i>phulkas</i> or
		1 plate (medium) salad (cabbage, lettuce, capsicum, 2 <i>phulkas</i> or 1 <i>chapati</i>)		1 <i>bhakri</i>
		1/2 cup rice		1 cup curd
		1 cup <i>palak</i> curry		1/2 cup rice
		1 cup thick <i>dal</i>		
		1 cup curd		

* No oil or fat to be applied to bread or *chapatis*, *phulkas*, *bhakri*, etc. One exchange is allowed for seasoning only.

3. Learn to curb your appetite before going out to attend parties. A glass of skimmed milk, an apple, or banana or a dry toast before leaving for the occasion prevents you from overeating at the party.
4. Do not eat absent-mindedly. This can be easily done by concentrating on the food that you eat. Do not eat while being distracted by conversation, reading or watching T.V.
5. Learn to become more mobile. Depend less on others to do your work. Be active. Go for long walks. Don't take a bus or rickshaw where walking will do. You must develop a habit of exercising at least for half an hour a day, such as jogging, running, aerobics, *yogasanas*, calisthenics, cycling, swimming or whatever form of exercise you may prefer.

Table 8.4 B 1500 kcal diet for an obese man

Food Exchange List				
	Item	No. of Exchanges	Protein (g)	Calories
1.	Milk	3	15.0	300
2.	Legume and Pulse	4	24.0	400
3.	Vegetable A	3	—	—
4.	Vegetable B	2	—	100
5.	Fruit	2	—	100
6.	Cereals	5	10.0	500
7.	Fat*	1*	—	100
8.	Sugar	15 g	—	60
			49.0	1560

Menu Plan				
<i>Tea</i>	:	1 cup tea with sugar (1½ tsp)	<i>Snacks</i>	1 cup tea with 1½ tsp sugar
			<i>Dinner</i>	1 cup tomato soup
<i>Breakfast</i>	:	1 glass skimmed milk without sugar (200 ml)		1 cup cabbage potato
		2 slices bread toast without butter		1 cup <i>usal</i>
		1 orange		1 <i>chapati</i> or 2 <i>phulkas</i> or 1 <i>bhakri</i>
<i>Lunch</i>	:	1 cup capsicum soup		1/2 cup rice
		1 plate (medium) salad (cabbage, lettuce, onion rings, cucumber, carrot)		1 cup curd
		1 cup spinach curry, with <i>mung dal</i>		
		1½ <i>chapatis</i>		
		1/2 cup rice		
		1 cup thick <i>dal</i>		
		1 cup curd		

* No oil or fat to be applied on bread, *chapatis*, *phulkas*, *bhakri*, etc. 1 exchange is allowed for seasoning only.

6. Seasonings such as lemon juice, vinegar, spices especially pepper and herbs may be used to give unique flavour to food.
7. Always make use of skimmed milk instead of whole milk. Skimmed milk has about half the calories of whole milk and more protein.
8. Weigh yourself every week to keep a check on the weight loss or gain, and accordingly modify the maintenance diet in the corresponding week.
9. Do not shop for food when hungry. Carry a limited amount of money when shopping.

10. Wear a dress which does proud to your figure.
11. Do not be misled on any occasion by the common phrase “*it doesn't harm to eat just this once.*”

8.8 DIET FOR AN UNDERWEIGHT PERSON

Just as there are several reasons for being overweight, there are as many reasons for being underweight. Very active, tense, nervous and people who obtain too little rest lose weight. Irregular eating habits and poor selection of foods are also responsible for an inadequate calorie intake.

Psychological factors which may cause a person to overeat may also cause him to eat less. *Anorexia nervosa* is a condition of severe weight loss due to some mental illness due to which the person refuses food.

Weight loss may occur in severe infections, high fevers, gastro-intestinal disturbances and hyperthyroidism.

It is necessary to make special efforts for such person to put on weight until the desirable weight is attained. Lean weight should increase along with an increase in strength, vigour and endurance.

Dietary Modification

The cause of loss in weight must first be removed and a high calorie diet may be given.

1. Energy About 500 calories a day will help to gain about one pound a week. Moderately active individuals may be given 2500 to 3000 calories diet for effective weight gain.

2. Protein About 1 to 1.2 g of the ideal body weight should be given. This may mean a daily intake of 60–80 g of protein.

3. Minerals and Vitamins A well-planned, high-calorie diet will provide liberal amount of vitamins and minerals. In such cases supplements may not be required.

4. Exercise Just as exercise is essential for an affective weight reduction programme it is equally vital for an effective weight gain programme. It benefits those who are underweight by stimulating their appetite to improve the intake of calories. It also helps in improving muscle tone especially of the digestive system, resulting in better absorption and assimilation of the food, which helps tremendously in weight gain. Exercise helps to increase lean weight and prevents fat accumulation. It also increases strength and endurance.

Some *simple rules* that can be followed are:

- (a) An underweight patient cannot initially adjust to a higher caloric intake. Hence, it is sensible to begin with his present diet and modify it in quantity and quality until the desired calorie level is reached.
- (b) Meal times should be as attractive and pleasant as possible.
- (c) Small but frequent meals should be taken. At least six small meals are advised. Mid-morning and mid-afternoon snack, in addition to the regular meals, do not give better results. Instead they interfere and decrease appetite for the next meals. On the other hand, bedtime snacks are more helpful.

- (d) No food should be forced for eating. Whatever food is appreciated at whatever time of the day by the underweight patient, should be eaten. Mild coaxing may be helpful, but if pushed on, no result is achieved.
- (e) No topics about food and their importance should be discussed during meal times, especially if it is undesirable for the person concerned.

A 2500 calorie diet for an underweight is shown in Table 8.5.

Table 8.5 A 2500 kcal Diet for an Underweight Person

Food Exchange List				
	<i>Item</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Calories</i>
1.	Milk	5	25.0	500
2.	Legume and Pulse	3	18.0	300
3.	Flesh food	1	10.0	100
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	2	—	100
7.	Cereals	10	20.0	1000
8.	Fat	2	—	200
9.	Sugar	50 g	—	200
			73.0	2500

Menu Plan					
<i>Tea</i>	:	1 cup tea	<i>Midnoon</i>	:	1 banana
<i>Breakfast</i>	:	1 egg or 1 cheese sandwich	<i>Tea</i>	:	1 cup tea
		1 glass milk or coffee			1 cup <i>batata pohe</i>
		1 orange	<i>Late</i>	:	1 cup cream of
<i>Lunch</i>	:	2 <i>chapatis</i> or 4 <i>phulkas</i>	<i>Evening</i>	:	tomato soup
		1/2 cup rice	<i>Dinner</i>	:	2 <i>chapatis</i> or 4 <i>phulkas</i>
		1 cup <i>dal</i>			1/2 cup rice
		1 cup <i>peas/rajma usal</i>			1 cup cauliflower potato
		1 cup <i>palak/methi/curry</i>			curry
		1 cup curd			1/2 cup <i>mung/matki usal</i>
		1 cup buttermilk <i>kadhi</i>			
			<i>Bedtime</i>	:	1 glass egg-nog



SUMMARY

The height-weight relationship is a simple yet effective yardstick of normal health. Being overweight or underweight under normal circumstances is not a disorder or disease, although it needs serious dietary attention to prevent health complications.

Being overweight puts strain on vital systems such as heart, kidney, lungs and interferes with physical mobility. The underweight conditions can result in general weakness and make the person vulnerable to infections and stresses.

The role of energy balance is vital in these cases. In energy balance, physical exercise matches the nutrition because of its decisive role in maintaining this balance as well as constructive effect on metabolic well-being and bodybuilding.



CASE STUDIES

- I Sex : female
 Age : 42 years
 Height : 5 feet 3 inches
 Weight : 82 kg
 Activity : sedentary housewife
 Symptoms : slightly hypertensive
 Other information : likes to eat all kinds of *farsan* and sweetmeats.
 What will be your advice to her with reference to:

1. Diet
2. Lifestyle modifications

For the solution, just scan the QR code given here OR visit <http://qrcode.flipick.com/index.php/234>.



Also check out the MCQ's related to this case in the next QR code OR visit <http://qrcode.flipick.com/index.php/305>.



- II Sex : male
 Age : 21 years
 Height : 5 feet 8 inches
 Weight : 42 kg
 Activity : works for a courier company which requires him to walk a lot
 Symptoms : he feels fatigued very early in the day
 Clinical picture : Normal.

1. What will be your dietary counselling to him?
2. Explain the reasons for the recommendations that you make.



REVIEW QUESTIONS

1. When does a person lose or gain weight ?
2. Define underweight, overweight, obesity and BMI.
3. Calculate your BMI or Quetelet index and find out the category to which you belong.
4. Why is it important to regulate weight?

5. Calculate the nutritional requirements of a person whose height is 5'2" and weight 76 kg. Draw a dietary plan to meet the requirements.
6. What are the benefits of exercising regularly?
7. Why is it more important to maintain the diet and exercise regime after attaining ideal weight?
8. What is the role of artificial sweeteners in weight regulation?
9. What precautions needs to be exercised in crash dieting?
10. What is the role of fibrous foods in a reducing diet?
11. Write a short note on "FAD DIETS".
12. What is lean body weight? What is its importance?
13. Give measures of obesity.
14. Prepare a diet plan for a girl aged 24 years, 5.2" height and weight 52 kg.

Chapter

9



Diet for Diabetes Mellitus

Diabetes mellitus, commonly known as diabetes, is a disorder of carbohydrate metabolism characterized by high blood sugar level (hyperglycaemia) and high level of sugar in urine (glycosuria). It is accompanied in many cases by secondary alterations of fat and protein metabolism, resulting in an array of physical disorders.

Diabetes therefore, is a metabolic disease. It can be kept well under control and reasonably managed with proper care though it cannot be cured once it occurs.

9.1 CAUSES OF DIABETES

Diabetes is the result of lack of effective insulin action. Insulin is a hormone secreted by the beta cells of islets of Langerhans which are an endocrine portion of the pancreas. Some minute quantities of insulin are also known to be secreted by the muscle tissue for its own use. For this reason moderate amount of muscular exercise (long walks, swimming, etc.) is always advocated for diabetic patients. This hormone is necessary for release of energy from glucose, which is a simple sugar obtained from carbohydrate sources.

Lack of insulin may be either absolute or relative. Absolute insulin deficiency does not occur normally. It occurs only in patients whose pancreas has been operated upon for the removal of a malignant tumour.

Relative insulin deficiency occurs when the quantity of insulin secreted is insufficient to metabolize the carbohydrates consumed.

In a majority of patients, however, the disease develops apparently unprovoked probably as a result of a hereditary predisposition, i.e. an inherent weakness of beta cells.

□ Factors Predisposing Diabetes

1. Acquired and Environmental Factors

- (a) *Infection*: It may precipitate insulin-dependent diabetes mellitus (IDDM) or non-insulin dependent diabetes mellitus (NIDDM).
- (b) *Direct*: Cell cytotoxicity—Alloxan, Pyrinuron are drugs which damage beta cells and produce diabetes.
- (c) Damaged beta cell function through other mechanisms, such as toxic substances, inadequate protein intake, nitrosamines in foods such as those found in smoked and cured mutton, precipitate diabetes.

2. Changes in Lifestyle

- (a) *Overnutrition and obesity* There is evidence to support the use of BMI in risk assessment for the diagnosis of diabetes or even response to weight loss. The BMI is a more accurate measure of total body fat. Waist circumference is a particularly helpful index of a normal or overweight person. Men whose waist circumference is more than 35 inches are at high risk of diabetes, dyslipidemia, hypertension, and cardiovascular disease.
- (b) Physical inactivity is an important risk factor in NIDDM.
- (c) Malnutrition
- (d) Severe or prolonged stress
- (e) *Drugs and hormones* There are several but of interest are the oral contraceptives. They cause glucose intolerance and in susceptible individuals may induce diabetes.
- (f) Pancreatic disorders

3. Metabolic and Endocrine Disturbances Hormones such as the adrenal cortical tropical hormone (ACTH), glycogen and adrenalin are shown to be diabetogenic since they increase the level of blood sugar.

9.2 CLASSIFICATION OF DIABETES

There are two main clinical groups of diabetics who may be differentiated as follows:

The Juvenile-Onset Type

This type occurs characteristically with an abrupt onset in patients who are less than 25 years old. They are also usually underweight. These patients are deficient in insulin in their blood plasma and show no insulin response when fed large amounts of glucose. They are liable to ketosis. Ketosis, as you may recall, described under carbohydrates earlier in the book, is an accumulation of ketone bodies in the blood, which in excess amounts can lead to coma and ultimately death. Hence, this type requires insulin therapy for control of the diabetes.

The Maturity-Onset Type

This type develops insidiously in middle-aged, usually, obese patients. They normally ignore their symptoms for several months before counselling help from a doctor. A second classification of diabetes mellitus and allied categories of glucose intolerance as per WHO is given below.

Clinical Classes

Diabetes Mellitus (DM)

1. Insulin-Dependent Diabetes Mellitus (IDDM) or Type 1
2. Non-insulin Dependent Diabetes Mellitus (NIDDM) or Type 2
 - (a) Non-obese
 - (b) Obese

3. Malnutrition Related Diabetes Mellitus (MRDM)
4. Other type of diabetes associated with certain conditions and syndromes
 - (a) Pancreatic disease
 - (b) Disease of hormonal etiology
 - (c) Drug-induced or chemical-induced conditions
 - (d) Abnormalities of insulin or its receptors
 - (e) Certain genetic syndromes
 - (f) Miscellaneous
5. Impaired Glucose Tolerance (IGT)
 - (a) Non-obese
 - (b) Obese
 - (c) Associated with certain conditions and syndromes
6. Gestational Diabetes Mellitus (GDM)

□ Statistical Risk Classes

(Subject with normal glucose tolerance but substantially increased risk of developing diabetes)

1. Previous abnormality of glucose tolerance
2. Potential abnormality of glucose tolerance

□ Clinical Presentation

The classic triad of diabetes mellitus is polydipsia (increased thirst), polyphagia (increased appetite and ingestion), and polyuria (increased urination caused by osmotic diuresis).

Amidst the increased appetite and craving for food, persons with diabetes mellitus (usually Type 1) may still experience weight loss because of the improper fat metabolism and breakdown of fat stores.

Other striking features include the presence of glucose and ketone bodies in the urine. Fatigue with weakness, irritability, blurred vision, numbness or tingling sensations in the hands and feet are also present.

□ Blood Glucose Levels

The normal fasting glucose concentration of the blood is 70–110 mg/100 ml using the glucose-oxidase colorimetric method. When the fasting level of glucose in blood rises above 170 mg/100 ml, sugar begins to appear in the urine. In severe diabetes the fasting blood sugar level may reach 400 mg/100 ml. The level of glucose in blood is the real confirmatory test for diabetes and not merely the appearance of glucose in the urine.

□ Renal Threshold for Glucose

An excessive excretion of glucose is not reabsorbed and consequently passes into urine. The transport maximum for glucose tubular transport system in adult humans is about 375 mg/min. Normally, filtered glucose is about 125 mg/min. In case there is a

significant increase of glomerular filtration rate or if the blood glucose concentration exceeds 300 mg/dl, transport maximum may be exceeded.

Generally, glucose starts to appear in the urine at a blood glucose level of 200 mg/dl, which corresponds to a filtered glucose level much lower than transport maximum. Thus, the blood glucose concentration (200 mg/dl) and the filtered load of 250 mg/min are termed the threshold for glucose.

9.3 SYMPTOMS OF DIABETES

The initial symptoms of diabetes include excretion of large amounts of glucose in urine.

In some cases it may be as 100 grams per day. This is termed as *glycosuria*. Losing so much solute in the urine causes osmotic diuresis and the volume of urine increases (*polyuria*). Hence, a diabetic urinates very often. The patient feels very thirsty constantly (*poly-dipsia*) and drinks large quantities of water. These symptoms which persist for many months cause the *maturity-onset* diabetic to approach a doctor.

In the *juvenile-onset* type further symptoms can easily complicate matters if treatment is not given soon. Although tissues receive a liberal supply of glucose from the blood, they are unable to utilize it efficiently in the absence of insulin. Such a diabetic, therefore, feels weak and tired. Since, carbohydrates cannot be used as fuel, fats are then mobilized. They are transported from the body stores to the liver. Thus, fat content of blood and liver increases. The plasma of such a patient is often opaque and fatty (*lipaemia*). This disproportionate metabolism of fat in a patient showing *lipaemia* results in excessive production of ketone bodies such as acetone, aceto-acetic acid and beta hydroxybutyric acid which cause *ketosis*, *ketonaemia* and *ketonuria*. When ketosis becomes severe, the patient's breath gives a characteristic smell like acetone. As by-products of fat metabolism such as aceto-acetic acid and beta hydroxy acids, are produced faster than they can be metabolized, the patient develops *acidaemia* (*acidosis*) which gives rise to hyperventilation (or air hunger as it is commonly known). Along with abnormal carbohydrate and fat metabolism there is extensive breakdown of protein in order to provide energy. This energy is obtained by deamination of the amino acids (refer to functions of proteins).

At this stage of ketosis, the patient develops lack of appetite (*anorexia*), nausea and vomiting. The increased loss of water and electrolytes through urine as well as orally leads to *dehydration*. The ketoacidosis is associated with increasing drowsiness and if untreated, the patient may become unconscious (*diabetic coma*) which can prove fatal. A combination of hyperglycaemia, ketosis, acidaemia and dehydration may cause the patient's death.

Other possible symptoms include blurred vision, skin irritation or infections. In women, skin irritation is particularly noticed around the vulva because of the heavy load of glucose in urine.

9.4 TESTS FOR DIABETES

Some household tests that can be carried out by making use of Benedict's solution are possible. The solution when heated with urine containing glucose gives yellow, green or red precipitate which indicates the severity of diabetes. Ready kits are also available in the market for diagnosis of diabetes.

Alternately, strips are also available for determining the amount of glucose and acetone in urine. These are easier to use since they do not involve heating but only dipping them in the urine. However, they may be expensive, which is their only drawback.

Clinically, the glucose tolerance test is carried out to see the blood glucose profile and the amount of glucose in urine when large amounts of glucose are administered orally.

Generally, 1.75 g glucose per kilogram body weight is administered orally and glucose levels of blood at 30, 60, 90 and 120 minutes are observed and sugar in urine is also checked at the same intervals. For adults 75g glucose is given.

Interpretation of the GTT Curve In a normal person the values of blood glucose while fasting is between 60–100 mg percent and may reach up to 130 mg percent post-prandially, with a peak value of 150 mg percent but not exceeding 170 mg percent. After about two hours, the blood sugar level would fall to around the fasting level. When simultaneously the urine is checked, it shows no appearance of glucose. The normal renal threshold of glucose is 150–170 mg percent.

Table 9.1 Interpretation of the oral glucose tolerance test

S.No.	Time of response	Health state	Glucose mg/dL	Interpretation
1	Fasting	Normal adult	60 to 100	Normal
2	Fasting	Normal adult	110–126	Impaired fasting glucose
3	Fasting	Pregnant woman	More than 105	Gestational diabetes
4	1 Hour	Normal adult	less than 200	Normal
5	1 Hour	Pregnant woman	190	Gestational diabetes
6	2 Hours	Normal adult	less than 110	Normal
7	2 Hours	Normal adult	140–180	Mild diabetes
8	2 Hours	Normal adult	140–200	Impaired Glucose tolerance (Pre-diabetes)
9	2 Hours	Pregnant woman	165	Gestational diabetes
10	3 Hours	Pregnant woman	145	Gestational diabetes

The GTT curve in the case of the lag type shows normal fasting level with values towards the higher side of the range and 30 minutes after the intake of food, the blood glucose level shoots above 170 mg percent. After about two hours, the blood sugar comes to almost fasting level. This shows that the person may be prone to diabetes and has a tendency to secrete insulin late.

The hyperglycaemic curve shows higher fasting blood glucose level, and this level continues to shoot to a much higher level after food intake and does not come to the normal fasting level. It is generally accompanied by spillage of glucose into the urine also.

□ Haemoglobin A1 and Haemoglobin A1C (HbA1C)

More and more asymptomatic people are being detected for diabetes as a result of screening programmes, so that diagnosis is certain. Today, it is possible to detect microvascular and macrovascular complications that can occur, more precisely, based on the determination of glucose and HbA1c levels in the blood. These are predictive since normal levels of HbA1c are below 6.5%.

Chromatographic techniques identify:

- HbA (HbA0) which is 92–94%.
- HbA1 which is 6–8% where the B chain has an additional glucose group.

HbA1 itself consists of three different glycations of which the HbA1c subgroup is the most useful. In the body, the glycation of haemoglobin occurs over the lifespan of the red blood cell (RBC), which is normally 120 days. Hence, the relative proportion of glycated haemoglobin at any one time depends on the mean glucose level over the previous 120 days. Normal levels will differ depending on whether HbA1 or HbA1c is measured, and the method used. Glycated haemoglobin (HbA1c) is usually a reliable indicator of diabetic control except in the following situations:

- *Increased red cell turnover:* blood loss, haemolysis, haemoglobinopathies and red-cell disorders, myelodysplastic disease.
- Interference with the test and haemoglobin variants, carbamylated haemoglobin (uraemic patients).
- In patients who fluctuate between very high and very low levels.

HbA1c can be very useful in identifying those patients whose home glucose tests are unrealistically good. *It must be remembered that the mean plasma glucose results are 10–15% higher than the equivalent HbA1c.*

□ Diagnosing Diabetes

Although HbA1c testing is mainly used for monitoring blood-sugar control in patients with diabetes, the World Health Organization (WHO) now recommends that HbA1c can be used as a diagnostic test for diabetes, provided that stringent quality assurance tests are in place and assays are standardized to criteria aligned to the international reference values. An HbA1c of 48 mmol/mol (6.5%) is recommended as the cut-off point for diagnosing diabetes. A value less than 48 mmol/mol (6.5%) does not exclude diabetes diagnosed using glucose tests. One advantage of using HbA1c for diagnosis is that the test does not require a fasting blood sample.

Normal range of HbA1c when expressed as a percentage would be 4–6% for non-diabetic ‘normal’ range. The equivalent normal non-diabetic range is 20–42 mmol/mol.

It is important to note that the diagnosis of diabetes in an asymptomatic person should not be made on the basis of a single abnormal plasma glucose or HbA1c value. **One additional HbA1c or plasma glucose test result with a value in the diabetic range must be observed, either fasting or in a random sample, or from the Oral Glucose Tolerance Test (OGTT).** The diagnosis should be made by the

best technology available, avoiding blood glucose monitoring meters and single-use HbA1C test kits.

It is not appropriate to use HbA1C for diagnosis of diabetes for the following:

- Children and young people.
- Patients suspected of having Type 1 diabetes.
- Patients having symptoms of diabetes for less than two months.
- Patients at high diabetes risk but who are acutely ill.
- Patients taking steroids, antipsychotics or any medication that may cause rapid glucose rise.
- Patients with acute pancreatic damage, including pancreatic surgery.
- Pregnancy.

Certain factors that influence HbA1c and its measurement:

- *Erythropoiesis:*
 - Increased HbA1c: iron, vitamin B12 deficiency, decreased erythropoiesis.
 - Decreased HbA1c: administration of erythropoietin, iron, vitamin B12, reticulocytosis, chronic liver disease
- *Altered haemoglobin:*
 - Genetic or chemical alterations in haemoglobin: haemoglobinopathies, HbF and methaemoglobin may increase or decrease HbA1c.
- *Glycation:*
 - Increased HbA1c: alcoholism, chronic liver disease.
 - Decreased HbA1c: aspirin, vitamin C and vitamin E
- *Erythrocyte destruction:*
 - Increased HbA1c: increased erythrocyte lifespan, e.g., splenectomy
 - Decreased HbA1c: decreased erythrocyte lifespan, e.g., haemoglobinopathies, enlargement of spleen, rheumatoid arthritis or drugs such as antiretrovirals, ribavirin and dapsone.
- *Other factors:*
 - Increased HbA1c: alcoholism, large doses of aspirin, chronic opiate use.
 - Variable HbA1c: haemoglobinopathies.
 - Decreased HbA1c: hypertriglyceridemia

Reference: Use of Glycated Haemoglobin (HbA1c) in the Diagnosis of Diabetes Mellitus; World Health Organization, 2011

9.5 ACUTE COMPLICATIONS OF DIABETES

Two complications may develop in diabetes mainly arising from severe insulin insufficiency. They are:

1. Hypoglycaemia Hypoglycaemia is insulin shock. This may take place in patients who are receiving insulin where there is imbalance between diet and insulin dosage, or it may be caused due to delay in eating, omission of food or loss of food by vomiting and diarrhoea. In some patients excessive exercise may also cause symptoms of insulin shock.

In such cases the patient becomes pale, nervous, weak and hungry. The person tends to have excessive perspiration and a moist skin. He may have uncoordinated movements, nausea, vomiting or convulsions. If not treated by giving sugar or fruit juice, the patient may go into coma and even die.

2. Diabetic Acidosis and Coma Diabetic acidosis or ketoacidosis as it is known, is also characterized by elevated level of ketones in the blood, feeling of weakness, headache, anorexia, pain in the abdominal region. The skin is hot and flushed while the breathing is painful and rapid. There may be symptoms as described in insulin shock.

Emergency treatment involves intake of foods and liquids having sufficient glucose such as fruit juices, *kheer*, broth, etc.

9.6 CHRONIC COMPLICATIONS OF DIABETES

1. Diabetic Eye Disease

- (a) Prevalence of diabetic retinopathy, especially in middle-aged and elderly people, causing visual disability.
- (b) Risk of blindness especially in older persons which is indicated by deposition of white exudate and haemorrhage or by oedematous swelling of retinal tissues.
- (c) Cataract and other eye diseases occur earlier and more often in diabetics than in non-diabetics.

2. Kidney Diseases Progressive impairment of renal function, accompanied by urinary protein loss and culminating in end-stage renal failure may be seen in diabetics.

3. Diabetic Neuropathy Damage to nerve fibres conducting sensation and blood vessels as well as the viscera is the most common complication of diabetes.

4. Cardio-Vascular Diseases CHD (Coronary Heart Disease) occurs more frequently and has notably more serious consequences in diabetics than in non-diabetics.

Atherosclerotic disease of the small arteries in diabetics is responsible for the high incidence of claudication and gangrene in the lower limbs, and for cerebral infarction, stroke and diffused cerebral disease.

5. The Diabetic Foot Diabetics are affected by a peculiar disability which severely damages the tissues of the foot. It is seen in the form of chronic ulceration, sepsis, and gangrene. It may necessitate amputation of the foot.

Three major factors have been identified which lead to the diabetic foot. They are:

- (a) Chronic diabetic neuropathy
- (b) Atherosclerotic obstruction of the arteries that supply the lower limbs
- (c) Bacterial infection

It is possible to control the extent of tissue damage with correct care.

6. Gastroparesis Gastroparesis is also called delayed gastric emptying. It results in food remaining in the stomach for a longer period of time than normal. Normally, the stomach contracts to move food down into the small intestine for digestion and the vagus nerve controls these contractions. Gastroparesis may occur when the vagus nerve is damaged and the muscles of the stomach and intestines do not work normally. Food then moves slowly or stops moving through the digestive tract.

Gastroparesis may be chronic or transient; transient gastroparesis may arise in acute illness of any kind, with the use of certain cancer treatments or other drugs which affect digestive action, or due to abnormal eating patterns as in bulimia or anorexia nervosa.

Chronic gastroparesis is more often due to autonomic neuropathy. This may occur in people with Type 1 or Type 2 diabetes. Due to a high blood glucose level for a long time, the vagus nerve becomes damaged resulting in gastroparesis. Gastroparesis has also been observed in various auto immune diseases and syndromes like Parkinson's disease. In case of abdominal surgery, the vagus nerve can be damaged resulting in chronic gastroparesis.

Dietary treatment includes dietary changes (low-fibre and low-residue diets, as well as, in some cases, restrictions on fat and/or solids).

In diabetics, it can cause fluctuations in blood glucose levels due to unpredictable digestion times, general malnutrition due to the symptoms of the disease (which frequently include vomiting and reduced appetite) as well as the dietary changes necessary to manage it and severe fatigue and weight loss due to calorie deficit.

9.7 PATIENT EDUCATION

The key to successful control and management of diabetes is sound and realistic patient education. It involves making the patient aware of his disease, its various control measures which include knowledge of hypoglycaemic agents as well as the importance of diet.

Education of the diabetic, in brief, involves the following:

1. Knowledge about the disease—its nature, symptoms and care.
2. The diet—a basic idea about the food values and individual diet plan as well as exchange list.
3. Hypoglycaemic agents involved in the control, and dietary management in relation to these agents.
4. Household methods for testing urine for sugar and acetone,
5. Importance of exercise in controlling diabetes and its relation to balance with insulin and food. Exercise improves metabolism and increases well-being in the patient and has been shown to enhance insulin action on target tissues.
6. Skin care and personal hygiene is important for good hygiene and circulation of blood.
7. Diabetic acidosis—recognition of signs and symptoms and the need for immediate medical care.
8. Insulin shock—how to recognize the symptoms and first-aid knowledge to counter-act these symptoms.

9. Personal identification—the need to always carry a personal tag or identity card to identify his name, address, doctor's name and address, and his emergency needs especially if he is receiving insulin therapy. Emphasize the need to always carry a candy or sugar product at hand.
10. Educational resource books and adequate reading material concerning the disease should be made available in the community library.

□ Alcohol Guidelines for Diabetics

The process of educating the diabetic should involve facts about the effects of alcohol on glycaemia.

Excessive alcohol consumption may lead to erratic behaviour, loss of consciousness, seizures, especially if food is not consumed with the alcohol. Hence, alcohol should not be consumed by diabetics on an empty stomach.

If on occasions a diabetic takes alcohol, it must be remembered that although the metabolism of alcohol does not require insulin, Type-1 diabetics should take alcohol in addition to the regular meal *without omitting any food*. However, Type-2 diabetics should substitute fat calories for calories consumed through alcohol.

One alcohol equivalent is 1 oz (15 grams) alcohol equivalent to 12 oz beer/5 oz wine/1.5 oz 80° proof-distilled spirits.

Some Tips for Diabetics

- Drinking alone should be discouraged.
- Wearing an identification tag is very important since symptoms of intoxication and hypoglycaemia can be confused.
- Monitoring blood glucose levels is important.

□ Exercise

Regular physical activity for the diabetic should be encouraged and incorporated into his daily routine. Aerobic exercises such as jogging, swimming, taking long walks, are recommended. Individuals over 30 years age or who have had diabetes for 10 years or more should have the physician's approval to begin an exercise programme. For people with IDDM, the major benefits of exercise are cardiovascular conditioning, weight maintenance, and lowering of lipid levels. For people with NIDDM, conditioning may also be a benefit, but even light exercise can be important in a management programme to control blood glucose and lipid levels. In general, exercise improves metabolism and increases well-being in the patient and has been shown to enhance insulin action on target tissues.

Since the physical activity may vary considerably from day to day, adjustments in energy intake and insulin dosage may be required to avoid hypoglycaemia in insulin-treated patients. Metabolic fuel utilization during exercise depends upon the intensity and duration of the exercise, the level of physical training, the antecedent diet, and the metabolic state of the individual. In IDDM individuals, the more vigorous exercises should be undertaken only if blood glucose is between 100–200 mg/100 ml and there is no ketosis present. If the pre-exercise blood glucose concentration is too low, hypoglycaemia can result during exercise. If it is too high and there is insulin deficiency, exercise may cause a further increase in blood glucose and ketosis.

Supplemental snacks containing carbohydrates may be taken before and during exercise to maintain blood glucose within the normal ranges; an increased energy intake primarily as carbohydrates, may be added for up to 24 hours after exercise to provide for repletion of muscle glycogen and liver glycogen stores and to prevent post-exercise hypoglycaemia. Hence, adjustments in insulin dosage and its time management may be needed.

Following are the additional benefits of exercise for persons with diabetes.

1. Increased sensitivity to insulin and improved glucose tolerance. A minimal level of insulin is needed for glucose uptake by the muscle at rest. An even smaller amount of insulin is needed to stimulate glucose uptake in exercising muscles. This reduces insulin requirements and increases the storage and utilization of glucose, thereby causing less extreme fluctuation in blood glucose over a 24-hour period.
2. Exercise adds to the blood glucose-lowering effect of injected insulin, so regular physical activity can permit a *reduction* in insulin dosages.
3. Physical training can help reverse the resistance to insulin that occurs as a result of obesity.
4. Reduction of risk factors for atherosclerosis, which occurs with increased frequency in the diabetic population. Regular exercise affects a lowering in triglycerides and very-low-density lipoprotein (VLDL), a decrease in total cholesterol and low-density lipoprotein (LDL) and an increase in high-density lipoprotein (HDL).
5. Lowers blood pressure. High blood pressure can increase the overall chronic problems that occur with diabetes. The reduction of blood pressure with exercise occurs even without weight loss or decrease in body fat.

Table 9.2 Relative sweetness of sugars and artificial sweeteners

Substance	Sweetness Value (as compared to Sucrose)
Natural Sweeteners	
Fructose	173
Invert sugar	130
Sucrose	100
Glucose	74
Sorbitol	60
Mannitol	50
Galactose	32
Maltose	32
Lactose	16
Artificial Sweeteners	
Cyclamate	30
Aspartame	180
Acesulfame-K	200
Saccharin	300
Sucratose	600
Alitame	2000

□ Use of Artificial Sweeteners

The use of alternate sweeteners of both types, nutritive and non-nutritive are acceptable in the management of diabetes. However, the use of caloric sweeteners such as fructose and sorbitol in the belief that their contribution to energy value of the diet is insignificant, may undermine efforts to lose weight and could lead to weight gain. Table 9.1 shows the relative sweetness of sugars and artificial sweeteners.

1. Nutritive Sweeteners These include sugar alcohols (polyols), i.e. sorbitol, mannitol, xylitol, isomalt, lactitol, maltitol, and hydrogenated starch hydrolysate. They are less sweet than sugar but add bulk to foods. Sorbitol is metabolized in the liver and is not available to the body. Polyols have a low glycemic index because they are absorbed more slowly and provide only 2.4 to 3.4 kcal/g as compared with 4 calories/g from other carbohydrates. If consumed in large amounts (50 g sorbitol or 20 g mannitol), it can cause osmotic diarrhoea due to incomplete absorption of the sugar alcohols.

2. Non-nutritive Sweeteners

(a) Acesulfame K Acesulfame K (acesulfame potassium) is a white, odourless, crystalline sweetener. It gives zero calories and is 200 times sweeter than sucrose. It has a clean, fresh taste but it may have a bitter taste when used in large amounts. Acesulfame K has a structure similar to that of saccharin. It is stable both in liquids and also during baking or cooking. It is not metabolized by the body. It is heat stable and can be blended with other sweeteners. It is safe for use.

(b) Aspartame It is the methyl ester of L-phenylamine and L-aspartic acid. In the intestines esterase hydrolyses aspartame to aspartic acid, methanol, and phenylalanine. Hence, the use of aspartame products in persons with phenylketonuria, should be avoided.

Aspartame contains 4 kcal/g but because of its intense sweetening ability provides negligible calories. It does not alter glycemic control and is metabolized in the gastrointestinal tract.

(c) Saccharin One of the most popular and widely used sweetener is the heat-stable saccharin that is 200 to 700 times sweeter than sucrose. Saccharin does not contribute calories, since it is not metabolized and is excreted unchanged. The carcinogenic potential of saccharin has lingered on for years and hence has been banned in several countries.

(d) Sucratose Sucratose is the most recent non-caloric sweetener to be approved for use in foods. Its use has been permitted throughout the world. It is 600 times sweeter than sugar. Sucratose is made from sucrose through a chemical process that alters the sucrose molecule by replacing three hydrogen/oxygen groups with three chlorine atoms. Sucratose is not recognized by the body as either a sugar or a carbohydrate. It does not affect carbohydrate metabolism and is eliminated unchanged by body. Sucratose is heat stable due to which it can be used in cooking and baking.

Individuals in whom diabetes is well-controlled may use fructose and sorbitol without any adverse short-term effects on blood glucose. The metabolic effects of chronic ingestion of these two sweeteners is still being studied. There is no evidence

yet to suggest that ingested sorbitol can gain access to the internal cellular milieu and contribute to the complications of diabetes.

Excessive intake of any sweetener requires individual counselling which will take into consideration the factors of any other sweetener used, the overall diet, and its nutritional adequacy.

9.8 HYPOGLYCAEMIC DRUGS

These can be administered in two ways: (i) as oral tablets, and (ii) as injected insulin.

Since the advent of insulin, most diabetics are treated with hypoglycaemic drugs to prevent reaching the stage of coma.

Diabetics of the maturity-onset type usually do not need insulin therapy. Those who are overweight generally respond to dietary restriction and weight reduction. Most of others can be controlled by oral hypoglycaemic drugs, such as tablets containing sulphonylureas, namely, tolbutamide and chlorpropamide.

□ Insulin

Insulin, like several other hormones, is a protein-based hormone containing 51 amino acids. It also contains zinc. Insulin is very important for glucose metabolism. Insulin is secreted by the cells of islets of Langerhans of the pancreas. For therapeutical purpose, it is obtained from the pancreas of pigs and cows.

Two scientists, Banting and Macleod, successfully extracted and used insulin for therapeutic purpose and for this work they were awarded the Nobel Prize in Physiology and Medicine by The Nobel Committee of the Caroline Institute in 1923.

Nowadays, DNA recombinant technology is being used to produce human insulin in the laboratory with the help of select microorganisms (*E.coli*, yeast).

It is available in several forms. Soluble insulin is always used in an emergency situation of diabetic ketosis, but for the long-term treatment it has the disadvantage of a rather short action so that two or three injections may be required every day. For patients requiring less than 60 units of insulin per day, a single daily injection of one of the modified insulins such as protamine zinc insulin or zinc-suspension suffices. Some insulins and their action are given in Table 9.3.

The following is a brief note on insulin and insulin analogues

1. Insulin

(a) NPH or Isophane Insulin Isophane insulin is known as NPH insulin as it was developed in Denmark at the Hagedorn Laboratory in 1940s. NPH insulin is slowly absorbed from subcutaneous tissue with peak at 5–7 hours and the action lasts for 12–15 hours. This insulin is most commonly used at bedtime to control fasting blood sugar.

(b) Lente Insulin If zinc is added in excess amount than that in NPH, it forms insoluble insulin-zinc complexes to form lenteinsulins. The action profiles of these preparations depend upon the physical conditions of insulin. *Semilente* has short duration of action. *Ultralente* is long acting crystalline

suspension. These insulins cannot be mixed with regular insulin due to their zinc content and are not very popular.

- (c) **Premixed Formulations** Regular and NPH insulin are available in a premixed formulation with 30:70, 50:50, 25:75 proportions. These preparations are very popular as there is no mixing involved. It is useful for patients of Type-2 diabetes on split mix regime who may be shifted to premixed preparation.

2. Insulin Analogues

(a) Rapid but Short-acting Analogues Regular insulin when injected, the action starts at 30 min, peaks at 60–90 min and is over by 4 hours. This action profile is very efficient in controlling postprandial glycemic excursions without any risk of delayed hypoglycaemia.

(b) Long-acting Analogues Long-acting analogues are designed in an attempt to obtain a steady basal insulin level without any peak unlike NPH, which has a risk of late night hypoglycaemia. In insulin glargine, after injection it gets precipitated in subcutaneous space and is released slowly, making its action last for even more than 24 hours. Most of the patients require a single dose for basal cover. *Insulin detemir* has a long action.

(c) Premixed Analogue Preparations Insulin glargine cannot be mixed with any other insulin. Premixed preparations are available with protamine insulin. In these preparations the protamine-insulin part has to be formulated with the same insulin analogue like lispro or aspart.

These preparations are available in 25:75, 30:70, 50:50 proportions.

Table 9.3 Types of insulin preparations: their onset, peak and duration of action

<i>Insulin</i>	<i>Onset of action</i>	<i>Peak action</i>	<i>Duration of action</i>
<i>Short-acting</i>			
Insulin aspart analog	25–30 minutes	1.0–1.5 hours	3–4 hours
Insulin lispro analog			
Regular insulin	30–60 minutes	2–3 hours	4–6 hours
<i>Intermediate acting</i>			
NPH insulin	2–4 hours	4–10 hours	14–18 hours
<i>Lente insulin</i>	3–4 hours	4–12 hours	16–20 hours
<i>Long-acting</i>			
Ultralente insulin*	3–4 hours	8–14 hours	18–24 hours
Insulin glargine	1–2 hours	No peak	Approx. 24 hours

* May soon be discontinued

In brief, the following are the types of insulin available in the market.

1. Short-Acting Insulin

- (i) Regular crystalline insulin, and (ii) Semilente lletin.

These cover a period of four to six hours. They are given before breakfast and dinner. They are used for short-term periods of control as indicated in surgery, during labour and delivery, or in periods of illness. They may be used in mixtures with other insulins for control of juvenile diabetes when a closer, more even control is necessary. The carbohydrate distribution in the meal is 2/5, 1/5, and 2/5 for breakfast, lunch and dinner respectively.

2. Medium-Acting or Intermediate-Acting Insulin

- (i) Natural Protamine Hagedorn (NPH) or Isophane, (ii) Lente, and
(iii) Globin.

NPH is most widely used. It is given in the morning, usually before breakfast. The peak activity of all the above-mentioned three types is eight to 10 hours after administration, that is about mid-afternoon and then last in the waning period, a total of 20–24 hours. The meal distribution pattern having a larger lunch and dinner with allocation for a midafternoon and bedtime snack may be used. This gives a 1/7, 2/7, 1/7, 2/7, 1/7, carbohydrate distribution in meal pattern for breakfast, lunch, midafternoon, dinner and bedtime respectively.

3. Long-Acting Insulin

- (i) Protamine zinc insulin (PZI), and (ii) Ultralente lletin insulin.

These are rarely used. They may be given alone or they may also be administered with regular insulin at breakfast. They require a more substantial evening meal and bedtime snack to cover the prolonged period through the sleep hours. The distribution of carbohydrates is usually 1/5, 2/5 and 2/5 for breakfast, lunch and dinner respectively; with 20–40 g carbohydrates for a bedtime snack.

If administered with regular insulin at breakfast, the distribution of carbohydrates in the meal is 1/3, 1/3, 1/3 for breakfast, lunch and dinner respectively; with 20–40 g carbohydrates for bedtime snack.

4. Mixtures Occasionally, two types of insulin may be mixed in a syringe and given in one injection. The meal distribution is then decided according to the actions of the insulin mixed.

□ Common Side Effects

1. Hypoglycaemia is the major side effect against which the diabetic must be guarded. It is necessary to start with small doses and adjust the requirement for insulin keeping in mind the time activity characteristics.
2. Allergic reactions may be usually seen with the use of the older insulin. Beef insulin differs from human insulin in three amino acids and this difference can give rise to antibodies causing local, and systemic, allergy; porcine insulin differs from human insulin in one amino acid and this may give rise to allergy, but it is rare; human insulins have same amino acid composition as endogenous insulin.

3. Insulin resistance used to occur in older insulins due to the impurities present in them. Now newer insulins are purer and the chances of insulin resistance minimal.
4. Edema may be seen since, insulin has salt retaining properties and may cause fluid retention. In some patients it may be necessary to adjust the dose of diuretics and/or salt intake for this reason.
5. Lipodystrophy comprises both, lipoatrophy and lipohypertrophy. Earlier, lipoatrophy was seen with the use of older insulins but now it is rare with the newer insulins.

□ Oral Hypoglycaemic Drugs

These act by promoting the secretion of insulin from the beta cells of the pancreas.

The sulphonylureas are usually indicated in patients with onset of diabetes after the age of 40 years and of short duration (less than 10 years). It is generally used in combination with Phenformin. It is not to be used in growth-onset diabetes, during surgery, severe infection and stress.

Phenethyl biguanide also used as an oral hypoglycaemic drug is one of the sulphonylureas. It is sometimes used with insulin to lower the dose requirement. It has been recently advocated for obese patients. In addition, dietary control is also essential in all patients and with special emphasis on obese patients. There are four sulphonylurea compounds currently available for the treatment of diabetics. The list of oral hypoglycaemic drugs is given in Table 9.5.

□ Medicinal Plants in the Use of Diabetes Mellitus

1. Jamun (*Syzygium cumini*) *Jamun* occurs naturally in India and is also widely cultivated in India for its delicious fruits. The fruit has an unusual taste, flavour and colour. It is generally purple and has a sub-acidic to sweet taste. The edible portion of the fruit is about 40 to 50% of the whole fruit and the seed is large, whereas the skin is thin and edible. Ayurvedically, it is recognized that a decoction of the dry leaves of the *jamun* exhibit hypoglycaemic effects. The fruit, bark and seeds have also been found to possess anti-diabetic properties. Some studies have also shown that the seeds have hypolipidemic properties. *Jamun* seeds contain quercetin, gallic acid and ellagic acid, which are known anti-oxidants.

2. Fenugreek (*Trigonellafoenum graecum Linn.*) Fenugreek seeds are used as a condiment and the leaves are widely consumed as a green leafy vegetable. The leaves are a rich source of calcium, iron, beta-carotene and other vitamins. The leaves and the seeds are bitter. The seed extract has been shown to exhibit hypoglycaemic effects. The seeds contain alkaloids (trigonelline), fat, fibre, saponins and proteins. Defatted fenugreek improves oral glucose tolerance and modifies pancreatic hormone levels. An insulin stimulating substance, 4-hydroxy isoleucine has been identified in fenugreek seeds. Blood glucose lowering effects have been reported in diabetics on consumption of 15 grams of fenugreek powder daily.

Table 9.4 Oral anti-diabetic medications: mechanism of action and side-effects

<i>Medication class and mechanism of action</i>	<i>Generic name</i>	<i>Some common side-effects</i>
Sulfonylureas		
Stimulate the pancreatic beta cells to secrete more insulin	Chlorpropamide (first-generation) Glyburide (second-generation) Glipizide (second-generation) Glimepiride (third-generation)	Risk of hypoglycaemia. Weight gain upon initiation of treatment common in the elderly. Higher doses should be avoided.
Meglitinides (glinides)		
Stimulate the pancreatic beta cells to secrete more insulin	Repaglinide Nateglinide	Need to be taken more frequently than sulfonylureas. Risk of hypoglycaemia, Weight gain.
Biguanides		
Reduce output of glucose from the liver	Metformin	May have gastrointestinal side effects. Interferes with B ₁₂ absorption but rarely associated with anaemia. Contraindicated in patients with renal dysfunction. Check creatinine clearance if over 65 years of age.
Alpha-glucosidase inhibitors		
Decrease rate of digestion of carbohydrate-containing foods	Acarbose Miglitol	Reduced risk of hypoglycaemia compared with other drug classes Gastrointestinal side-effects, including gas and diarrhoea
Thiazolidinediones		
Enhance insulin sensitivity	Rosiglitazone Pioglitazone	Fluid retention, which can lead to congestive heart failure in the elderly or other high-risk patients Contraindicated in liver disease. Check liver enzymes on an ongoing basis. Weight gain
<i>Dipeptidyl peptidase 4 inhibitors</i>		
Prevent breakdown of GLP-1	Sitagliptin	Do not cause hypoglycaemia. Upper respiratory tract infection risk.

3. Karela/Bitter Gourd (*Momordica charantia Linn.*) Bitter gourd is cultivated for the use of its unripe fruit as a vegetable, locally known as *karela*. It is used as a tonic, emetic and laxative. Sometimes it is used in the treatment of gastroenteritis, diabetes, tumours and some viral infections. The juice of the unripe fruit is taken once or twice a day as an anti-diabetic remedy. It helps improve glucose tolerance.

Other plants which may help in the treatment of diabetes mellitus but presently there is no convincing scientific evidence to this effect include *guduchi* (*Tinospora cordifolia Miers*), *gurmar* (*Gymnema sylvestre R. BR.*) and *vijayasar* (*Pterocarpus marsupium*).

9.9 OBJECTIVES OF DIABETES MANAGEMENT

1. To preserve the life of the diabetic patient and relieve the symptoms of the disease.
2. To enable the patient to have a social life as normal as possible.
3. To establish and maintain good metabolic control.
4. To avoid the complications of diabetes mellitus.

Three methods of treatment are generally followed depending on the individual and severity of the condition: (i) Diet alone, (ii) Diet and oral hypoglycaemic drugs, and (iii) Diet and insulin.

A mild diabetic can manage his disease with control on his diet alone. A severe diabetic requires dietary control along with insulin. However, whatever the form of controlling diabetes, regularity, routine and regulation should be strictly followed.

Diet Alone

Meal planning requires educating the patient in both, the principles of good nutrition and their effective implementation. The fundamental principle of dietary control in diabetes is to give the individual only the necessary calories according to the body's daily requirement. The total calories advised will vary for each patient. The obese patient who is required to reduce his weight must have lower calorie diet but on the other hand a markedly underweight patient requires a comparatively high calorie diet.

Similarly, a young hardworking person requires much more calories than an elderly sedentary person. It has been found that reduction of body weight alone results in better functioning of the beta cells and increased sensitivity to insulin action. The caloric requirement of the person can be readily calculated according to his desirable body weight. Determination of energy requirements has been discussed in Chapter 8. Before prescribing a diet it is important to know the patient's normal food pattern. It is necessary to advise modification in his diet in such a way so as to minimize drastic changes in his normal meal pattern. This will help to ensure his willing cooperation and there are lesser chances that he would neglect his prescribed diet. Besides, other dietary factors such as *methi* (fenugreek), *karela* (bitter gourd) and *jamun* (blackberry) have been found to help in lowering the blood glucose levels in diabetics, especially in those belonging to the maturity-onset type.

General principles that must be borne in mind when planning a diet are as follows:

1. Carbohydrates These should provide about 40 to 50 percent of the total energy intake of which simple carbohydrates must be about 20 percent and complex carbohydrates should fulfil the remaining carbohydrate requirement.

Dietary fibre may be enhanced to an intake of 25–30 g per day.

2. Fats About 25 to 35 percent of the total energy intake must be fulfilled by fats. Of this about 25 percent must be obtained from saturated fatty acids, 50 percent from monounsaturated fatty acids and 25 percent from polyunsaturated fatty acids (nuts, olive oil, fish). Cholesterol intake must not exceed 150 mg per day.

3. $\omega 3$ Fatty Acids These have been found to lower serum cholesterol moderately and serum triglyceride level markedly. Popularly, they are known as fish oils, which have been found to decrease platelet aggregation, which may potentially reduce cardiovascular disease in diabetes. The intake of fish oils must not exceed four grams per day.

4. Proteins The normal RDA for protein is 0.8 g/kg IBW. Thus, 25% of the calories must come from protein, plant as well as animal sources. However, if nephropathy is seen, the protein intake may be reduced to 0.6 g/kg body weight per day. About 25 percent of the total energy needs must be fulfilled by proteins. A diabetic individual on an average consumes more protein than non-diabetics, and excessive protein consumption is linked with diabetic nephropathy. Hence, high biological value protein at about 10 percent of the total energy intake is ideal. Preferable sources are fish, chicken, soya, etc.

5. Sucrose If sucrose containing foods are included in the diet, patients are found to adhere to their diets better. Sucrose when combined with fats as in baked goods, ice-cream, chocolate bars, etc., tend to contribute towards elevated serum lipid levels and weight gain.

6. Fibre Benefits of fibre are well known. Diabetics must consume 20–35 g fibre daily in order to get the benefit. Diets high in soluble fibre (pectins, gums, storage polysaccharides and few hemicelluloses found in fruits, legumes, lentils, roots, tubers, oats and oat-bran) help to reduce serum levels of glucose and insulin. Water insoluble fibres such as cellulose, lignin and most hemicelluloses found in whole-grain breads, cereals, and wheat bran do not impact the plasma glucose, insulin or cholesterol levels.

Although it is still not clear if improved glycaemic control that is associated with high-fibre intake is mainly due to an increase in total fibre or its fractions like soluble fibre or insoluble fibre, convincing scientific evidence has established that fibre is beneficial to diabetics. It is thus important that the present intake of fibre in a patient's diet must be increased gradually to a maximum of 50 g per day. The gradual introduction of the fibre minimizes gastrointestinal problems such as osmotic diarrhoea and flatulence. An increase in fibre intake must be accompanied by an increase in fluid intake and blood glucose levels must be carefully monitored. This is because intake of large amount of fibre can delay or reduce peak glucose responses

to carbohydrate and may necessitate the dosage of anti-diabetes medication to be adjusted to compensate for this effect.

7. Sodium The daily intake must not exceed 3000 mg sodium per day. Some may recommend 2400 mg sodium per day, especially for people having congestive heart failure, nephropathy or hypertension.

8. Salt Salt substitutes contain potassium and excess consumption of potassium can be harmful for people with kidney problems. It may be safer to use salt-free seasoning blends.

9. Alcohol Restriction or abstinence from alcohol may be required for those with hypoglycaemic unawareness, neuropathy, poor control of food glucose or blood lipids, apancreatitis, obesity or those who have had a history of abuse. Pregnant women must definitely abstain from alcohol.

Type 1 diabetics can consume alcohol without omitting any food. **Metabolism of alcohol does not require insulin.** *Type 2* diabetics should substitute fat calories for alcohol.

$$1 \text{ alcohol equivalent} = 2 \text{ fat exchanges}$$

An alcohol equivalent is that which contains 1 oz (15 g) alcohol (equivalent to 12 oz of beer/5 oz of wine/1.5 oz of 80 proof distilled spirit).

Men may consume up to 2 alcohol equivalent per day while women may consume up to 1 alcohol equivalent per day.

10. Supplementation Supplementation with vitamin and minerals is usually not needed if the dietary intake is balanced and adequate. It should not be used in place of a varied, balanced diet which can ensure adequate nutrients.

However, the following persons may respond positively to multi-vitamin supplementation:

- (a) Those who are on VLCD for weight reduction.
- (b) Those taking medications that may alter certain micro nutrients.
- (c) Those having micronutrient deficiencies like anaemia, osteoporosis.
- (d) Those who are strict vegetarians.
- (e) Pregnant and lactating women.
- (f) Elderly and confined or unable to eat.
- (g) Children and teenagers who severely limit food consumption.
- (h) Those who have uncontrolled hyperglycaemia with glycosuria which can result in excess excretion of water-soluble vitamins.

9.10 GLYCAEMIC INDEX

It is found that factors other than fibre may result in a food producing relatively flat blood profiles. These foods may favourably influence blood lipids. Classification of foods in terms of their glycaemic effects may facilitate application of this information in day-to-day management. Increase in levels of plasma insulin and glucose produced by various carbohydrate containing foods vary considerably from one food to another. For example, the post-prandial blood glucose response

of glucose and potato of similar caloric value is higher than that produced by bread or rice. Glucose alone produces the largest increase in blood glucose levels and is assigned a glycaemic index of 100. Fibre-rich foods, acidic foods, and high fat foods often have low glycaemic indexes. Many such researches are being carried out to elicit the glycaemic response of various foods. Similarly, other factors that influence the glycaemic response must also be considered. A low glycaemic index diet consisting of vegetables, fruits and legumes, a moderate amount of protein and unsaturated fats and fewer refined carbohydrate foods—along with overall decreased calorie intake and increased physical activity – will assist patients in their weight loss efforts. This system may be used as a part of the exchange system. The glycaemic index provides a means of identifying starchy food with a lower glycaemic potential (i.e foods less likely to cause a rise in blood glucose) that may be offered on trial to diabetics. The glycaemic index of some food preparations is shown in Table 9.6. To further determine the impact of carbohydrate foods on blood glucose levels, researchers have come up with a way to describe the extent to which the blood glucose rises (GI) and remains high. This is called the glycaemic load (GL). The GL provides not only a measure of the level of glucose in the blood, but also the insulin demand produced by a normal serving of the food.

- The GI determines how rapidly a particular carbohydrate food may raise food glucose.
- The GL determines how much impact a carbohydrate food may have on blood glucose levels, depending on the number of grams of carbohydrate in a serving.

GI divided by 100 (glucose is set to equal 100) multiplied by the carbohydrate grams/serving = GL.

In general, the GL is highest if high GI foods are eaten in large quantities. Low GI foods usually have a low GL, but medium to high GI foods can range from low to high GL. Therefore, you can reduce the GL by limiting foods that have both a high GI and a high carbohydrate content.

It is not necessary to completely avoid foods with a high glycaemic index, because many are healthy, nutritious foods that can be eaten in moderation. However, patients should be encouraged to include more unprocessed, high fibre foods, for which a lower glycaemic response has been generated. Examples of high-fibre foods include lentils, beans, legumes, raw and unpeeled fruits and vegetables, or foods that have been minimally cooked.

$$\text{Glycaemic Index} = \frac{\text{area under 2 hour blood response curve of test food}}{\text{area under 2 hour blood response curve for equivalent amount of glucose}}$$

Steps in Modification of Diet

1. Interview the patient to determine his nutritional needs and analyze his dietary habits.
2. Determine the desirable weight from the height-weight tables given in Appendix IV and his present weight.

Table 9.5 Glycaemic index of some food preparations

<i>Recipes</i>	<i>Glycaemic index</i>
Glucose	100
<i>Adai*</i>	72
<i>Chapati*</i>	74
<i>Dalia*</i>	65
<i>Dhokla*</i>	75
<i>Dosa*</i>	87
<i>Idli*</i>	89
<i>Pesarattu*</i>	79
<i>Pongal*</i>	90
<i>Ragi Roti*</i>	77
<i>Ragi Idli*</i>	78
<i>Rava Dosa*</i>	65
<i>Besan Paratha*</i>	84
<i>Rice Upma</i>	84
<i>Wheat Upma</i>	74
<i>Wheat Chapati</i>	78
<i>Wheat Dosa</i>	77
Custard	43
Quick cooking wheat	54
Shortbread biscuits	64
Wholemeal bread	77
Wafer biscuits	78
Puffed wheat	80
Puffed crispbread	81

* Preparations contain fenugreek seeds.

Table 9.6 Factors influencing glycaemic response

<i>Food-related factors</i>	<i>Factors pertaining to individuals</i>
Composition of food	Hereditary factors
Proportion of fibre	Variable rates of digestion and absorption
Presence of fat	Stimulation of gut peptides
Soluble NSP (non-starch polysaccharides)	Associated diseases
Resistant starch	Body weight
Digestibility of starch	Pre-prandial blood glucose level
Maturity	Composition of previous meal
Ripeness	Exercise or activity
Cooking or Processing methods (particle size, blending, grinding)	Time of the day
Protein or Starch interrelationships	Gender
Staleness of food	Age
Food storage procedures	Ethnicity and race

3. Determine how much loss or gain in weight is required.
4. Calculate his *caloric* requirements based on energy needs. These can be calculated from Table 9.7A.

Table 9.7 Calories/kg of desired weight of the worker

	Sedentary	Moderate	Heavy
Obese	20–25	30	35
Normal	30	35	40
Underweight	35	40	40–50

5. *Protein* Determine the requirement of protein at 0.8 to 1.0 g per kg body weight for usual normal cases. Use 1.0 g per kg body weight for purpose where protein needs to be replenished. The proteins must be adequate in the quality and quantity to maintain synthesis of body proteins and other nitrogen-containing substances. Children, pregnant and lactating women need large amounts.
6. *Carbohydrates* At least 100 g carbohydrates per day are needed to prevent ketosis or protein breakdown. A maximum of 1800 kcals from carbohydrates per day (about 450 g) can be stored in the body as liver glycogen. It is usually recommended that in a diabetic diet carbohydrate intake should not exceed 250 g per day. Complex carbohydrates such as those found in wheat, rice, *jowar*, *bajra*, should be eaten rather than the simple sugars present in fruits juices, fruits, honey, etc.
7. *Fats* Fat is usually given in the diet, since it improves the palatability of the diet and supplies essential fatty acids to the body. Fat can be included in the diet as ± 10 g of the protein content of the diet. This amount is usually adequate. This value may be restricted to a much lower value in obesity and other special conditions. It is usually recommended that fats should supply less than 30 percent of the total calorie requirements, of which less than 7 percent may be from saturated fats, less than 10 percent from PUFA and the rest from mono-unsaturated fats. So also, since saturated fats like *vanaspati*, butter, margarine tend to raise the level of serum cholesterol, while diets relatively rich in polyunsaturated fatty acids found in corn and safflower oils, tend to lower this, it appears logical to use these in place of saturated fats whenever possible, in a diabetic's diet. Cholesterol in the diet should be less than 150–200 mg per day. This is important since several diabetics have a higher incidence of coronary heart disease. This can be achieved by avoiding the fats of mammals and dairy products and substituting these with vegetable oils and fish fats.

A sample calculation of the diet of a diabetic (control by diet alone):

A diabetic who is 25 years old, obese and 148 cms tall, weighs 62 kg when her ideal body weight should be 48 kg. She has sedentary activities. She is controlling the disease by diet alone.

1. Weight to be reduced = $62 - 48 = 14$ kg
2. Calories requirement per day = $25 \times 48 = 1200$

3. Protein requirement per day = $0.8 \times 48 = 38.4$ g
4. Calories supplied by the protein = $38 \times 4 = 153$
5. Non-protein calories = Total calories requirement per day minus calories from protein = $1200 - 153 = 1047$
6. Carbohydrates should give 50% non-protein calories = $1047 / 2 = 524$ calories
7. Carbohydrate requirement per day = $524 / 4 = 130$ g
8. Fat should give remaining 50% of the non-protein calories which is 524 kcal.
9. Fat requirement per day = $524 / 9 = 58$ g

Thus, the total requirements per day are as follows:

Calories	=	1200
Protein	=	38 g
Carbohydrates	=	130 g
Fat	=	58 g

This diet may be followed by the diabetic until ideal body weight is attained. After that the caloric requirement may be calculated as 30×48 kg = 1440

Total calories, especially those from carbohydrates, are distributed as 1/5, 2/5 and 2/5 for breakfast, lunch and dinner respectively. Equal distribution of the calories as 1/3, 1/3, 1/3 may also be followed.

□ Diet and Oral Hypoglycaemic Drugs

When a diabetic is required to manage his disease using oral anti-diabetic tablets along with dietary control, it becomes necessary to know if the tablet has a short or long action. The dietary requirement is the same as when planning for a diet alone, but the distribution of calories during the day will depend on when the action of the tablet is seen most.

Example

A diabetic who is taking orinase (tolbutamide) at breakfast should have moderate calories at breakfast and snack time but higher calories intake at lunch and dinner. Generally, distribution of the total calorie requirements among the three meals would be 1/5, 2/5 and 2/5 for breakfast, lunch and dinner respectively.

However, since, these drugs act by promoting the secretion of insulin from the beta cells of pancreas and are not insulin themselves, it is necessary that the patient follows a strict dietary.

□ Diet and Insulin

As compared to the oral sulphonylurea drugs, insulin offers a more liberal approach towards the patients's diet. However, the diabetic should not take undue advantage of this fact and go often on an eating spree by taking an additional dose of insulin.

The meal pattern of a diabetic on insulin alone is determined according to the time at which the insulin is administered.

Table 9.8 gives a brief idea about the distribution of calories from meals when using insulin.

Table 9.8 Distribution of calories and carbohydrates while using insulin

Type of insulin	Breakfast	Lunch	Snacks	Dinner	Bedtime
Short-acting (regular, semilente)	2/5	1/5	—	2/5	None
Intermediate acting (NPH, lente, globin)	1/7	2/7	1/7	2/7	1/7
Long-acting (PZI, ultralente)	1/5	2/5	—	2/5	20–40 g carbohydrate
Regular insulin at breakfast	1/3	1/3	—	1/3	20–40 g carbohydrate

□ Other Dietary Restrictions on Diabetics

Besides distributing the total calories, especially carbohydrate calories, it is necessary for the diabetic to control the intake of all types of concentrated carbohydrates. These are summarized in Table 9.9.

9.11 TIPS FOR DIABETICS

1. Eat starches such as those present in wheat, *jowar*, *bajra*, *ragi*, etc. instead of sugars like sucrose, glucose and fructose present in table sugar, honey, fruit juice, etc.
2. Use whole pulses like *chana*, *rajma*, soybean instead of split pulses or their *dals*.
3. Soybean or gram flour can be incorporated into the *atta* and *chapatis* made out of it, thus increasing the protein content of the food.
4. Green leafy vegetables and all types of raw vegetables such as cucumber, carrot, cauliflower, cabbage, lettuce, onion and tomato can be eaten in plenty to fill the stomach.
5. Use such cooking methods which require minimum amounts of fat. So one should eat boiled, broiled, steamed and grilled food instead of fried food. Using a non-stick pan reduces the fat consumption.
6. Fibre-rich foods such as whole grain pulses and raw vegetables can be preferred to refined flours and cooked vegetables and peeled fruits. Consumption of potatoes, *chikoos*, apples and pears with their peel on is beneficial.

Before the idea of the Food Exchange List was propagated, the diabetic diet remained closely calculated. It was necessary to stick to a rigid diet routine. However, such a diet had several practical and psychological drawbacks. Hence it was necessary to make the diet as flexible as possible in order to break the monotony.

This realistic approach to the diabetic diet was based on a system of grouping foods according to the similarity in their nutrient composition. This grouping of foods which has about the same food value as the other foods within that group is known as the *Food Exchange List* wherein eight food groups are listed: milk, legume and pulses, vegetables (group A and B), fruit, cereal, meat (flesh food) and fat. We have already referred to these in Chapters 2 and 9 in detail.

Table 9.9 Foods avoided, prescribed and allowed liberally in diabetes

<i>Foods avoided</i>	<i>Foods to be allowed in prescribed amount</i>	<i>Foods to be allowed liberally</i>
1. Sugar, <i>jaggery</i> , sweets, candies, jams, jellies, etc.	Cereals such as wheat, rice, <i>jowar</i> , <i>bajra</i> , <i>ragi</i> , etc.	Clear soups
2. Alcohol and alcoholic beverages and soft drinks.	Spaghetti, macaroni, noodles, bread, etc.	Raw and green leafy vegetables
3. Concentrated milk preparations, <i>mawa</i> preparations such as <i>pedha</i> , <i>burfi</i> , <i>rabdi</i> , ice-creams, <i>gulab jamun</i> , <i>rasogolla</i> and other Bengali sweets.	<i>Dals</i> and pulses	Thin buttermilk
4. Fried preparations	Root vegetables such as potato, yam, sweet potato, colocasia root (<i>arvi</i>)	Spices to taste
5. Nuts and oilseeds such as groundnut, coconut, etc.	Vegetable oils,	
6. <i>Vanaspati</i> , <i>ghee</i> , cream, margarine, etc.	Lean meat, fish and eggs.	
7. Fatty meat cuts, organ meats like liver, kidney, brain, etc.	Fruits according to, exchange list.	
8. Shell-fish like shrimp, lobsters, mackerel, oysters, etc. and oily fish like sardines.		
9. Bakery products such as cakes, doughnuts, pastries, sweet biscuits, etc.		

The items that are listed out within each group can be freely exchanged since, all foods in that group in *the serving size or portion* indicated have approximately the same nutritive value.

The food exchange lists have been shown in Appendix V. A similar list of exchanges of some recipes used in the daily diet is given below.

Table 9.10

Diabetic Exchange list recipes providing a fixed quantity of carbohydrates within a group

Pulse group (All preparations prepared using 30 g pulse):

Carbohydrates: 15 g

3/4 big cup thick *dal*

	or
1 big cup medium thick <i>dal</i>	or
2 big cups thin <i>dal</i>	
<i>Cereal group</i> (All preparations made using 30 g wheat flour or <i>maida</i> and 2 g fat: Carbohydrates: 15 g	
3/4 <i>Chapati</i> 6.5" diameter	or
1½ large <i>puris</i>	or
2 small <i>puris</i>	or
1½ <i>phulkas</i> or 1½ slices of unbuttered bread	or
3 pieces of sandwich prepared with minimum butter and other vegetables.	or
1/2 <i>thalipith</i> medium 5.5" diameter with moderate fat	or
1 <i>bhakri</i> (5" diameter)	or
3/4 <i>paratha</i> 5.5" diameter with moderate fat	or
3/4 small cup cooked rice	
<i>Snacks group</i> (providing 15 g carbohydrates):	
4 pieces <i>dhokla</i> with seasoning	or
1¼ plate of puffed rice <i>chiwda</i>	or
1/2 big cup of rice flakes (<i>chiwda</i>)	or
1½ to 2, 4.5 cm diameter <i>methi</i> or <i>dudhi theplas</i> with moderate fat	or
1/2 big cup <i>batata pohe</i>	or
3/4 big cup <i>usal</i>	or
1½ <i>idlis</i>	or
1 plateful <i>rava upma</i>	or
1/2 big cup rice <i>mung dal khichdi</i> with a little <i>ghee</i> ,	
<i>Vegetables group</i> (providing 5 g carbohydrates):	

2 small cups spinach vegetable	or
1 3/4 small cups <i>dudhi</i> curry	or
1 big cup cauliflower curry	or
3/4 big cup brinjal curry	or
1/3 small cup lady's fingers curry	or
1 3/4 small cup French-beans curry	or
1/2 small cup green peas curry	or
1 small cup red pumpkin curry	or
1 medium beet-root	or
3/4 big cup cabbage curry	or
3/4 small cup potato curry	or
1 small cup yam curry	or
1/2 small cup clusterbeans curry	
<i>Fruits group</i> (providing 10 g carbohydrates)	
3 pieces of a small apple	or
1/2 medium banana	or
3/4 medium guava	or
16 pieces sweet lime	or
6–7 pieces orange	or
1 1/4 slice papaya	or
3/4 medium <i>chiku</i>	or
3/4 small cup grapes	

The system of food exchange lists help the dietitian and even the housewife to easily calculate a diet, and help the patient to make wise selection and substitution of foods.

Planning a Diabetic Diet with the Help of the Food Exchange Lists

A diabetic, whose requirements, as calculated in the earlier pages, are as follows:

Calories	= 1200
Carbohydrate	= 130 g (524 calories)
Protein	= 38 g (153 calories)
Fat	= 58 g (524 calories)

He would require the dietary exchange as given in Table 9.10.

9.12 THE DIABETIC ASSOCIATION OF INDIA

The Diabetic Association of India was started on 26th January 1955. Dr S S Ajgaonkar of Bombay was the founder of the association. Its activities are as follows:

1. It provides an organization for the benefit of the diabetics and others interested in the study of diabetes. It also promotes the study of the causes and treatment thereof and the diffusion of information concerning diabetes.
2. It acts as an authoritative and advisory body to safeguard the social interests of the diabetics and it assists them in providing work or otherwise arrange the rehabilitation of diabetics in society.
3. It arranges lectures, discussions and publicity for the information and benefit of diabetics and the public, generally on diabetes and associated diseases, and cooperates with similar organizations.
4. It prints, publishes and circulates journals, books, pamphlets, etc.
5. It promotes plans and programmes for early detection of diabetes mellitus.
6. It has been publishing a quarterly journal since 1960. In order to encourage patients to achieve good health in spite of diabetes, the association awards two medals namely *S M Ajgaonkar Victory over Diabetes Gold and Bronze Medals* and the other for workers to achieve scientific distinction in diabetology.

The Diabetic Association of India is thus a joint organization of scientist and people interested in diabetes.

The association had arranged two conferences. The first World Congress on Diabetes in the Tropics was held in January 1960 and the second in Bombay on November 14, 1981, when Shri M B Joshi from Nasik was awarded gold medal by the Association for his successful control over diabetes for more than 25 years without complications and with moderate or nil medical intervention.

The address of the association is Diabetic Association of India, SL Raheja Hospital, Raheja Rugnalaya Marg, Mahim, Mumbai 400016, India Tel. No. +91-22-66529999, Fax No. +91-22-24449418, E-mail info@rahejahospital.com

The Diabetic Association of India launched a very ambitious project. All India Institute of Diabetes dedicated entirely to the service of diabetics in their various needs as well as for research and education in the field of diabetology. The AIID, of which S L Raheja Hospital, Mahim, Bombay is a part, has come into existence. The complex, which includes research and education wing besides the hospital, is the first

Table 9.11 Vegetarian diet exchange list

Item	No. of Exchanges	Calories	Carbohydrates (g)	Protein (g)	Fat (g)
1. Milk	4	400	18	20	20
2. Legume and pulse	2	200	30	12	—
3. Vegetable A	4	—	—	—	—
4. Vegetable B	1	50	10	—	—
5. Fruit	1	50	10	—	—
6. Cereals	3	300	60	6	—
7. Fat	3	300	—	—	33
		1300	128	38	53

Meal Plan for the Day (1/3,1/3,1/3 calories from carbohydrates)

Tea	: 1 cup tea or coffee without sugar	Tea	: 1 cup skimmed milk (carbohydrates — 4 g) without sugar
Breakfast	: 1 exchange milk 1 exchange cereal 1 exchange fruit 1/2 exchange fat Total calories—300 Carbohydrates—35 g	Dinner	: 1 exchange cereal 2 exchanges veg. A 1 exchange legume (sprouts) 1 exchange vegetable B 1/2 exchange fat Total calories—450 Carbohydrates—45 g
Lunch	: 1 exchange cereal 2 exchanges vegetable A 1 exchange vegetable B 1 exchange legume and pulse 1 exchange fat Total calories—400 Carbohydrates—35 g	Bedtime	: 1 glass whole milk (without sugar); Carbohydrates—4 g

* Supplementation with sugar-free a high-protein supplement is necessary.

** A similar dietary exchange for a non-vegetarian diabetic can be calculated from Appendix V.

of its kind in India. In 1982, January, during the Silver Jubilee year of the association the hospital wing was commissioned. It has become a pioneer, national centre for service, research and education on diabetes in the tropics.



SUMMARY

Diabetes mellitus is a metabolic disorder. It involves arrest of carbohydrate metabolism robbing the body of a primary energy source. It encompasses the whole process of metabolism indirectly. Undue banking on lipid metabolism invites risk of ketosis. Burning of proteins for energy liberation results in weight loss and deprives the body of the basic building material and involves high turnover of the aminonitrogen cycle.

The dietitian needs to look into all these aspects carefully and plan the diet to suit individual needs of the patients. Restricting any particular dietary exchange is of little help. It calls for balanced planning to avoid the imbalance in any of the metabolic pathway and minimize the harmful side-effects.



CASE STUDIES

I	Sex	:	female
	Age	:	49 years
	Height	:	5 feet 3 inches
	Weight	:	65 kg
	Activity	:	sedentary lifestyle
	Symptoms	:	feeling of thirst, and polyuria Diagnosed for impaired glucose tolerance and now has frank diabetes
	Treatment	:	managing her disease by taking oral drugs
	Clinical picture	:	Fasting blood glucose is 130 mg/dl Post-prandial glucose is 200 mg/dl Blood cholesterol levels are 255 mg/dl. Prescribe a diet plan explaining the dietary principles.

II	Sex	:	male
	Age	:	20 years
	Height	:	5 feet 6 inches
	Weight	:	65 kg
	Activity	:	college going, away from home for about 11 hours
	Symptoms	:	Polyuria, polydipsia and excessive perspiration
	Clinical picture	:	Fasting glucose: 110 mg/dl; Post-prandial: 250 mg/dl He needs to know the options in order to choose between various insulins.

- a) What will be your advice regarding the various types of insulins.
- b) What precautions will you ask him to take?

III	Sex	:	male
	Age	:	78 years

Height : 5 feet 2 inches

Weight : 68 kg

Activity : sedentary

Clinical picture : acute renal failure, severely hypertensive, undergoing CAPD
Taking NPH regularly.

- a) What will be the dietary guidelines for him?
- b) Which nutrients need special emphasis?
- c) Which nutritive and non-nutritive sweeteners can he use? Also give their advantages and disadvantages.

*For the solution, just scan the QR code given here
OR visit <http://qrcode.flipick.com/index.php/235>.*



*Also check out the MCQ's related to this case in the next
QR code OR visit <http://qrcode.flipick.com/index.php/306>.*



REVIEW QUESTIONS

1. Differentiate between diabetes mellitus and diabetes insipidus.
2. What factors predispose a man to diabetes?
3. What are the two main clinical types of diabetics?
4. Why is diabetes also known as “a disease of stress”?
5. Outline the symptoms of diabetes. Which tests can be carried out at home to detect diabetes?
6. What is a lag-type? What precautions must such a diabetic exercise?
7. What are the acute complications of diabetes? Briefly outline how they can be overcome?
8. What are the chronic complications of diabetes?
9. How is exercise beneficial for a diabetic?
10. How are artificial sweeteners useful for a diabetic? Make a list of the alternate non-nutritive sweeteners available in the market.
11. What are the different types of insulin administered to diabetics? List them out and state the distribution of carbohydrates for each one of them.
12. What is meant by glycaemic index? How is it important for a diabetic? List out five foods in their descending order of glycaemic index?
13. Plan a diet for a lag type diabetic woman aged 42 years whose height is 5'3" and weight 76 kg. Write briefly the nutritional considerations for each nutrient in the diet.
14. What is the importance of monitoring in the management of diabetes?
15. What are the visible health complications seen in diabetics?

Chapter

10



Diet for Cardiovascular Diseases

10.1 CARDIOVASCULAR DISEASES

A World Health Organisation report had predicted that by the year 2010, more than 60 percent of the world's heart patients will be from India. In fact, according to a 10 year long research study conducted by the Coronary Artery Disease Institute (CADI), USA, Indians are far more genetically predisposed to heart disease regardless of their lifestyle, sex or age. The study pointed out that Indians have the highest levels of a lipoprotein that thickens blood flow, as well as high level of triglycerides, in other words, factors involved in atherosclerosis. Syndrome X, which afflicts several Indians, is another alarming feature.

Cardiovascular diseases as most of us are aware today, are the most potent killers, particularly so in advanced countries of the world. The incidence of hypertension (increase in blood pressure), heart attacks (mild to severe) and atherosclerosis has increased multi fold. There is not one but many causes leading to these diseases. Today, life is a race in which each person tries to compete with the other in terms of wealth, status, success, reputation, etc., through fair and unfair means. The accompanying tension and worries, the craving for the cigarette, the compelling peg, the leisurely or hectic mode of travel, the rich food and overweight, all drag the person towards a disease which either debilitates him physically and mentally for the rest of his life or can even be fatal.

The main cardiovascular diseases include increased blood pressure (high BP). Ischemic heart disease, angina pectoris, cardiac infarction, and other related diseases.

Populations in which coronary heart disease is common are characterized by widespread and severe involvement with coronary atherosclerosis—a fibrous fatty change in the arteries serving the heart muscle, often associated with thrombosis. The disease may, without warning, result in sudden death, or it may manifest itself as an acute and often fatal attack of myocardial infarction, or as angina pectoris, congestive heart failure, or arrhythmias. It causes death or disability in many who are still in the active years of life . Its personal and social costs are profound, both for the individual and families involved and for the countries in which it is common.

□ Types of Cardiac Disorders

The different types of cardiac disorders may be broadly classified as follows:

1. *Birth defects or congenital defects* such as atrial septal defects (holes between collecting chambers) may occur, but are less serious than defects in the septum separating the ventricles.

2. In valve disease, generally the mitral valve and aortic valve are affected. This can cause stenosis (obstructions to blood flow) or regurgitation (leakage of blood flow in the wrong direction).
3. *Coronary artery disease (myocardial infarction)* The coronary arteries start near the top of the heart and encircle it. Although, they are only a few millimetres in diameter they are among the most vital blood vessels in the body. Initially, there are two, right and left, though the left coronary artery divides so quickly that we usually think in terms of three major blood vessels. These vessels branch off to form a dense network and penetrate the full thickness of the heart muscle beneath. An obstruction in any of these vessels can cause a heart attack since, the blood supply to the cardiac muscle is decreased. These arteries are affected in many adults resulting in atherosclerosis (deposition of fat and fibrous blood components—also called atheroma). This results in hardening of the arterial walls (sclerosis) and gradual obstruction of the vessel, thereby reducing the flow of blood. Besides causing blockage which can occur in any of the coronary arteries, if any of the atheroma splits it may cause blockages (embolism). These clots may grow to block the blood vessel at the place where the plaque is ruptured or may again be carried off to an obstruction elsewhere. These processes can occur in all arteries. When such an obstruction occurs in the brain, it results in a *stroke*. In the heart, complete obstruction of the coronary arteries leads to death of that part of the heart muscle during a heart attack. Angina and heart attacks are two aspects of the same disease. Ischemic heart disease is the term given to a heart attack due to lack of blood to the heart muscle.
4. Abnormal heart beats and rhythms may occur. In medical terminology this is known as arrhythmias.
5. Infections of the heart are rare but may affect people especially those who already have heart abnormalities such as congenital defects and diseased or artificial valves.

10.2 RISK FACTORS

There are several risk factors which lead to cardiovascular diseases. Some of the specific factors which may lead to cardiovascular diseases are shown in Table 10.1.

They may act individually or jointly. The personal characteristics such as a strong family history of cardiac diseases, short stature or a tendency to be overweight or obesity are very closely involved. People who are more reactive to strain and are in the age group of 30 to 55 years have a greater risk of heart diseases. Men normally suffer more from heart attacks than women.

Behaviour patterns such as heavy smoking, drinking, especially since an early age, make the person prone to cardiovascular and other diseases. Eating a heavy diet rich in saturated fats, sucrose and a high intake of salt, multiply the problems of obesity and hypertension. A sedentary lifestyle with minimum physical activity adds to the already worse situation.

Diabetes, high blood-pressure and hyperlipidaemia are common disease situations which seem to be metabolically correlated with the incidence of heart diseases.

Table 10.1 Multiple risk factors in cardiovascular diseases

<i>Personal characteristics</i>	<i>Behaviour pattern</i>	<i>Metabolic relationships</i>
Family history Sex—higher incidence in males Age—between 30 and 55 years Overweight or obese Stress and tension, the type of personality addicted to work under tension and having limited hours of sleep.	Heavy smoking Drinking alcohol regularly and in large amounts Eating habits—use of refined food only, excess saturated fats, salt, sugar, and eating heavily in greater quantity, physical activity little or almost negligible. Exercising—having little exercise or no physical activity.	Diabetes High blood pressure (hypertension) Hyperlipaemia (elevated levels of serum lipids, triglycerides, lipoproteins and cholesterol)

Example People who are diabetic seem to have an intolerance for carbohydrates and have elevated serum levels of lipids including triglycerides, lipoproteins and cholesterol. Diabetics, therefore, are predisposed towards high blood pressure. Of all these lipids, cholesterol is much more publicized than the other two. This is perhaps due to the advertisements by several oil manufacturers who harp on cholesterol to indicate that the oil manufactured by them is of much lower or nil cholesterol value than the other oils which contain higher amounts of cholesterol, which may cause heart diseases. This, however, is a half truth since low dietary cholesterol does not rule out the synthesis of cholesterol in the body and its subsequent storage in the body. Its influence is minimal. Synthesis of body cholesterol is irrespective of the amount of dietary cholesterol and depends on the hereditary characteristics of the person. It is genetically related. However, one should note that the plaque lining the arteries of the body in atherosclerotic conditions is composed of lymphocytes, plasma cells, giant cells, fibroblast, calcium deposits and lipids, cholesterol being prominent.

Countries with total cholesterol (TC) value around 4.14 mmol/l (160 mg/dl) or lower manifest little or no clinical coronary heart disease or severe atherosclerosis. Populations with mean TC value between 4.14 mmol/l (160 mg/dl) and 5.17 mmol/l (200 mg/dl) are to be found over wide areas (the Mediterranean basin and the Orient); these people show no excess of non-cardiovascular disease mortality and have good life expectancy at all ages. Population having an average TC of 6.09 mmol/l (235 mg/dl) show a significant burden of coronary heart disease.

□ Etiology of High Blood Pressure

Blood Pressure (BP) is the amount of force exerted against the walls of the arteries as blood flows through them. High blood pressure is also known as hypertension. In order to diagnose high BP, the BP should be measured repeatedly. If the pressure is chronically elevated it confirms the diagnosis of hypertension.

In a majority of cases, the cause of high blood pressure (hypertension) is unknown but several factors can increase the risk of developing this condition.

High blood pressure is classified as follows:

1. Primary or Essential Hypertension Where there is no specific cause. The risk factors are:

- Age The risk of developing high blood pressure increases as age advances
- Family history of high blood pressure
- People of African or Caribbean origin
- A high intake of salt
- Lack of exercise
- Overweight or obesity
- Smoking
- Drinking alcoholic beverages in large amount

2. Secondary Hypertension About 10% of high blood pressure cases are the result of an underlying cause, such as

- Kidney disease
- Diabetes
- Narrowing of the arteries (large blood vessels) supplying the kidneys
- Hormonal conditions, such as Cushing's syndrome
- Conditions that affect the body's tissue, such as lupus
- Oral contraceptive pills
- Painkillers such as Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), e.g., Ibuprofen
- Recreational drugs, such as cocaine, amphetamines and crystal methamphetamine
- Herbal remedies

Two types of blood pressure are measured. It is expressed in millimetres of mercury.

1. *Systolic pressure* The blood pressure when the heart contracts, specifically the moment of maximum force during the contraction. This happens when the left ventricle of the heart contracts.
2. *Diastolic pressure* The blood pressure between heartbeats, when the heart is resting and dilating.

The definition of high blood pressure (hypertension) means blood pressure is 140/90 mmHg or more for a sustained period.

Stage	Systolic in mmHg	Diastolic in mmHg
Hypotension (low blood pressure)	90 or less	60 or less
Normal	90–119	60–79
Prehypertension	120–139	80–89
Stage 1 Hypertension	140–159	90–99
Stage 2 Hypertension	Over 160	Over 100

□ Salt and Blood Pressure

The average diastolic pressure in the population appears to increase by 0.8 mmHg (0.1 kPa) per g of habitual salt intake.

Both systolic and diastolic values of blood pressure are strong, good, and independent predictors of coronary heart disease risk. In some high-incidence populations, the upper 20% distribution of blood pressure has a four times greater relative coronary heart disease risk than the lower 20% with a continuous relationship between risk and the blood pressure level.

Factors associated with high blood pressure include family history, obesity and weight gain, alcohol intake and in some cultures low education and socioeconomic status.

In a few traditional, isolated subsistence economies there is total absence of high blood pressure as they have a habitual salt intake of less than 3 g daily. (1 gram salt contains 400 mg sodium.)

It is also seen that with a reduction of 5 g in average daily salt intake of a population, average diastolic pressure can be lowered by 4 mmHg (0.5 kPa).

Body Weight In some adult black populations the occurrence of high blood pressure might be reduced by as much as 25% and 50% in some adult white populations through the control and prevention of obesity in the population.

Prevention of coronary heart disease may therefore be achieved by the following guidelines:

- Saturated fat intake should be less than 10% of the daily energy intake
- Salt consumption should be less than 5 g/day
- Intake of cholesterol should be less than 300 mg/day

10.3 DEFINITION OF ATHEROSCLEROSIS

It is necessary here to understand the process which culminates in a heart attack.

1. *Atherosclerosis* is a term used to define the basic pathological process involved in coronary heart disease, commonly called CHD. This condition is characterized by hardening or thickening of the major blood vessels by porridge-like deposits, plaque. These plaques consist of proliferation of the blood vessel walls of connective tissues in which lipids are deposited. These lipids include free cholesterol, esters, and triglycerides in proportions that are approximately as much as those of the circulating lipids.
2. *Ischaemic heart disease* or *IHD* also known as *myocardial ischaemia* is a cardiac disability due to inadequacy of the arterial system of the heart to meet the needs of the heart muscle for oxygen and nutrients. Such a disability may result in sudden death, myocardial infarction or angina pectoris.
3. An *infarct* is a localized area of necrosis (death) that occurs when the blood supply to that area is not sufficient for its cellular survival. Such an infarct in the heart is known as myocardial infarction (heart attack) and one in the brain as cerebrovascular accident (stroke). If the infarct is small, healing of the tissue takes place with a resultant scar but the rest of the organ can continue to function.

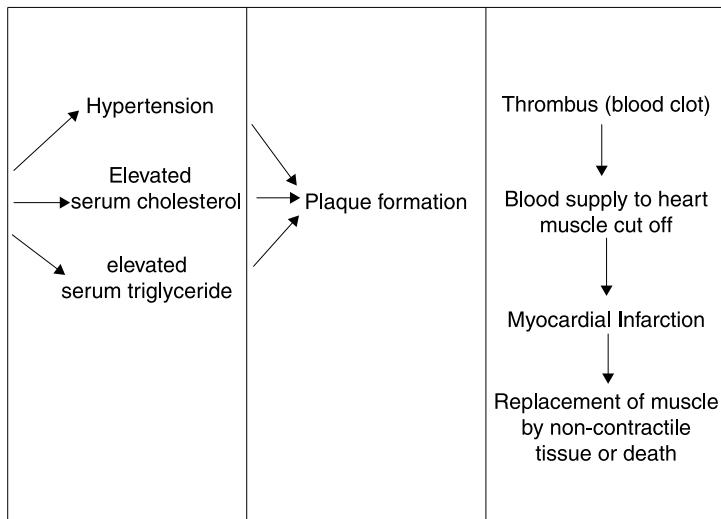


Fig. 10.1 Possible process involved in the development of ischaemic heart disease

Thus, if such attacks of myocardial infarctions are repeated, they continue to reduce the functioning ability of the organ, which may finally prove fatal.

4. *Angina pectoris* refers to tightness in the heart. This pressing, burning and sometimes severe pain across the chest that follows exertion is a result of inadequate oxygen supply to the myocardium (heart muscle). As the blockage in the coronary artery increases the pain occurs with even lesser exertion.

10.4 BLOOD PROFILE RELATED TO CORONARY HEART DISEASE

Measurement of various blood constituents have been made use of not only to determine the presence of abnormal concentrations of lipids and other related materials in the blood but they can also be used to evaluate the effect of dietary changes and therapy on their levels. Various types of lipid storage diseases are outlined in Table 10.2.

Alteration in the lipoprotein fractions of the blood have been implicated in the progression of cardiovascular diseases. There are various types of hyper and hypo lipoproteinaemias which are detailed in Table 10.3.

The terms associated with lipoproteinaemias are:

1. *Hyperlipidaemia*—is a general term used to indicate an increase in the level of one or more lipids in the blood.
2. *Hypercholesterolaemia*—is a term which indicates the increase in the level of serum cholesterol.
3. *Hypertriglyceridaemia*—refers to increased serum triglycerides.

The various types of lipoproteinaemias are as follows:

Table 10.2 Lipid storage diseases

Disease	Enzyme deficiency	Name of lipids accumulated in the body	Effects on health
Niemann-Pick disease (sphingomyelinosis)	Sphingomyelinase	Sphingomyelin	More common in female Jewish children. Deposition of sphingomyelin in most tissues; loss of functions, frequently fatal before the third year
Tay-Sachs disease	Terminal N-acetyl galactosamine cleavage enzyme	Gangliosides	Amaurotic familial idiocy. Accumulation of abnormal gangliosides mainly in brain resulting in impairment of mental and somatic function and vision.
Gaucher's disease	Glucocerebrosidase	Glucosyl ceramide	Familial disease more common in Jewish children. Pigmentation of skin, marked enlargement of spleen due to cells distended with lipids, liver and sternal marrow affected.
Fabry's disease	Trihexosidase Ceramide	Trihexosyl	Skin rash; extreme pain, disease progressive renal failure
Metachromatic leucodystrophy	Sulphatase	Sulphatide	Impairment of motor function; staggering and jerky movements due to lack of muscular control (ataxia); progressive demyelination
Refsum's disease	α-Oxidation enzymes	Phytanic acid	Chronic pathological changes in nervous tissues; night blindness; visual field narrows; skeletal malformation

□ Lipoproteinaemias

1. Primary It is normally inherited and may be due to the lack of an enzyme that removes lipoproteins from the plasma, a defect in the cell membrane receptors that control their uptake from plasma into tissues or due to a defect in a key pathway of lipoprotein metabolism, possibly in the liver.

Type I This is due to a defect in lipoprotein lipase and can be controlled by restricting the intake of triglycerides containing long chain fatty acids and substituting MCT's.

Table 10.3 The lipoproteinaemias

<i>Classification of disease</i>	<i>Diagnostic lipoprotein changes</i>	<i>Lipids involved</i>	<i>Treatment</i>	<i>Clinical characteristics</i>
HYPERLIPOPROTEINAEMIAS				
Type I	Raised chylomicrons in fasting plasma VLDL is generally normal	Triglycerides free cholesterol	Restricted fat diet (less than 10% of total energy intake); replace long chain fats by medium chain triglycerides (MCT)	Rare; mainly diagnosed before age 10
Type II	Raised LDL but the LDL are normal in composition	Cholesterol esters	Restrict dietary cholesterol by limiting the dietary intake of egg yolks, liver, dairy products. Use polyunsaturated oils, and skimmed milk	A common disorder; strong associations with premature heart disease (IHD). It may be visibly seen as massive accumulation of cholesterol in the skin and as a white ring in the eyes, both of which are common features of the disease; occurs both as a heritable disorder and secondary to hypothyroidism.
Type III	Raised abnormal LDL concentrations	Cholesterol esters Triglycerides	(i) Restrict cholesterol (ii) Reduce weight (iii) Diet composition protein : carbohydrate : fat = 20:40:40 (iv) Drug treatment with the physician's advice	The third common disorder after Types II and IV; it is usually accompanied by extensive vascular disease.
Type IV	Elevated VLDL concentrations	Triglycerides	(i) Weight control (ii) Avoidance of excessive carbohydrate intake (iii) Hypolipidemic drug treatment with the physician's advice	Associated with diabetes; obesity is extremely common; not associated with IHD to the same extent as Type II; occurs as a heritable disorder and secondary to diabetes, pancreatitis, etc.

(contd.)

(contd.)

<i>Classification of disease</i>	<i>Diagnostic lipoprotein changes</i>	<i>Lipids involved</i>	<i>Treatment</i>	<i>Clinical characteristics</i>
Type V	Elevated chylomicrons and VLDL	Triglycerides Cholesterol esters	(i) Weight reduction (ii) Low energy diets not rich in either carbohydrate or fat. Very low fat diet (iii) Less than 10% energy intake from fats; increased physical activity	Very rare, Appears late in life. Most patients have insulin resistance in liver.
HYPOLIPOPROTEINAEMIAS (VERY RARE)				
Familial LDL deficiency	Deficiency or complete absence of LDL; poor ability to form chylomicrons after a fatty meal	Cholesterol esters Triglycerides	Restrict intake of long chain saturated fatty acids and replace by MCT and some PUFA vegetable oils	Neuromuscular disturbances; retinal changes; red cell abnormalities; bulky and excessively fatty stools (steatorrhoea)
Familial HDL deficiency (Tangier disease)	Abnormally low HDL concentrations	Cholesterol Phospholipids		Tonsils, spleen, liver and lymph nodes show enlargement; lipids accumulate in reticuloendothelial tissues

Type II This shows abnormally high concentration of LDL. The intake of dietary cholesterol and of saturated fats has to be restricted and the P:S ratio should be raised by the inclusion of more PUFA in the diet. Extensive vascular disease occurs within the first few years of life and to increase life expectancy, drug therapy often has to be combined with dietary management. Among the drugs used are resins that very strongly bind to bile salts in the gut, thus, increasing their excretion in the faeces. This has the effect of increasing the elimination of bile salts and therefore cholesterol through the entero-hepatic circulation.

2. Secondary

The secondary hyperlipoproteinaemias occur when the metabolism of lipoproteins is altered as a result of recognizable disease which if treated will lead to normalization of the lipoprotein pattern, e.g. diabetes and obesity, which are frequently accompanied by abnormal lipoprotein patterns characteristic of type IV hyperlipoproteinaemia.

Diseases associated with fat metabolism are the following:

(a) Metabolic Syndrome Metabolic syndrome is characterised by high fasting glucose levels, hypertension, dyslipidemia and abdominal obesity. Hyperinsulinemia is an attempt by the body to regulate blood sugar. Although, hyperinsulinemia and impaired glucose tolerance are characteristics of Type 2 diabetes (NIDDM) it can also be seen commonly in other people. Figure 10.2 below depicts the pathophysiologic etiology of Metabolic Syndrome.

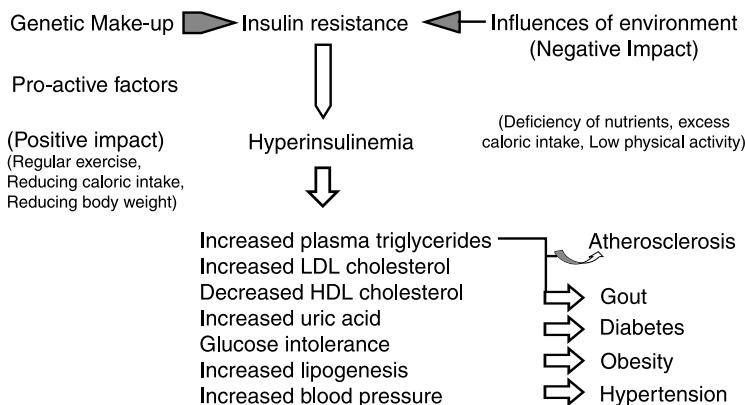


Fig. 10.2

3. Insulin Resistance

It is a condition in which the cells of the body become resistant to the hormone insulin. It may be a part of the metabolic syndrome, and it has been associated with higher risk of developing cardiovascular diseases. In many cases it precedes the development of Type 2 diabetes (T2D).

Insulin resistance is associated with other medical conditions, including fatty liver infiltration, arteriosclerosis, reproductive abnormalities in women, and acanthosis nigricans (a dermatosis characterized by velvety, papillomatous, brownish-black, hyperkeratotic plaques, typically on the skinfold surfaces and neck).

Individuals are more likely to have insulin resistance if they have any of several associated medical conditions.

Factors commonly associated with insulin resistance are obesity, lack of physical fitness, close relative with Type-2 diabetes, essential hypertension, coronary artery disease, pregnancy, Polycystic Ovary Syndrome (PCOD), endocrine disorders, e.g. acromegaly, Cushing's syndrome, drug therapies, e.g., protease inhibitors, corticosteroids, thiazide, diuretics, long-standing hyperglycaemia, elevated free fatty acids, etc.

While there are genetic risk factors, insulin resistance can be managed with diet and proper medication.

(b) Syndrome X Obesity is associated with resistance to insulin stimulated glucose uptake and hyperinsulinemia. Weight loss increases a person's sensitivity to insulin. About 25 to 40 percent non-obese (non-diabetic hypertensives) are also insulin resistant. The combination of insulin resistance, reactive hyperinsulinemia, increased serum triglyceride concentrations, decreased HDL cholesterol and hypertension are designated as syndrome X. This phenomenon may be partly heredity related.

(c) Diabetes In "Juvenile onset" diabetes, the cells of the pancreas that normally produce insulin are defective and the patient is unable to maintain a normal control of blood glucose concentration. This condition is often associated with leanness and a reduced level of fatty acid synthesis, which is controlled by administration of appropriate amounts of insulin as well as controlling the diet to maintain stable blood glucose concentrations.

"Maturity Onset" diabetes is associated with obesity, hyperlipoproteinaemia and increased tendency to develop atherosclerosis. In contrast to the juvenile type, fat synthesis seems to be enhanced and blood glucose as well as insulin concentrations are elevated. The condition is associated with a decreased sensitivity of tissues such as adipose tissue to insulin; in other words, more hormone than normal is required to produce a given metabolic effect. The pancreas respond by producing more insulin, which in turn enhances the general level of lipid synthesis. Since, insulin is not lacking, the management of the disease is predominantly by means of dietary modification.

Whereas diabetes was once regarded as a disease of carbohydrate metabolism, it is now apparent that faulty fat metabolism is an equally important factor. The main practical implication is a radical change in the dietary management of diabetes. Extremely low carbohydrate diets are no longer emphasized to the extent they used to be although it is recommended that any increase in carbohydrates should contain a higher proportion of complex carbohydrates (starch) and of non-digestible polysaccharides (dietary fibre). The chief measures are to reduce total energy intake to avoid obesity and to increase the proportion of polyunsaturated fats to saturated fats in order to control hyperlipoproteinaemias.

(d) Vascular Disease Certain biochemical substances in our body cause specific actions. Two such lipid mediators are the prostacyclins found in the arterial wall and thromboxanes found in platelets. Arachidonic acid can generate a whole range of related compounds but with subtle differences in structure, which exert profound physiological activities at very low concentrations. These include the ability to

contract smooth muscle, to inhibit or stimulate the adhesion of blood platelets and to cause constriction or dilation of blood vessels with a related influence in blood pressure.

Two groups of these metabolites, the ‘prostacyclins’ and the ‘thromboxanes’ have essentially opposite physiological effects.

The balance between these activities is important in maintaining normal vascular function. If thrown into imbalance due to dietary influence, the progress of vascular disease may be hastened. They are so potent in their action that they need to be generated locally and destroyed immediately after they have produced their effect by enzymes that convert them into inactive metabolites.

Cardiovascular and cerebrovascular diseases are commonly associated with dietary fats. The Ischaemic Heart Disease progresses by developing plaque, thickening the arteries and resisting blood flow. This can be said to be the first stage of the disease. Gradually, there may be a damage to the arterial wall leading to a thrombus or blood clot formation in the coronary artery. This is the second stage. When there is severe blood flow constriction in the artery, it leads to infarction and death of the tissue to which the blood flow is restricted.

Generally, it is desirable that people over 55 years of age should not have more than 220 mg per 100 ml serum cholesterol and fasting triglycerides should not be more than 150 mg per 100 ml.

Hyperlipoproteinæmia refers to the elevation of any one of the classes of lipoproteins, namely the VLDL (very low density lipoproteins), LDL (low density lipoproteins) and HDL (high density lipoproteins).

The approximate composition of lipoproteins is shown in Table 10.5.

Table 10.4 *Opposing effects of prostacyclins and thromboxanes*

<i>Physiological effect</i>	<i>Thromboxanes in platelet</i>	<i>Prostacyclins in arterial wall</i>
Platelet aggregation	Stimulates	Inhibits
Arterial wall	Constricts	Relaxes
Platelet cyclic AMP	Lowers	Raises
Blood Pressure	Raises	Lowers

Table 10.5 *Composition of lipoproteins in blood*

	<i>Lipid fraction</i>				
	<i>Lipoprotein</i>	<i>Triglycerides</i>	<i>Cholesterol</i>	<i>Phospholipids</i>	<i>Total</i>
	<i>%</i>	<i>%</i>	<i>%</i>	<i>%</i>	<i>%</i>
Chylomicrons	0.5–1.0	85	2–5	3–6	97
Very low density lipoproteins (VLDL)	5–15	50–70	10–20	10–20	95
Low density lipoproteins (LDL)	25	5–10	40–45	20–25	75
High density lipoproteins (HDL)	45–55	2	18	30	50

Generally, for people below 50 years age, total cholesterol is a useful predictor of risk, but for persons above 50 years HDL cholesterol is a more reliable indicator. However, it is more important to calculate the ratio of total or LDL cholesterol to HDL cholesterol than the individual absolute values. (Refer Appendix X for Lipid Profile of Blood).

One should bear in mind that not all persons with these alterations in serum cholesterol levels will develop coronary disease.

In some people, constant intake of saturated fats or high cholesterol content in food may result in elevated levels of these in the blood. This case is more common with non-vegetarians, whereas pure vegetarians have been found to have thinner blood than non-vegetarians, which corroborates with lower occurrence of heart disease, since a vegetarian diet contains less cholesterol and saturated fats. Sucrose and fructose have also been found to cause an increase in serum triglyceride levels.

A patient who is hypertensive or has suffered from a mild or severe heart attack should maintain the following record which should be available for quick reference. Besides, a regular health check-up is an absolute necessity for these patients. The *proforma* may be as follows.

Name of the patient: _____

Age: _____ Years _____ Address: _____

Telephone: _____ Residence: _____ Office: _____

Name of the family physician Dr _____

Address of the family physician _____

Telephone: Residence: _____ Dispensary: _____

Medication consuming regularly: Mention dosage and period for which taken:
Results of the regular check-ups:

Date	Weight	B.P.	Blood Sugar (fasting) mg%	Blood Sugar (post lunch) mg%	Serum Cholesterol mg%	ECG	X-ray Heart Size

Some Quantitative Facts about Cholesterol in the Human Body

The average adult body contains more than 100 g of cholesterol, which is present either as the free sterol or as cholesterol ester. It is found in all the membranes of all tissues and organ, in the fat stored form in adipose tissue and in the blood as lipoprotein cholesterol.

Some comes from the diet, some from synthesis within the body. Most tissues are able to synthesize cholesterol but the rates at which they carry out this synthesis vary considerably from tissue to tissue and also depend on the extent to which dietary cholesterol depresses tissue synthesis. There is a continual exchange of cholesterol between the cholesterol in blood and cholesterol in tissues. The rates of exchange are usually expressed in ‘half-lives’, i.e. the time taken for half the substance in a given tissue to exchange with that in another “pool”. The half-life of cholesterol tends to be short in tissues such as liver and intestine (a matter of hours) with slower rates of exchange in muscle and adipose tissue and even slower in the arterial wall.

The body may synthesize about half to one gram of cholesterol per day, whereas one-fourth to three-fourth gram are taken from the diet, of which only about 50 percent may be absorbed. Thus, the average adult human body is making about two to four times as much cholesterol as is taken in from the diet in order to satisfy the body's demands for maintaining membrane structure and for providing bile acids and steroid hormones.

10.5 DRUGS USED IN THE TREATMENT OF CARDIOVASCULAR DISEASES

The major cholesterol lowering medicines are bile acid sequestrants and HMG-CoA reductase inhibitors (statins).

These drugs can be listed out as follows:

1. Beta Blockers These are the most useful of all medicines. They help in controlling blood pressure itself and help to relax the heart muscles.

2. Vasodilators These increase the diameter of the blood vessel, thus encouraging the flow of blood through the coronary arteries. The nitrate class of vasodilators, such as glyceryl trinitrate, are used by angina patients for short-term relief. Another class known as calcium channel blockers or calcium antagonists such as verapamil (cordilox) are also used.

3. Foxglove Drug Digoxin It helps to protect the ventricles from the effects of arterial fibrillation.

4. Atropine It is used to accelerate the heartbeats in bradycardia.

5. Diuretics They may be used especially in heart failure to reduce the amount of blood in circulation and reduce sodium levels.

10.6 DIETARY MANAGEMENT IN ATHEROSCLEROSIS AND HYPERLIPIDAEMIA

There are several controversies regarding dietary recommendations in preventing and controlling cardiac diseases. It has been shown that several factors (risk factors) lead to a heart disease but elimination of any one factor cannot be considered as a remedy. Cholesterol has been much talked about in relation to heart diseases but it is not cholesterol alone but the intake of high levels of lipids in the food that is more relevant. A recent study has shown that strict vegetarians tend to have thinner blood than non-vegetarians, as mentioned earlier. This type of predisposition of non-vegetarians to heart diseases than vegetarians may be caused by more than one dietary factor.

Fibre is another constituent of the diet which has shown hypocholesteremic effects. Pectins, gums and soluble fibres tend to lower serum cholesterol levels, by altering the intestinal absorption.

Whatever the mechanism of action, the outcome that is beneficial to our body is of importance to the diet-conscious person. Effective dietary modification alone may achieve lowering the LDL—cholesterol without the need for medicines. Besides,

when drugs are required, the dose of drugs may be lessened by the use of maximal non-drug therapy, i.e. by avoiding those factors which predispose the person to problem of lipid metabolism, like smoking, high salt intake, excess weight. Lowering intake of dietary cholesterol and increasing the intake of fruits and yellow-orange vegetables (their contribution of flavonoids) and increasing the intake of anti-oxidant vitamins C and E. All this must also be accompanied by regular physical activity. In short, lifestyle modification.

General guidelines about the diet:

1. The total fat should be less than or equal to 20 percent of the total energy intake.
2. Cholesterol raising fatty acids, i.e. the saturated C_8 to C_{16} and trans-fatty acids should be less than seven percent
3. MUFA should be between 10% and 15%, PUFA less than 10%
4. Carbohydrates should contribute 55% and protein 15% of the daily energy requirement.
5. Cholesterol intake must be less than 200 mg per day.

The dietary management in cardiovascular diseases may be as follows:

1. Calorie Balance and Body Weight Being overweight, as we have seen, is a predisposing factor. In general, a reduction in the calorie intake by about 800 to 1000 kcals is advised to return to a normal weight. A patient in bed may be given a 1000–1200 kcal diet. Increased body weight has its greatest effect by increasing the work load of the heart. If diabetes is associated with overweight, the risk of suffering from a cardiac disease is high. Reduction in weight should be accomplished by reducing the total calorie intake.

2. Fats Dietary fat should be controlled in quality and quantity by substituting PUFA in the diet for part of the saturated fats which were customarily consumed earlier. A normal person fulfils about 15–20% of his calorie requirements through fat intake. These should be lowered to contribute only about 10% of daily calorie requirement. The effect of dietary fats on blood lipids is shown in the Table 10.6.

Table 10.6 Effect of dietary fats on blood lipids

Type of fatty acids	Increase	Decrease
Saturated	Total cholesterol	-----
	LDL	
Polyunsaturated	-----	Total cholesterol
		LDL cholesterol
		HDL cholesterol
Mono-unsaturated	HDL cholesterol	Total cholesterol
		LDL cholesterol
Omega – 3	-----	Triglycerides
		Total cholesterol
Trans	Total cholesterol	HDL cholesterol
	LDL cholesterol	

So also, the nature of the fats should be altered so that the ratio of PUFA to saturated fats is 2:1 in the diet. Substituting PUFA in the diet for part of the saturated fats which were customarily consumed earlier goes a long way for the cardiac patient. Table 10.7 elucidates this fact.

Predominantly, saturated fats such as *ghee*, *vanaspati*, butter, lard and margarine should be restricted and preferably avoided. Vegetable oils are permitted in moderate amounts, the best recommendation being safflower (*kardi*) oil, followed by corn oil, soya-bean oil and sesame oil. The reason for recommending safflower oil for heart patients is because of its high linoleic acid content as compared to the other oils. Coconut and palm oils also contain high amounts of saturated fatty acids, and should be best avoided.

Table 10.7 Recommended intake of fat and cardiac health

Type of dietary fat	Recommended intake (as % of energy intake)
Total Fat	15–30
Saturated Fat	< 10 ; 7 in high risk individuals
Total MUFA	10–12
Trans Fat	< 1
Total PUFA	Up to 10
LA (<i>n</i> -6 PUFA)	3–8
ALNA(<i>n</i> -3 PUFA)	1–2.5
PUFA/SFA ratio	0.8 to 1.0
<i>n</i> -6/ <i>n</i> -3 ratio	2.5:1–8:1
Cholesterol	< 200 mg

Table 10.8 elucidates this point.

Cholesterol intake through diet should be curtailed. Foods containing high amounts of cholesterol like eggs, liver, cheese, butter, cream, *shrikhand*, (not if prepared with skim milk) chocolates, cakes, etc. should be restricted. Table 10.7 gives the approximate cholesterol content in some common foods.

3. Carbohydrates As mentioned earlier, sucrose, glucose and fructose, the easily assimilable sugars, also cause hyperlipidaemia only if consumed in excess. Hence, their intake should be minimal. On the other hand, complex carbohydrates and resistant starch which are less likely to cause lipaemia are desirable, such as those found in whole-grain wheat flour, legumes, etc. Consumption of dietary fibre through leafy vegetables, raw unpeeled fruits is also advised, since fibre has shown a beneficial effect on the blood lipid profile.

4. Other Dietary Factors Certain minerals such as copper, zinc, hardness of water, electrolytes like sodium, may also be involved in the cause and prevention of cardiac diseases but concluding evidence is found to be lacking. In India, foods such as garlic are stated to have medicinal properties in lowering blood cholesterol. However, they have not yet been definitely proved as a cure. Non-dietary factors

Table 10.8 Relative percentage of saturated and unsaturated fatty acids in different foods

Food	Fatty Acids		
	Saturated (%)	Unsaturated	
		Mono-unsaturated % (Oleic acid)	Polyunsaturated % (Linoleic acid)
A. Vegetable Oils and Fats			
1. Safflower	6.0–10.0	13.0–25.0	67.0–74.0
2. Sunflower	8.0–11.0	14.0–18.0	65.0–70.0
3. Corn	13.0–15.5	26.0–29.0	55.0
4. Cottonseed	23.0–30.0	17.0–25.0	50.0–54.0
5. Soybean	14.0–15.5	25.0	50.0–60.0
6. Sesame	13.0–14.0	38.0–49.0	38.0–42.0
7. Groundnut	16.0–19.0	47.0–60.0	20.0–30.0
8. Mustard	5.0	32.0	18.0
9. Olive	11.0–15.0	75.0	7.0–10.0
10. Coconut	80.0–90.0	5.0–6.0	1.0–2.0
11. <i>Vanaspati</i>	25.0	72.8	2.0
B. Animal Fats			
1. Butter	45.0–65.0	27.0–32.0	1.0–4.0
2. <i>Ghee</i>	64.2	33.2	Nil
3. Poultry	30.0–40.0	40.0–44.0	14.0–20.0
4. Beef, lamb, pork	45.0–50.0	44.0	2.0–6.0
5. Fish (<i>Mackerel-Bangra</i>)	5.0	3.0	4.0
6. Fish (<i>Salmon</i>)	2.0	2.0	4.0
7. Whole milk (cow's)	64.0	29.0	4.0
8. Yoghurt, fruit flavoured (low fat)	62.0	26.0	3.0
9. Cheddar cheese	65.0	28.0	3.0
10. Human milk	46.0	38.0	8.0
11. Egg	10.0	13.0	2.0
C. Nuts			
1. Walnuts	4.0	10.0	40.0
2. Peanuts	9.0	25.0	14.0

Note These values are useful mainly to indicate the trend. They have been rounded up. The absolute values may be somewhat different.

such as smoking tobacco and drinking alcohol have been found to have harmful effects in the etiology of heart diseases. A person who has suffered a heart attack and has these two habits, is predisposed for more trouble. It is wiser to completely avoid them.

Table 10.9 Cholesterol content in mg per 100 g of food (Moist weight)

	<i>Foodstuff</i>	<i>Cholesterol (mg)</i>
1. Fish		50–470
Shell-fish (Oysters)		14.5–47
2. Dairy Products		
(i) Butter (86% fat)		280
(ii) Cheese—whole milk (24% fat) (Cottage cheese)		135–160 1.7
(iii) Cream (25% fat)		87
(iv) Milk (Fluid)—4% fat		0.90–14
(v) Milk (Powder) skim—1% fat		0.4
(vi) Milk (skim, fluid) 1% fat		0.004
(vii) Milk (whole) 6–8% fat		11.0
(viii) Sweets		65.0
3. Eggs (Hen's)		
(i) Egg-yolk, frozen		133
(ii) Frozen, whole		56
(iii) Liquid, whole		51.8
(iv) Dehydrated, whole		214
(v) Dehydrated yolk		281
(vi) Fresh, whole		468
4. Organs and Animal Meats		
(i) Beef		70.0
(ii) Lamb (raw)		70.0
(iii) Pork		70.0
(iv) Veal		90.0
(v) Chicken with skin		80.0
(vi) Chicken without skin		60.0
(vii) Liver		300.0
(viii) Heart		150.0
(ix) Brain		2000.0
(x) Kidney		375.0
(xi) Lard and other animal fats		95.0

Hence, a diet with moderate intake of calories, carbohydrates and modified fat with a liberal intake of proteins and moderately restricted sodium is advised. Supplementation with minerals and vitamins may not be necessary if large quantities of fruits and raw vegetables are eaten which furnish adequate quantities of minerals, vitamins and fibre.

5. Trans Fatty Acids This has been dealt with in detail in Chapter 3. Trans fats increase the shelf life of foods. Major dietary sources are polyunsaturated vegetable oils used in solid margarines, salad dressings, shortening, and many baked goods. Trans fats increase LDL-C and decrease HDL-C and are associated with an increased risk of CHD.

Low and Modified Fat Diet for Atherosclerotic Conditions

A low-fat diet which has been modified in quality of fat to include more amounts of PUFA is generally prescribed for heart patients, hypertensive patients and also obese and diabetic individuals who are more prone to heart disease. The dietary management stated earlier in this chapter acts as a guideline. The following suggestions may also be kept in mind:

1. *Butter has no more calories than margarine. Therefore, do not consider that a cake or any other food item made with margarine will have less calories than that made with butter or other saturated fat.*

5 g butter or margarine (1 teaspoon) = 36 calories

5 g oil/vanaspati = 45 calories

2. Shallow frying does not utilize less oil than deep frying so all fried foods should be avoided.
3. For shallow-fried foods such as *dosas*, cutlets, etc. use non-stick pans to minimize the use of fat. You safeguard your health as well as save money.
4. Make use of the oven or gas tandoor more than the frying-pan by baking, grilling or roasting foods, e.g. chicken tandoori, stuffed potatoes may be baked in tandoor or oven
5. Nowadays, aluminium foil is available. Wrapping the food in an aluminium foil and roasting it is better than roasting it in oil.
6. White meats contain less fat than red meats. Hence, chicken may be preferred to pork or beef.
7. Indian sweets like *halwa*, *burfi* should be avoided.
8. Cream from milk may be removed before drinking. Use of skim milk can be made more often than whole cream milk.
9. Cholesterol content of the diet should not exceed 150 to 200 mg/day. The list of foods to be avoided, eaten moderately and liberally in cardiovascular diseases is shown in Table 10.10.

Recommended Combinations of Vegetable oils are shown in Table 10.11.

Table 10.12 illustrates a low and modified fat diet.

A primary strategy for patients with hyper cholesterolæmia, before they use cholesterol-lowering medications is **nutrition education**. Key education points for patients should include the following:

1. *Understanding the difference between dietary and blood lipids. They should know how to change and decrease the dietary fats to lower blood lipid levels.*
2. The total fat intake must be less than 25% of the caloric intake, with less than 7% of calories from saturated fat. Seafood should be a part of the diet (at least in case of non-vegetarians).
3. The emphasis should be preferring vegetable sources than animal sources of fat.
4. Using liquid, unsaturated oils, as well as reducing the use of foods with partially hydrogenated oils (margarine).
5. Increasing the fibre intake by the inclusion of more whole grains, vegetables, and fruits.

6. Understanding that fat is a concentrated source of calories in the diet and should be minimised for those who want to lose weight or are obese.
7. Alcohol intake should be reduced or eliminated for persons with dyslipidaemia, especially those having elevated triglyceride levels.

Table 10.10 *Foods to be avoided, eaten moderately and allowed liberally in cardiovascular diseases*

<i>Foods to be avoided</i>	<i>Foods to be included in prescribed amounts</i>	<i>Foods to be allowed liberally</i>
1. Concentrated milk preparations, <i>mawa</i> preparations like <i>rabdi</i> , <i>burfi</i> , <i>pedha</i> , etc. cream, ice-cream, rich puddings, processed cheese.	Cereals such as rice, wheat, <i>jowar</i> , <i>bajra</i> , <i>ragi</i> , etc. <i>Dals</i> and pulses Spaghetti, macaroni noodles, bread, etc.	Raw and green leafy vegetables, fruits Clear soups, salads. Sour lime, tamarind, <i>kokam</i> , vinegar for taste.
2. Fried and oily preparations like <i>bhajias</i> , <i>pakodas</i> <i>farsan</i> <i>batatawadas</i> , etc.	Milk without cream	Thin buttermilk.
3. Fatty red meat cuts, organ meats such as liver, kidney, brain, etc. all type of processed meats, i.e. ham, bacon, etc. egg-yolk.	Root vegetables such as potato, sweet potato, yam, beetroot, pink radish, etc. Lean white meat, fish, egg white	Spices to taste and flavour Coconut water
4. Shellfish like prawns, lobsters, oysters, shrimps, etc. and oily fish like sardines.	Vegetable oils Sugar and jaggery. Salt	Garlic, onions
5. Alcohol and all alcoholic beverages and soft drinks.		
6. Animal fats like <i>ghee</i> , butter and vegetable oils such as coconut oil, palm oil, vanaspati and margarine.		
7. Sauces and all oil-based dressings.		
8. Nuts and oilseeds like cashewnuts, groundnuts, coconut, almonds, etc.		
9. Salted foods, puffed-rice (<i>kurmura</i>), pickles <i>chutneys</i> , vegetables salted and dried, <i>papad</i> , foods canned in brine (salt)		
10. Bakery product such as cakes, doughnuts, pastries, sweet and salted biscuits, <i>nankhatai</i> , <i>khari</i> and cream biscuits.		

Table 10.11

<i>Oil combinations</i>	<i>Proportion</i>
Groundnut/Sesame ^b :Mustard ^a	3:1
Groundnut/Sesame ^b :Canola ^a	2:1
Groundnut/Sesame ^b :Soyabean ^a	2:1
Palmolein ^c :Soyabean ^a	2:1
Safflower : Palmolein : Mustard ^a	1:1:1
Note:1) a – Alpha linolenic acid containing oils 2) b – Sesame oil – Lignans 3) c – Palmolein - Tocotrienols	

Adapted from Seminar on Cardiac Health, Nutrition Society of India, 2008

Table 10.12 Low and modified fat diet vegetarian (1300 calories)

Food Exchange List					
<i>S. No.</i>	<i>Item</i>	<i>Exchanges</i>	<i>Protein (g)</i>	<i>Fat (g)*</i>	<i>Calories</i>
1.	Milk (skim)	3	15.0	—	300
2.	Legume and Pulse	3	18.0	—	300
3.	Flesh food	1	10	—	70
4.	Vegetable A	2	—	—	—
5.	Vegetable B	2	—	—	100
6.	Fruits	2	—	—	100
7.	Cereals	3	6.0	—	300
8.	Fat (vegetables oils rich in PUFA)	1	—	11	100
9.	Sugar	15 g	—	—	60
			39	11	1260

Total Calories—1260; Fats—11.0 g; Protein—39.0 g

<i>Morning</i>	:	Tea—1 cup with 1 tsp sugar	<i>Snacks</i>	:	1 cup tea using 1 tsp sugar
<i>Breakfast</i>	:	Milk—1 glass	<i>Dinner</i>	:	2 phulkas or 1 chapati (no fat applied)
		Bread—1 unbuttered bread slice			1 cup dal/dal soup
		Orange—1 small			1 cup usal.
<i>Lunch</i>	:	1 cup tomato soup without cream or butter			1 cup vegetable
		1/2 cup vegetable rice/pulao			1/2 cup rice
		1 cup leafy vegetable			1/2 cup curds
		1 chapati or 2 phulkas (no fat applied)			(made with skim milk)
		1 piece fish (grilled)	<i>Bedtime</i>	:	1 glass milk (without sugar)
		1 cup dal			
		1 cup curds			
		(made with skim milk)			

* Intake of all invisible fats is minimised.

10.7 FAT REPLACERS

The medical need to decrease fat in the diet of those with Type-2 diabetes has increased the demand for palatable lower fat foods and has led to the creation of fat replacers. Fat replacers are used in many fat-free, non-fat, reduced-calorie and low-fat foods in an attempt to lower fat and calorie intake. At present, most fat replacers are carbohydrate-based, but some are protein or fat-based. Example, olestra used in snack foods and crackers.

Fat replacers have the potential to reduce total and saturated fat in the diet and can help to lower total cholesterol and LDL-C in persons consuming either a high or a low cholesterol diet. It is important to educate patients with Type-2 diabetes that fat replacers are fat-free but most fat replacers being mixtures of carbohydrates or proteins, they cannot be eaten liberally without affecting caloric intake, glycaemia and weight.

10.8 DIETARY MANAGEMENT OF ACUTE DISEASES OF THE HEART

The heart is the pumping station for the whole body. If it is damaged slightly but maintains its near normal circulation, then this stage is known as *compensation*. The person can rest and yet continue his normal activities with a little restriction of vigorous and exerting activities.

Decompensation occurs when the heart is no longer able to maintain normal circulation of blood and the person has to be supplied with oxygen and drug therapy to relieve the strain. He is also advised bed rest.

The heart disease may be acute with no prior warning as in the case of a coronary occlusion (blockage).

Impairment of the heart is seen by dyspnoea on exertion (laboured breathing), weakness and pain in chest. In severe heart failure the circulation of blood is hampered to such an extent that there is retention of sodium and water in the body tissues. This is known as congestive heart failure. Loss of appetite, (anorexia) nausea, vomiting and other digestive disorders are common symptoms of acute heart disease, culminating in death.

Modification of Diet

1. Energy Loss of weight results in reducing the load on heart. Usually, a 1000–1200 kcal diet is suitable for an obese patient in bed. Those who are normal for their weight are advised a maintenance diet until convalescence is complete and they return to their normal activity.

2. Carbohydrates, Fats, Proteins, Vitamins and Minerals These must be adequately provided. Carbohydrates should be given in the complex form. Fat should be derived more from oils containing high amounts of PUFA than saturated fats. Vitamins and minerals should be as per their daily requirements.

3. Sodium A sodium-restricted diet is recommended whenever there is a retention of sodium in the body along with fluids. Generally, sodium may be permitted in amount of 1600–2300 mg/per day. A further reduction may not be required if the patient is being given diuretics.

4. Fluid Restriction on fluids may not be necessary in most cases. Hence an intake of up to two litres of fluids per day may be allowed. In severe congestive heart failure in spite of treatment with diuretics, if fluid retention in the body is seen, then restriction of fluid intake may be introduced.

5. Distribution of Meals Smaller and more frequent meals may be advised. Five or six meals a day prevent loading the stomach, which in turn does not bring about excessive pressure on the heart at any given time.

6. Consistency The food may be liquid or soft. Foods which are easily digested and which require little chewing should be fed in the acute stage. Hard foods may be avoided even in the chronic stage.

7. Choice of Food Foods which cause abdominal distension must be avoided. These include milk in case of some patients. Other gas-forming foods are the vegetables of the cabbage family, cauliflower, turnip, onions, potatoes, legumes especially dal, chana and moth beans. Fruits and vegetables in the raw form may be used in plenty to prevent constipation. Constipation must be prevented at all costs since it subjects the heart to excessive pressure and may be fatal.

□ Progression of Diet

In the initial critical stage of decompensation, a liquid diet is prescribed. It may then progress to a soft diet. Besides hard texture, extremes in temperatures of foods are also avoided. Very hot or very cold beverages are not given. Stimulants such as coffee and tea, which contain caffeine, are avoided. However, tea contains isoflavones which are effective antioxidants and are proven to be beneficial.

A sodium restricted soft diet providing adequate complex carbohydrates, protein, low fats is generally given. If decompensation is very severe then a 500 mg sodium diet is advised. A sample menu is shown in Table 10.13.

□ A Low-sodium Diet

A low-sodium diet is designed for use in conditions where there is sodium retention, like swelling on the body, nephritis, cardiac diseases, toxæmia of pregnancy and hypertension.

A severe restriction of sodium is generally not necessary. It is not always possible and not advised. It depends upon the patient's condition.

- Mild restriction – 2 to 3 g sodium per day (intake allowed)
- Moderate restriction – 1 to 2 g sodium per day (intake allowed)
- Severe restriction – less than 1 g sodium per day (intake allowed).

□ General Instructions

1. *Limit the use of salt during cooking and avoid using salt on the table. One teaspoon salt contains about 1500 to 2000 mg sodium.*

2. Limit the use of animal foods which are rich in sodium and use more of fresh vegetables and fruits which are low in sodium, except carrots, celery, spinach and beet.
3. Boil fresh meats and fish in water and discard the liquid.
4. Avoid use of sodium bicarbonate or baking soda in preparation of meals or snacks such as *idlis*, cakes, *dhoklas* or in preparation of vegetables and legumes.
5. Read labels on foods bought from the market. Watch for the words "Salt" and "Sodium" on labels when selecting foods for a sodium restricted diet. One milliequivalent (MEq), of sodium chloride is 23 mg sodium. This unit of expression is sometimes used, hence, the clarification for the term milliequivalent.

1 MEq = 23 mg sodium

Table 10.13 Diet in decompensation (soft diet, with complex carbohydrates, high protein, low fat, more pufa, sodium restricted)

Food Exchange List				
<i>Exchange</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Sodium (mg)</i>	<i>Calories</i>
1. Milk (skim)	2	10.0	40	200
2. Legume and pulse	2	12.0	60	200
3. Flesh food	—	—	—	—
4. Vegetable A	2	—	10	—
5. Vegetable B	2	—	10	100
6. Fruit	2	—	6	100
7. Cereal	6	12.0	45	600
8. Fat (Oil)	2	—	—	200
9. Sugar	25 g	—	—	100
		34.0*	171	1500

Menu Plan	
<i>Tea (Weak tea)</i>	: 1 cup
<i>Breakfast</i>	: 1 slice toasted bread
	1/2 glass orange juice**
<i>Lunch</i>	: 2 <i>phulkas</i> (dry)
	1/2 cup rice
	1/2 cup <i>dal</i>
	1/2 cup <i>mung dal</i>
	1/2 cup curd (made with skim milk)
Cooked beet and carrot salad	
	<i>Dinner</i> : 2 <i>phulkas</i> (dry)
	1/2 cup rice
	1/2 cup <i>dal/mung</i> curry
	1 bowl tomato soup
	1 cup red pumpkin curry
	1/2 cup curds (made with skim milk)
	<i>Bedtime</i> : 1 glass warm milk

* Use protein supplements such as Casilan or equivalent.

** Whole fruit should be consumed instead of juice.

Foods to be Avoided

1. Papads, pickles, chutneys, sauces and all canned, brined, preserved and seasoned products unless declared to be Saltfree.
2. Sea fish, salted meat, salted dry fish and organ meats.
3. Snack items such as potato chips, salted pop-corn, salted nuts, chiwda, sev, bhajia, vada and chana.
4. Sodium is found in drugs such as laxatives, antibiotics, alkalizers, cough medicines, sedatives.
5. Salted butter and processed cheese.
6. Baked products such as bread, cakes, pastries, doughnuts, biscuits.
7. Fruits like *lichies* and muskmelon.
8. Vegetables such as knol-khol, amaranth, field beans and tender redgram.

A low sodium diet is generally unappetizing because of the blandness in taste of the food served without salt. Salt substitutes like sodium-free calcium glutamate can be added unless there is renal or liver diseases, but should be used sparingly. Spices, herbs and lemon juice may be used freely to make the sodium restricted diet more palatable and appetizing. Chilli powder often contains added table salt and, hence, should be used carefully.

Table 10.14 shows a list of common food stuffs which supply sodium in our diet.

□ Dangers of a Sodium-Restricted Diet

Diets which are very low in sodium must be used with caution, since there is occasional danger of depletion of body sodium. In summers, when hot weather prevails in our country, much sodium is lost through the skin in the form of sweat. Vomiting, diarrhoea, surgery, renal damage or use of mercurial diuretics also increases sodium loss from the body.

Table 10.14 Common foodstuffs as sources of sodium

Sodium content (mg/100g)	Foodstuff
Less than 10	<i>Jowar</i> , rice, <i>maida</i> , colocasia root, onion, sweetpotato, jam, bitter-gourd, brinjal, cucumber, French beans, ladies' finger, <i>parwar</i> , peas and pumpkin. Guava, orange, papaya, peaches, pears, plums, pomegranate and <i>chiku</i> , washed cottage cheese, tapioca chips (dried).
10 to 25	<i>Bajra</i> , barley, maize, <i>ragi</i> , <i>suji</i> , whole wheat, horsegram, cabbage, potato, bitter-gourd, cucumber, green plantain, tomato, cow and buffalo milk.
25 to 50	Most <i>dals</i> and whole legumes, carrots, radish, celery leaves, broad beans, pink beans, snake gourd, tomato, apple, banana, jack fruit, mango and pineapple.
50 to 75	Coriander leaves, lettuce, spinach, beetroot, radish cauliflower, tender field beans, fish, meat.
75 to 100	Fenugreek, tender red-gram, cow peas, amaranth, <i>lichi</i> , rock melon, tinned cheese, salted butter.

Symptoms of Sodium Depletion Weakness, abdominal cramps, lethargy, oliguria, azotaemia and disturbances in the acid-base balance are some of the symptoms. A patient on a sodium-restricted diet must be aware of these symptoms and consult the doctor immediately in case of their occurrence or even a doubt.

□ Control of Blood Pressure

Hypertension or increased blood pressure means that the patient has a systolic and diastolic blood pressure much higher than what is considered normal for his age. There are some people who normally have a slightly higher or lower blood pressure than the average.

Hypertension in adults is arbitrarily defined as a systolic pressure equal to or greater than 160 mmHg (1.3 kPa) and/or a diastolic pressure (fifth phase) equal to or greater than 95 mmHg (12.7 kPa).

Readings of 140/90 represent borderline hypertension. In young adults the systolic blood pressure is 120 while the diastolic blood pressure is 80. As age advances the systolic to diastolic blood pressure is about 160/90. Severe hypertension is indicated if the diastolic pressure exceeds 120. According to WHO, arterial hypertension indicates a chronically elevated systolic and/or diastolic arterial (blood) pressure.

General measures may be prescribed which can be summed up as follows:

1. Reduce weight and maintain average weight level.
2. Maintain regular habits especially regarding your work and rest.
3. Take regular walks. Walking at a medium speed is shown to be one of the best ways of stabilizing your hypertensive conditions.
4. Do *yogic* exercises. *Yogasanas* have been found to be effective in regulating the breathing pattern of a person. They also help to gain control over emotions. In general, *yogic* exercises are found to be helpful in stabilizing the blood pressure if it is a borderline case.
5. *Diet control*—All measures applied to the diet of a cardiac disease patient may be used. In addition, stress may be given on a low sodium diet by including foods low in sodium content. This has been elaborated earlier in this chapter. Sodium levels of various foods are shown in Table 10.15

10.9 CARDIOLOGICAL SOCIETY OF INDIA (CSI)

The Cardiological Society of Bengal was born on the 11th April 1946 with Dr. B.C. Roy, the legendary physician (who later on became the Chief Minister of West Bengal) as its first President.

On 11th January 1948, the eminent physicians of India met in Calcutta and decided to form a National Society of the Cardiologists. The decision was conveyed to all the physicians of India interested in Cardiology. The response was overwhelming.

And thus, the Cardiological Society of India (CSI) was born on the 4th April, 1948 at Calcutta, a long march to a glorious future was flagged off.

Table 10.15 Sodium levels of various foods

<i>Foods high in sodium</i>	<i>Foods moderate in sodium</i>	<i>Foods low in sodium</i>
Bread	Beetroot	<i>Chapati</i> (unsalted)
Biscuits	Carrot	Fruits
Cakes	Radish	<i>Ghee</i> , oil
Pastries	Leafy vegetables	Cream
Butter	Maize	Nuts
Cheese and cheese-spread	Riceflakes	Sugar
Salted snacks wafers	(puffed)	
Any food containing baking soda or <i>papad khar</i>	Cornflakes	Honey
Meat extracts	Red-gram (tuvar)	Cabbage
Shellfish	Tinda	Cauliflower
Pickles	Green tomatoes	Tomato
Sauces/ketchup	Milk, curds	Peas
<i>Papads</i>	Meat	Onion
	Fish	Potato
	Poultry	

It is interesting to note that the CSI was established one year earlier than the formation of the American College of Cardiology and the International Society & Federation of Cardiology (ISFC).

The first Executive Committee Meeting of the CSI was held at Calcutta with Dr. BC Roy as the President. Many stalwarts in the field of cardiology have graced this prestigious post, after Dr BC Roy.



SUMMARY

The cardiovascular diseases generally manifest due to overload on the heart than its rated capacity, and alteration in the walls of arteries resulting in obstruction to the normal blood flow.

The dietary management first requires shedding of the overload (proper height-weight relationship) and restoration of normal arterial posture.

Cholesterol, high calorie diet and excess electrolyte sodium, in particular, are the main points of focus and require restraint in a patient's diet.



CASE STUDIES

- | | |
|--------|-------------------|
| I Sex | : male |
| Age | : 64 years |
| Height | : 5 feet 4 inches |
| Weight | : 67 kg |

- Activity : sedentary worker
 Symptoms : diagnosed for angina pectoris, has difficulty in brisk walking or climbing stairs

Clinical picture : Blood pressure 190/90

His blood picture is (values are in mg/dl):

Total cholesterol	195
Serum triglycerides	189
HDL cholesterol	38
VLDL cholesterol	37.8
LDL cholesterol	119.2
TC/HDL-C Ratio	5.13
LDL-C / HDL-C Ratio	3.14

What will be your suggestions to the patient regarding the following:

1. improving his blood picture
2. appropriate form of exercise
3. any other investigations which you feel are necessary.

For the solution, just scan the QR code given here OR visit <http://qrcode.flipick.com/index.php/236>.



Also check out the MCQ's related to this case in the next QR code OR visit <http://qrcode.flipick.com/index.php/307>.



- II Sex : Male
 Age : 45 years
 Height : 5 feet 3 inches
 Weight : 77 kg
 Activity : sedentary worker
 Symptoms : undergone cardiac by-pass surgery
 Food habits : moderate alcoholic consumption, smoker, predominantly non-vegetarian

Clinical picture : Blood pressure 180/90

His blood picture is (values are in mg/dl):

Total cholesterol	290
Serum triglycerides	220
HDL cholesterol	32
VLDL cholesterol	43.7
LDL cholesterol	137.2
TC/HDL-C Ratio	9.06
LDL-C / HDL-C Ratio	4.28

What will be your advice to him regarding the following:

1. post-operative recovery
2. diet
3. lifestyle.



REVIEW QUESTIONS

1. Define hypertension, CHD, stenosis, regurgitation, atherosclerosis, infarct, and angina pectoris.
2. Describe the role played by hereditary factors in the incidence of CHD.
3. What role is played by cholesterol in the progression of CHD?
4. What are the other dietary factors of prime importance in the management of CHD?
5. What is a low sodium diet? What are the dangers of sodium restricted diet?
6. List out five foods rich in sodium and five foods low in sodium.
7. Plan a diet for a patient of angina pectoris, aged 53 years, whose height is 5'3" and whose weight is 63 kg. His lifestyle is moderately sedentary and he consumes a mixed diet. What changes will you make in his diet and why?

Chapter

11



Diet for Kidney Diseases

11.1 INTRODUCTION

The kidneys are the main organs of the body through which nitrogenous wastes are excreted in the form of urea. They are carried through the blood stream where the blood capillaries are coiled up in lakhs of tufts called glomeruli. The water-soluble small molecular compounds such as urea, waste salts and other materials, nutrients such as amino acids, sugars, uric acid, creatine, detoxified derivatives of foreign chemicals, along with much water, pass through the walls of these capillaries and into a small cavity that surrounds each glomerulus. Blood cells and large molecular substances such as blood plasma proteins are retained. The excreted fluid empties from the cavity through a long much-coiled tubule. This structure is also surrounded by capillaries and most of the water, salts and other essential nutrients are reabsorbed through them into the blood. The fluid that remains in the tubule is the urine.

An adult human being has a blood volume of about seven to eight percent of his body weight, i.e., an approximate range of four to five litres of blood which flow through the kidneys. A normal healthy human being has a pair of kidneys that filter about 135–150 litres of fluid every 24 hours while only about 1.5 litres of urine is eliminated from the body during the same period. This clearly shows the tremendous reabsorption capacity of the kidneys at work and a slightest disturbance at any stage can cause havoc. Figure 11.1 illustrates the two parts of a nephron, namely the glomerulus and the tubules. The nephron is the functional unit of our kidneys. There are approximately one million nephrons in each kidney.

In brief, the kidney is a very efficient filter of the body. It has several functions. It maintains the normal composition and volume of the blood. It does so by excreting nitrogenous and other metabolic wastes, by regulating the excretion of electrolytes such as sodium, potassium as well as fluids, so that a delicate balance of water is maintained and, in turn, the osmotic pressure and pH of the blood are regulated. It effectively flushes out the soluble toxic substances.

11.2 KIDNEY FUNCTION TESTS

Any disturbance in the functioning of the kidneys can be judged from a series of tests conducted on the blood and urine of the patient. The extent of damage to the kidneys, if any, can be easily detected on the basis of the following biochemical tests.

In Blood

1. Blood urea
2. Serum creatinine

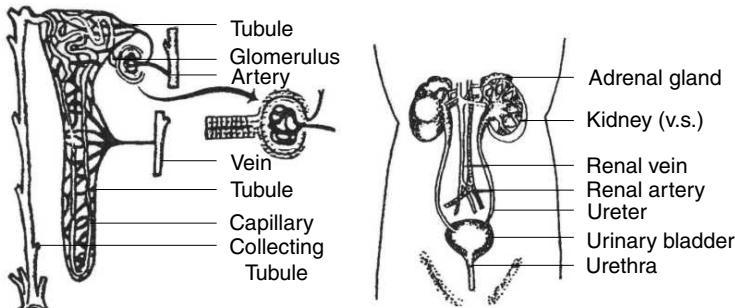


Fig. 11.1 The urinary system of the human body

3. Serum uric acid
4. (a) Serum total proteins
(b) Serum albumin
(c) Serum globulins
(d) Albumin: globulin ratio
5. Serum electrolytes: sodium, potassium, chloride
6. Serum bicarbonates
7. Serum inorganic phosphorus

Normal and abnormal observation in the blood as related to the kidney function tests can be seen in Table 11.1.

□ In Urine (24-Hours Collection)

Urine analysis involves clarity and colour, microscopic examination, pH, specific gravity, glucose, protein, ketone bodies, blood, total solutes, osmolality, phenolsulfonphthalein test and renal clearance tests.

Clearance tests are designed to measure the efficiency with which the kidneys remove certain substances from the blood. Urea and creatinine are commonly measured for clinical purposes. The normal values for adults for creatinine clearance ranges between 100–180 ml/minute while normal urea clearances are 50–100 ml/minute. These values multiplied by 1.4 give litres per day. Ideally, clearance should be corrected for body size.

In early cases of kidney diseases, a fall in the clearance rate may occur before the serum creatinine and urea level rise above normal.

The kidney may be affected by various inflammatory and degenerative diseases which ultimately disturb the metabolism of proteins, electrolytes and water. The main function disrupted is that of filtration and reabsorption. Therefore, the dietary considerations in kidney disease primarily warrant control over protein, restriction on calcium, and moderate to rigid control over sodium, potassium and phosphorus.

Diseases of the kidney involve the nephrons, the tubules and the glomerulus. Nephritis, therefore, is a general term used to describe the disease which affects the nephrons. If the glomeruli are specifically affected, it is termed as glomerulonephritis. In this disease, the functioning of the tubules is also affected.

Table 11.1 Normal and abnormal observations in the blood in kidney function tests

Determination	Normal values	Increased in	Decreased in
1. SGPT	5–35 IU at 37°C	—	Renal insufficiency
2. Albumin	3.3–4.8 g/dl	—	Renal disease
3. Calcium	9.0–11.0 mg/dl 4.5–5.5 mEq/L	—	Chronic renal disease
4. Chloride	95–106 mEq/dl	Renal tubular disease	Salt-losing renal disease
5. Cholesterol	150–250 mg/dl	Nephrotic syndrome	—
6. Creatinine	0.7–1.5 mg/dl	Impaired renal function	—
7. Glucose	70–110 mg/dl	Chronic renal failure	—
8. Magnesium	1.2–2.4 mEq/L	Renal disease	—
9. Inorganic Phosphorus	2.5–4.5 mg/dl (adults) 4.0–6.0 mg/dl (children)	Renal insufficiency	—
10. Potassium	3.8–5.6 mEq/L	Renal glomerular disease	Renal tubular disease
11. Sodium	133–146 mEq/L	—	Salt-losing nephritis
12. Total protein	6–8 gm/dl	—	Renal disease (protein-losing)
13. Triglycerides	10–190 mg/dl	Nephrotic syndrome	—
14. Uric acid	2.0–7.0 mg/dl	Renal failure	Renal tubular defect
15. Urea nitrogen	7.0–23 mg/dl	Impaired renal function Post-renal conditions	

Adapted from: *Interpretative Clinical Chemistry* by Bernard E. Statlands.

Kidney stones, also known as urinary calculi, is another disease of the kidneys. These occur in the kidneys or associate organs and hamper the function of excretion. Besides these diseases, the other ailments which affect the kidney are discussed below.

1. Nephrosclerosis This is a disease in which the kidneys are damaged by arteriosclerosis or arteriolosclerosis. Under these conditions, as the arterial vessels (either large or small) become progressively narrower, the portions of renal substance which they supply are gradually damaged by anoxia and eventually die, to be replaced by scar tissue. The blood pressure is very high and death occurs early.

2. Lower-Nephron Nephrosis It is an acute reversible form of severe kidney shut-down. It occurs following prolonged shock and hypotension, or after absorption of certain haemoglobin compounds following incompatible, blood transfusion, or after destructive injuries of muscles. There is suppression of urinary secretion, usually complete, followed by rising blood levels of nitrogenous wastes. The kidneys may take up to two months to return to normal. This patient is relieved by the technique of dialysis.

A kidney disease or disorder may be acute, sub-acute, chronic or latent. In a latent stage the patient is asymptomatic for months or even years and hence, determination of the level of renal function before beginning the treatment and dietary control is very important.

Some patients suffering from acute disease may progress to the chronic stage. This is seen in some patients suffering from acute nephritis who progress to chronic nephritis.

Some of the important kidney disorders are discussed in the following section.

11.3 GLOMERULONEPHRITIS

Glomerulonephritis is a specific form of renal inflammation, particularly involving the glomeruli as a result of a reaction between circulating streptococcal toxins and antibodies present in the cells of the glomeruli. Generally, two types are seen in this disease. Type I cases have an abrupt onset, usually one or two weeks after an acute streptococcal infection. The urine is smoky or bloody, the blood pressure is high and nitrogenous waste products are markedly increased in the blood. Most patients recover completely, some die, while a few develop chronic nephritis. Type II cases have an insidious onset without an obvious preceding infection. Their symptoms include oedema of the legs and eyelids, anaemia, proteinuria and later hypertension. These cases usually progress to complete kidney failure. Protein and the red blood cells appear in the urine due to leakage through the damaged glomeruli.

□ Acute Glomerulonephritis

In this disease, primarily the glomeruli are affected. This disease normally occurs commonly after a streptococcal fever, tonsilitis, pneumonia or respiratory infection.

It occurs more frequently in children than in adults.

Symptoms The characteristic symptoms are haematuria (blood in urine) and proteinuria or albuminuria (albumin in urine). Other symptoms include blurred vision, cough containing mucus or pink, frothy material, decreased alertness, drowsiness & confusion. The person may experience general aches and pains in joints and a general feeling of illness. There may be shortness of breath and the person's movements may be slow & sluggish. There may be varying degrees of oedema, hypertension and renal insufficiency. Urine output decreases or in some cases there may be no urine output. Swelling around the ankles, puffiness around the eyes, headache, nausea and vomiting are very common symptoms.

□ Modification of Diet in Acute Glomerulonephritis

Dietary modification aims at complete recovery of the patient. In case of acute glomerulonephritis it may take from two to three weeks to several months to recover completely.

The diet may be based on the following nutritional considerations:

1. Fluid Balance This should be maintained by restoring as much fluid as is lost by the body. That is, the input should match the output. If it is seen that the urine is diminished, then the intake of fluids should be between 500–700 ml per day.

2. Protein Unless renal failure develops or there is diminished urine output (oliguria) protein is not restricted. An adequate protein intake may be given. However, if protein restriction is necessary, a diet not exceeding 40 g protein is used. It may gradually be increased over the next two weeks. If there is loss of albumin in urine (albuminuria) then the protein intake may be increased in proportion to the protein lost in it. Protein of a high biological value should be preferred to other foods having low biological value.

3. Energy Caloric value of the diet may be according to the recommended dietary intake as published by the ICMR, 1989, according to the requirements of the patient's height, age and sex. If he is advised bedrest, then the allowances may be lowered a little. When protein intake is lowered then the caloric intake is met by using sources which yield calories but no protein, such as low-protein desserts, sugars, jellies, hard candy, butter or margarine, vegetable oils and carbonated beverages. Information on a low sodium diet is given in Chapter 9.

□ Chronic Glomerulonephritis

Clinical Characteristics It is not yet confirmed as to what causes this but it may be asymptomatic for several years and may indicate gradually increasing involvement; proteinuria, haematuria, hypertension, and vascular changes in the retina. Frequent urination and nocturia are seen. In some patients nephrotic syndrome characterized by massive oedema and severe protein losses through urine may develop. Eventually, renal failure may occur.

□ Modification of Diet in Chronic Glomerulonephritis

1. Protein When protein loss through the urine is found, the protein intake may be increased to compensate for the losses. But if retention of urea nitrogen in blood is seen then the protein in diet must be decreased to 40 g or less, per day. Protein of high biological value should be included.

2. Carbohydrates and Fat The energy needs from these sources should be met as per the requirements so that there is no breakdown of body protein for energy.

3. Sodium Restriction This may be done to supply 500–1000 mg sodium in the diet if oedema is present. Mild sodium restriction (intake of 2,000–3,000 mg) may be advised even if there is no oedema. During the diuretic phase when large volumes of urine are excreted along with sodium ions, excessive restriction of sodium may

cause body depletion of sodium and result in weakness, nausea and other symptoms of shock (described under sodium in Chapter 3). A sample menu in acute and chronic glomerulonephritis is shown in Table 11.2.

Table 11.2 Diet in acute and chronic glomerulonephritis calories—1900; protein—40 g; sodium—800 mg

Food Exchange List				
<i>Exchange</i>	<i>No. of Exchanges</i>	<i>Protein (g)</i>	<i>Sodium (mg)</i>	<i>Calories</i>
1. Milk	2	11.0	30.0	200
2. Legume and Pulse	2	12.0	30.0	200
3. Flesh Food	1/2	5.0	—	50
4. Vegetable A*	2	—	20.0	—
5. Vegetable B*	2	—	20.0	100
6. Fruit*	2	—	20.0	100
7. Cereals	9	18.0	225.0	900
8. Fat	2	—	—	200
9. Sugar	25 g	—	—	100
		45.0 **	345.0 ***	1850

Menu Plan				
<i>Tea</i>	— 1 cup	<i>Afternoon</i>	—	1 cup tea
<i>Breakfast</i>	— 1 cup tea			3/4 cup pohe
	2 slices bread			1/2 small banana
	1 egg	<i>Dinner</i>	—	2 small phulkas
	1 small orange			3/4 medium cup vegetable
<i>Lunch</i>	— 1 small phulka			1 cup rice
	3/4 cup vegetable			1 medium cup dal
	1 medium cup rice 1			1/2 cup curds
	medium cup dal			
	1/2 cup curds			

* Vegetable and fruits containing sodium less than 10 mg% should be used.

** Protein may be increased to 50–60 grams if there is normal output in acute stage. In chronic glomerulonephritis this may be increased in proportion to protein loss in urine.

*** Sodium restriction may be required if oedema is seen. If there is no oedema, an intake of 2,000–3,000 mg sodium may be advised. 1 tsp. of table salt contains 1,500–2,000 mg sodium.

Nutritional Considerations in Diabetes and Chronic Kidney Disease (CKD)

Patients with CKD may have complications that are significantly influenced by dietary intake and include conditions such as hyperkalemia, hyperphosphatemia, and hypertension. If these are present then the diet should be modified to reduce foods

with high levels of potassium, phosphorus, and sodium. The dietitian who is trained in both diabetes and kidney disease may help to improve dietary intake goals and clinical outcomes in patients with CKD. Multidisciplinary management is often a cornerstone in the successful management plan for patients with diabetes and CKD.

A reduction of dietary protein intake to 0.8 g/kg body weight for CKD Stages 1-4 is recommended to try to reduce albuminuria and reduce the rate of loss of kidney function and would be most effective in patients with type 1 diabetes. Thus, for patients with CKD, high-protein diets are not recommended.

For Renal patients undergoing dialysis it is important to prevent undernutrition. Some guidelines are as follows:

- (a) Dose of small solute removal is necessary to prevent undernutrition. It is recommended that dialysis dose meets recommended solute clearance index guidelines (e.g. URR, Kt/V)
- (b) Correction of metabolic acidosis and nutrition. It is recommended that venous bicarbonate concentrations should be maintained above 22 mmol/l
- (c) Minimum daily dietary protein intake:
 - (i) 0.75 g/kg IBW/day for patients with stage 4-5 CKD not on dialysis
 - (ii) 1.2 g/kg IBW/day for patients treated with dialysis
- (d) Recommended daily energy intake of 30-35 kcal/kg IBW/day for all patients depending upon age and physical activity.
- (e) Vitamin supplementation in dialysis patients: Haemodialysis patients should be prescribed supplements of water soluble vitamins.
- (f) Exercise programs in dialysis patients: Haemodialysis patients should be given the opportunity to participate in regular exercise programmes. Progressive resistance training and aerobic exercise have shown to bring about improvement in physical function.
- (g) Regular screening will help to identify when the dietary prescription needs to be modified.

□ Screening for Undernutrition in CKD

The frequency of screening for dialysis patients varies. It is needed at the beginning of dialysis in order to identify those who require nutritional supplementation as well as those who need water removal and need to be advised on the various dietary restrictions that may be necessary. After 6-8 weeks of dialysis, many patients have symptomatic relief. For stable patients, nutritional changes are likely to be gradual.

A full nutritional assessment includes a medical history, assessment of dietary intake, anthropometric measures, dialysis adequacy and residual renal function.

In dialysis populations there are a number of measures that at least partially reflect the nutritional state and could predict patient survival. This decrease in survival has been attributed to poor nutrition. There is a strong correlation between inflammation, atherosclerosis and poor nutrition, referred to as the MIA complex. Some of the measures include:

- serum creatinine (creatinine is dependent on both renal function and muscle mass)

- serum cholesterol
- serum albumin: a low serum albumin and poor survival of dialysis patients predominantly reflects the association between serum albumin and inflammation, co-morbidity and fluid overload.
- subjective global assessment: Subjective global assessment (SGA) includes gastrointestinal symptoms (appetite, anorexia, nausea, vomiting, diarrhoea), weight change in the preceding 6 months and last 2 weeks, evidence of functional impairment and a subjective visual assessment of subcutaneous tissue and muscle mass.
- body mass index, lean body mass, and handgrip strength.

Serum albumin is considered a marker of visceral protein and is strongly predictive of mortality in pre-dialysis, dialysis and transplant populations. Assessment might include C-reactive protein, evidence of atherosclerosis, 24-hour urinary protein loss, 24-hour peritoneal protein loss and determination of circulatory volume status by clinical examination and / or bio-electric impedance.

The multi-disciplinary approach of the doctor, nurse and dietitian in case of CKD patients cannot be underestimated.

□ Diabetes Management Issues for Patients With Chronic Kidney Disease (CKD)

Issue Action

- Diagnosis Analysis of urine for protein
- Analysis of serum for creatinine
- Measurement of Glycemic control A1C
- Monitor blood glucose with glucose meter
- Medications: Oral hypoglycemic agents/Insulin May need to adjust dose/ discontinue use
- Comorbid diseases: Blood pressure ACE Inhibitors/ARB's; Hyperlipidemia Need to adjust dose
- Complications of CKD Anaemia, Hyperphosphatemia, Hyperparathyroidism
- Nutrition Avoid high protein intake, Restrict sodium, potassium and phosphorus

The National Kidney Foundation has outlined KDOQI clinical practice guidelines and clinical practice recommendations for diabetes and chronic kidney disease (Stage 3 to 5) regarding the use of hypoglycemic agents, their dose and possible complications during dialysis. (For further reading :Am J Kidney Dis 49 : S1-S180,2007)

11.4 NEPHROTIC SYNDROME

Nephrotic or lipid nephrosis is a disease which affects small children.

The primary degenerative effect in nephrosis is in the capillary, basement membrane of the glomerulus. As this degeneration continues, the kidney tissue pore size increases to allow the passage of protein into the filtrate. This disease is characterized by large amounts of protein (albumin) loss in urine by the body.

Initially, there is accumulation of body fluid seen as swelling of the eyelids and legs. Serum albumin falls while blood cholesterol rises to a very high level. The cause

of this disease is unknown though most cases may be a form of glomerulonephritis and related to streptococcal toxins. Mortality rate in this disease is high.

□ Clinical Symptoms

In the urine, massive loss of albumin along with globulins as well as specialized binding proteins for thyroid and iron is seen. The blood levels of plasma proteins drop and serum cholesterol level increases.

Due to loss of serum proteins, the tissue proteins are broken down and a general state of malnutrition prevails. Fat accumulates in the liver, sodium is retained and oedema occurs.

□ Modification of Diet in Nephrotic Syndrome

Treatment should be to control the major symptoms, i.e. oedema, malnutrition and massive loss of protein. The dietary modification may be as follows:

1. Protein The daily protein allowance is increased to 100–200 grams. This should be provided through high quality protein. High protein supplements with low sodium contents, if available in the market, are useful for some patients.

2. Calories Sufficient calories should be provided to permit the protein supplied to be utilized for tissue synthesis. A high calorie intake of 50–60 kcal per kg body weight should be given. It is up to the dietitian to coax the patient to consume the diet completely. The food must be appetizing and easily tolerated.

3. Sodium To prevent massive oedema, sodium levels in the diet must be low. Usually, a 500 mg sodium diet is satisfactory.

Hence, a high protein (100–200 g), high carbohydrate and low sodium diet is prescribed. A typical diet in nephrotic syndrome is shown in Table 11.3.

Table 11.3 Diet in nephrotic syndrome weight of patient – 50 kg, calories 50–60/kg body weight; calories—2500 kcal; protein—100–150 g/day; sodium—500 mg/day

Food Exchange List				
Exchange	No. of exchanges	Protein (g)	Sodium (mg)	Calories
1. Milk	4	20.0	60.0	400
2. Legumes and Pulses	4	20.0	60.0	400
3. Flesh food	1	10.0	—	100
4. Vegetable A*	2	—	—	—
5. Vegetable B*	2	—	20.0	100
6. Fruit*	2	—	20.0	100
7. Cereals	10	20.0	250.0	1000
8. Fats	3	—	—	300
9. Sugar	30 gm	—	—	120
		70.0**	410.0**	2520

(Contd.)

(Contd.)

Menu Plan

<i>Tea</i>	—	1 cup	<i>Tea</i>	—	1 cup tea
<i>Breakfast</i>	—	1 glass ragi <i>kheer</i> (porridge)	<i>Dinner</i>	—	3/4 cup <i>rawa upma</i> 2 <i>chapatis</i> or 4 <i>phulkas</i>
		1 small banana			3/4 cup vegetable
		1 egg			1 cup rice
<i>Lunch</i>	—	2 <i>chapatis</i> or 4 <i>phulkas</i> 3/4 cup vegetable 1 cup rice 1 cup <i>dal</i> 1 cup curds	<i>Bedtime</i>	—	1 cup <i>dal</i> 1 cup curds 1 glass milk with Casilan

* Vegetables and fruits containing sodium less than 10 mg% should be used.

** To increase protein intake without increasing sodium, the patient may use supplements such as Casilan or Edosol or equivalent.

11.5 CHRONIC RENAL FAILURE—URAEMIA

Uraemia is the term given to the complex symptom of advanced renal insufficiency. Generally, chronic glomerulonephritis, nephrosclerosis and chronic pyelonephritis are the principal diseases leading to kidney failure.

Renal failure occurs when the kidneys are unable to carry on their normal function of excreting wastes and balancing the internal chemical environment of the body. This may occur abruptly as in nephrosis or obstruction of the urinary tract, but most often develops gradually because of progressive destruction of renal tissue by the disease.

In the early or compensated stage, the kidneys lose their functional reserve, i.e. the ability to excrete concentrated urine when little fluid is taken in or to excrete dilute urine when much fluid is ingested. This results in urine having a fixed 1.010 specific gravity. The urine also contains large amounts of nitrogenous wastes. It is also unable to maintain a constant blood pH at 7.4.

In the decompensated stage, complete excretion of certain substances is no longer possible and their concentrations in the blood rise. This includes potassium, phosphates and nitrogenous wastes such as urea and creatinine. Sodium and water accumulate in the tissues, resulting in oedema. Oedema is aggravated by a fall in serum albumin, caused both by loss in the urine and poor intake of diet. Children may suffer from renal rickets. Anaemia is usually present.

The final stage renal failure is uraemia. The symptoms are convulsions, vomiting, diarrhoea and coma.

□ Clinical Symptoms

Usual symptoms are anaemia, loss of weight and hypertension. Sometimes aches and pain in bones and joints occur. Later, signs of progressive illness include skin, oral and gastro-intestinal bleeding caused by increased capillary fragility. There may be ulceration of the mouth and foetid breath. Resistance to infection is decreased.

Haemodialysis is required to be done at regular intervals in cases of chronic renal failure.

□ Modification of Diet in Uraemia

Because uraemia is seen in advanced renal insufficiency, the diet must take into account not only the protein content but also the acid-base balance and fluid and electrolyte balance, too.

However, in the world of modern scientific inventions, haemodialysis has proved to be a boon. In this technique, the blood of the patient circulates outside the body through coils or sheets of semi-permeable membrane that are constantly bathed by a hypotonic dialyzing fluid so that the nitrogenous wastes are removed into the dialysate. The membranes do not allow bacteria to enter the blood nor can proteins from the blood enter the dialyzing fluid. Yet, some amino acids are lost into the dialysate.

This process is repeated at least twice or thrice for a few hours every week. The dietary modification must take into account the following considerations:

- (a) to provide adequate calories;
- (b) to regulate the protein content of the diet;
- (c) to provide sufficient sodium, potassium and fluid intake; and
- (d) to restrict phosphate and supplement the diet with calcium, iron, trace minerals, ascorbic acid and the B-complex vitamins.

1. Energy Calorie content should be adequate in order to prevent tissue loss and also for protein build-up. About 2,000 to 3,000 kcals per day are sufficient. Sago porridge, rice porridge, sago *khichdi*, sago *vada*, ice-cream, *rasgulla*, and *gulabjamun* may be used in the diet.

2. Protein Patients on haemodialysis should be given good-quality protein of one gram per kg body weight. Eggs and milk powder having a high biological value should fulfil at least 75% of the total protein demands. Patients who are not being haemodialyzed show better nitrogen balance with 0.6 g protein per kg body weight.

3. Carbohydrates and Fat The PUFA should be stressed upon. The ratio of PUFA to saturated fats in the diet should be 1:1 or more. Carbohydrates should satisfy not more than 60% of the total calorie requirements and cholesterol should be restricted to 150 to 200 mg or less per day.

4. Potassium In chronic uraemia, hyperkalaemia is found. For a non-dialyzed patient, potassium intake is limited to 1,500–2,000 mg. A dialyzed patient may be given up to 2,500 mg potassium. All animal proteins are rich in potassium and, hence, must be used judiciously. Also refer Appendix for Foods rich in potassium.

5. Sodium The dietary sodium may be restricted depending on its level in urine and serum restriction of sodium is necessary due to swelling, hypertension and risk of congestive heart failure. Generally, an intake between one to two gram is allowed.

6. Other Minerals Phosphorus may be restricted to 600 to 750 mg per day. Supplements of calcium about 1.5 to 2.0 g per day and that of vitamin D 300,000 to 600,000 IU may be given twice weekly to prevent hyperparathyroidism.

7. Fluids A strict control of the fluid intake is necessary in order to prevent excess retention in the body. Patients not being dialyzed can take 400–600 ml fluids per day, while dialyzed patients can take a little less than one litre per day. Patients requiring dialysis may gain weight up to one pound per day, which is normal. It is attributed to water retention in the body. This excess weight is taken care of by dialysis. Table 11.4 shows a sample menu advised to a patient suffering from uraemia (chronic renal failure).

Table 11.4 Diet in chronic renal failure (2000 kcals; 30.0–40.0 g protein; 500 mg sodium)

Food Exchange List				
Exchange	No. of exchanges	Protein (g)	Sodium (mg)	Calories
1. Milk	1	5.0	20.0	100
2. Legume and Pulse	1	6.0	10.0	100
3. Flesh food	1/2	5.0	—	50
4. Vegetable A	2	—	35.0	—
5. Vegetable B	3	—	20.0	150
6. Fruit	2	—	20.0	100
7. Cereals	8	16.0	20.0	800
8. Fats	4	—	—	400
9. Sugar	50 g	—	—	200
		32.0	125.0	1900

Menu Plan					
<i>Breakfast</i>	:	1 potato <i>parantha</i> 1 cup tea 1 banana	<i>Tea</i>	:	1 cup tea 3/4 cup <i>rawa upma</i>
<i>Lunch</i>	:	3 <i>phulkas</i> 1 cup <i>palak</i> curry 1 cup medium thick <i>dal</i> 1/2 cup rice	<i>Dinner</i>	:	4 <i>phulkas</i> 1 cup cabbage curry 1 cup egg curry (containing 1 egg) 1 cup rice 1 orange/sweetlime

* All preparations should be made with minimum salt. No salt should be served at the table.

11.6 DIALYSIS

This modern artificial technique has proved a boon to patients suffering from acute and chronic renal failure. Haemodialysis and peritoneal dialysis enable patients with essentially little or no renal function, to live for many years. The symptoms that an end stage renal patient exhibit are fluid overload, hyperkalemia and severe acidosis.

Dialysis may be employed on a daily basis or two to three times a week, depending upon the amount of toxic waste product accumulating in the blood. Dialysis cannot replace the healthy and normal function of kidneys but it allows patients to avoid the life threatening features of uraemia. Dialysis does not help to relieve all the symptoms of chronic renal failure and the patient must continue to observe dietary and fluid restrictions.

The principles of dialysis are the same for both haemodialysis and peritoneal dialysis. A semi-permeable membrane acts as a filter, which separates the blood from the dialyzate compartment. Diffusion of solutes across the dialyzer membrane results in the removal of uraemic toxins from the blood compartment while retaining high molecular weight substance such as proteins. Excess electrolytes and urea from the blood are diffused out. Either acetate or bicarbonate is used in the dialysate to correct acidosis. Water is removed by ultra filtration, which is achieved in haemodialysis by generating hydrostatic pressure across the dialysate membrane and in peritoneal dialysis by osmosis using various concentrations of glucose in the dialysate fluid.

□ Continuous Ambulatory Peritoneal Dialysis (CAPD)

Peritoneal dialysis is an intra-corporeal dialysis where the heart acts as a blood pump and Peritoneum and Intra-abdominal segment with mulneum act as dialyzer. The total surface area of peritoneum is approximately the surface area of adult skin and blood supply is 60–70 ml/min.

Necessary elements for CAPD are a healthy peritoneal cavity lined by a functional membrane, an indwelling catheter placed in the peritoneal cavity and dialysis fluid with a delivery system.

Advantages

1. It can be carried out by the patient in his own home. Dialysis exchanges can be modified according to the patient's lifestyle.
2. It may be necessary to transport the patient to hospital only for clinic or emergency visit. The dialysis fluid can be delivered at home with prior notice.
3. It is easy to establish access and the patient has freedom from mechanical equipment.
4. It shows better preservation of residual renal function than haemodialysis.
5. Compared to haemodialysis there are fewer dietary and fluid restrictions. Hence, there is a decreased incidence of anaemia and better control of hypertension.
6. Avoidance of needle prick and systemic heparinization. Chances of hepatitis B and C are less.
7. Exit site infection—rarely serious. Peritonitis usually resolves after catheter removal and is rarely fatal.
8. Safer for patients with poor cardiac function and severe ischaemic heart disease.

Complications These can be infectious and non-infectious. Infectious complications include peritonitis, tunnel infection and exit site infection.

Table 11.5 Composition of peritoneal dialysis fluid

<i>Electrolytes</i>	<i>Standard solution (mmol/L)</i>
Sodium	132
Potassium	0
Magnesium	0.5, 1.5
Lactate	35–40
Glucose (g/dl)	1.5, 2.5, 3.5, 4.25
pH	5.2–5.5

□ Dietary Management

Due to technical advances in dialysis, dietary restrictions have become less severe and the patient's life has improved substantially.

1. Protein Since dialysis is a catabolic process releasing catabolic hormones like glucagon, glucocorticoids and adrenalin, an adequate protein intake is essential. There is loss of as much as 7 g of amino acids and 2–3 g of peptides into the dialysate. An intake of 1 to 1.2 of proteins per kg IBW is recommended of which at least 70 percent must come from animal protein because the loss of essential amino acids in the dialysate is proportional to the plasma concentration and not limited by adapted and restricted catabolism. In case of anorexic or elderly patients, it may be necessary to use protein supplements.

2. Carbohydrates Adequate carbohydrates must be taken to fulfill energy requirements. The diet must consist of high fibre, low fat and low sugar in order to limit the risk of hyperlipidaemia.

3. Energy Intake Weight loss in obese patients may be achieved by carefully restricting their energy intake to a level of 500 kcal below their current needs. Generally, an intake of 35 kcal per kg per day is recommended. Underweight patients may need energy supplements.

4. Electrolytes The aim after dialysis should be to maintain serum potassium level within limits (3.5 to 4.9 mmol per litre) with sufficiently frequent and effective dialysis to limit pre-dialysis potassium to less than 5.5 mmol per litre. Hence, an intake of 30–60 mmol of K is recommended. It is necessary to consider other factors like constipation, K content of the dialysis fluid, acidosis, infection, tissue damage and medicines being used.

Potassium intake can be reduced by reducing the intake of all fruit and vegetables to one or two servings. Boiling vegetables and potatoes in a large volume of water for about half an hour and then using them after discarding the water, can achieve a further reduction in potassium.

Intake of phosphate may be restricted to about 0.8 to 1.1 g per day by reducing the intake of phosphate-rich food like cheddar cheese, eggs, milk, animal foods especially organ meats, whole wheat flour, all types of nuts, malted milk drinks,

drinking chocolate, cocoa and its products, yeast extracts, baking powder, etc. Sometimes oral phosphate binders may be taken.

Sodium restriction of 80 to 100 mmol per day is normal. Salt intake (NaCl) must be restricted since it causes excessive thirst and it may be difficult for the patient to control his fluid intake. Also, hypertension may be controlled by restricting the salt intake.

5. Fluids Generally, the urinary output diminishes the longer a patient remains in dialysis. The patient must be educated about this fact at the time of dialysis. Roughly, about 500 ml of fluid in addition to that equivalent to urine output is allowed. Accumulation of fluid is measured by weighing the patient between dialysis. (1 kg weight = 1 litre of body water.) A maximum of 2 kg may be gained between dialyses. Patients must be taught to measure their urinary volume as well as keep their own fluid charts.

6. Vitamins Dialysis patients require supplementation with the B-complex group of vitamins and vitamin C since several of them are lost due to prolonged cooking methods (to remove potassium) and dialysis itself. B-complex vitamins, vitamin C and Folic acid are generally prescribed. Vitamin A, which is bound to retinal, is a high molecular weight protein and not dialyzable; hence, no vitamin A supplementation is required. Iron supplements may be given to makeup for blood losses during haemodialysis. Vitamin D supplementation may also be done.

□ Clinical and Metabolic Disorders in Dialysis

These include:

1. A type of hyperlipidaemia and other disorders of lipid metabolism
2. A high incidence of CV disease particularly IHD
3. Osteodystrophy with disordered bone architecture, osteoporosis or osteomalacia
4. Anaemia
5. Impaired immune function and decreased resistance to infection
6. Mildly impaired peripheral and CNS function
7. Muscle weakness and atrophy
8. Frequent occurrence of viral hepatitis
9. Sexual impotence and infertility
10. Generalized wasting and malnutrition
11. A general feeling of bad health or emotional depression
12. Poor rehabilitation

These complications can be improved with good nutrition.

11.7 RENAL TRANSPLANTATION

Kidney transplant is the optimum treatment for end-stage renal failure. The kidney may be obtained from a cadaver or a living relative (donor). It is of importance that the donor and recipient's blood groups are compatible. Besides, there are a battery of tests which are conducted to determine the compatibility of the transplant.

After the transplant operation is carried out successfully, the patient is given immunosuppressive drugs like prednisolone, azathioprine and cyclosporin A. These drugs produce a number of undesirable side effects like leucopenia, susceptibility to infection, weight gain, renal dysfunction, hypertension, osteoporosis and hyperlipidaemia. A renal transplant patient requires regular follow-ups. There may be episodes of transplant rejection, which require treatment with high doses of steroids or monoclonal antibodies. Sometimes there may be irreversible rejection which may lead to the patient requiring dialysis again.

Hence, the patient who has undergone renal transplant is a unique medical and nutritional challenge to the nutritionist.

□ Dietary Management

The patient needs to be encouraged to increase his nutritional intake. If excessive weight gain is seen, he may be advised to eat a diet low in fat and sugar and high in non-starch polysaccharides, so that he may maintain his Ideal Body Weight (IBW).

Since, hyperlipidaemia may be seen in these patients, lipid-lowering drugs may be prescribed. In case of hypertensive patients, the sodium intake may be lowered.

11.8 URINARY CALCULI OR KIDNEY STONES

Kidney stones may be found in the kidney itself, ureter, bladder or the urethra. They are made up of an organic matrix into which crystals of various sizes are interspersed.

Different chemical types of calculi occur under different circumstances. Uric acid and urate calculi reflect excessive metabolic production of these substances and appear particularly when the person suffers from gout. Calcium oxalate calculi commonly occur if there are excessive oxalates in the diet, mainly derived from fruits and vegetables. Crystalline calcium carbonate and phosphate stones may occur when a hyperactive parathyroid gland increases the excretion of calcium, when too much milk is consumed, or when alkalosis decreases the solubility of calcium salts. Amorphous carbonates and triple phosphates are characteristically found in calculi as a result of infection and stasis. Small calculi may be composed of a single component, while large calculi are usually of a mixed composition.

Most calculi pass out of the body via the ureter, bladder and urethra. Those which are not passed may require surgical treatment or else the obstruction and infection permanently damage the kidney.

Most of the stones contain calcium in large amounts. Many stones are generally a mixture of calcium oxalate and magnesium ammonium sulphate. Other types of stones that may be found are those of uric acid and xanthine. A unique type of stone that may be found is purely that of cystine and it is due to a hereditary metabolic defect in the renal tubular reabsorption of cystine. Uric acid stones may be caused due to increased excretion of purines as in gout.

Dietary correlation to formation of kidney stones is very difficult to establish. They occur mostly due to some disease such as hyperparathyroidism, osteoporosis, gastro-intestinal disorders, milk therapy in peptic ulcer for a long time and urinary tract infections, or there may be an excessive excretion of calcium thereby facilitating the formation of a stone.

Sometimes persons exposed to hot temperatures or hot climates for several days may suffer from concentration of urine. So also, if the nature of the urine shifts to a more acid or alkaline state it may cause the formation of a kidney stone. Continuous intake of acidic or alkaline medicines may precipitate stone formation.

Foods that produce minerals which are acidic or alkaline in nature are listed out in Chapter 3. This list is useful in the treatment of the patient who is prescribed an acid or alkaline mineral diet.

□ Clinical Symptoms

Acute and severe pain and other urinary symptoms may result. The person may feel exhausted, sometimes symptoms may be accompanied by fever.

□ Modification of Diet in Urinary Calculi

Diet alone cannot dissolve the stone, but if some factors in the diet have predisposed the formation of the stone, these factors can be completely taken care of by diet adjustment. However, the nature of the stone must be determined first.

1. Fluid Intake It should be increased as much as possible depending on the tolerance of the patient, since it helps dilute the urine which discourages the concentration of the constituents of the stone. An intake of about three litres of fluids or more per day is generally advised.

2. Diet It may involve restriction of the mineral which is the main component of the stone. Minerals that may be restricted are:

(a) *Calcium Restriction*— This mineral may be restricted along with oxalate. Calcium may be permitted to be consumed up to 400–600 mg per day. Phosphorus may be consumed about two grams per day, since it is found to inhibit the growth of crystals. Generally, foods rich in calcium are also rich in phosphorus with the exception of meat, which contains less calcium but is very rich in phosphorus.

(b) *Oxalate Restriction*— All foods which contain large amounts of oxalates should be avoided if the stone is a calcium-oxalate stone. Foods rich in calcium, phosphorus and oxalate are listed out in Table 11.6.

Table 11.6 Foods rich in calcium, phosphorus and oxalates

Rich Sources of Calcium

1. Almost all green leafy vegetables especially, cauliflower greens (626 mg%), colocasia leaves (black variety 460 mg%) knol-khol greens (740 mg%), amaranth (200 mg%), and omum (celery leaves) (230 mg%)
2. Most dry fruits
3. All kinds of fish
4. Mutton muscle
5. Milk
6. Curds
7. *Chainna* (cottage cheese)
8. Cheese

(Contd.)

(Contd.)

9. *Khoa*
10. Milk powder

Rich Sources of Phosphorus

<i>Phosphorus content</i>	<i>Foods</i>
1. More than 100 but less than 150 mg%	Rice (parboiled, milled, puffed), double beans, green peas, colocasia leaves, cauliflower greens, drumsticks, cow's milk, buffalo's milk, <i>chainna</i> made from cow's milk.
2. More than 150 but less than 200 mg%	Rice (raw, milled), beef muscle, buffalo meat, mutton muscle and pork.
3. More than 200 but less than 250 mg%	Barley and <i>jowar</i>
	Rice flakes, <i>samai</i> , moth beans (<i>matki</i>)
4. More than 250 but less than 300 mg%.	<i>Bajra</i> , <i>ragi</i> , <i>papad</i> , rice (hand-milled) <i>chainna</i> made from buffalo's milk.
5. More than 300 but less than 450 mg%.	Dry maize (corn), oat meal, whole wheat and flour, all pulses and legumes (except <i>moth</i> beans), poppy seeds, <i>khoa</i> and liver.
6. Very rich sources	Milk powder (700–1000 mg%), cheese, carrot (500–550 mg%), nuts, oil-seeds (up to 750 mg%) and fish.

Rich Sources of Oxalic Acid

Horsegram, <i>kesari dal</i> , tender amaranth, curry leaves, drumstick leaves, gogu (<i>pitva or ambadi</i>), mustard leaves, <i>neem</i> leaves, palak (spinach) tamarind leaves (tender), dry lotus stem colocasia leaves, <i>paan</i>	Plantain flower, green plantain, rhubarb stalk, almonds, cashewnuts, garden-cress seeds, gingelly seeds, <i>amla</i> , <i>phalsa</i> , wood apple, ripe chillies, cocoa and tea.
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SUMMARY

Kidney is one of the most important organs of the body. It maintains water balance, electrolyte level, pH and osmotic pressure of the blood through its wonderful double filtration system, besides flushing out all the metabolic wastes, toxic substances and unwanted excess materials present in the blood.

Nephrons are the basic functional units of the kidney. Injury due to toxicants, infections, or physiological stress affects the nephron as a whole or part thereof. This results in loss of precious substances from the body through the damaged kidney and retention of toxic wastes in the body due to faulty filtration, which results in many complications. The nutritional management of kidney disorder therefore, requires recouping the loss of precious body nutrients, maintenance of normal water and electrolyte balance and selection of such dietary substances which minimize accumulation of toxic wastes in the body. All this is to reduce the excretory load on the kidney.



CASE STUDIES

- I**
- | | | |
|----------|---|---------------------|
| Sex | : | Male |
| Age | : | 40 years |
| Height | : | 5 feet 7 inches |
| Weight | : | 60 kg |
| Activity | : | sedentary lifestyle |

Clinical picture

His blood picture is (values are in mg/dl):

Haemoglobin	10.5
Creatinine	2.0
Urea Nitrogen	35.0
Uric acid	7.8
Total protein	6.9
Albumin	3.9
Serum calcium	8.7
Sodium	141
Potassium	5.1
Chloride	106

Plan a day's diet for him. Mention nutrients that need special emphasis.
Also list out do's and dont's.

- II**
- | | | |
|----------|---|---|
| Sex | : | male |
| Age | : | 76 years |
| Height | : | 5 feet 4 inches |
| Weight | : | 87 kg |
| Activity | : | sedentary |
| Symptoms | : | viral fever and is severely dehydrated. |
- Clinical picture
- | | | |
|-------------------|---|---|
| Urine output | : | Nil |
| Blood pressure | : | 200/100. |
| BUN | : | 27 mg/dl |
| Creatinine levels | : | 8.7 mg/dl |
| Diagnosis | : | acute renal failure |
| Other symptoms | : | unable to eat since he feels nauseated |
| Treatment | : | intravenous oral fluids and undergoing dialysis |

1. What will be your strategy to improve his fluid and diet intake?
2. Which foods will you recommend for more consumption?
3. Which foods will you ask him to avoid?

*For the solution, just scan the QR code given here
OR visit <http://qrcode.flipick.com/index.php/237>.*



*Also check out the MCQ's related to this case in the next
QR code OR visit <http://qrcode.flipick.com/index.php/308>.*



REVIEW QUESTIONS

1. Which part of the kidney is known as the ultrafiltration unit?
2. Name five blood and urine constituents which are impaired in renal disease.
3. What are the dietary modifications in acute glomerulonephritis? In case of which nutrients do they differ from chronic glomerulonephritis.
4. Which renal diseases lead to chronic renal failure?
5. Which principles must be taken into consideration when planning a diet during uraemia?
6. What is dialysis? Describe the process briefly and identify the problems in dialysis. Visit the nearest hospital to observe the process.
7. What is a kidney transplant? Outline the effects of post-operative maintenance drugs advised for a patient of kidney transplant.
8. Plan a diet for a patient of renal calculi whose diet must be restricted in calcium content.
9. What is a kidney stone? What are the constituents of kidney stones? Describe the correlation between kidney stone and dietary components.

Chapter

12



Diet for Gastrointestinal Diseases (Stomach and Intestines)

Different organs constitute our digestive system. The stomach is an enlargement of the alimentary canal and it can hold as much as two litres of food at a time. In the digestive juices along with water, hydrochloric acid and pepsin are present. (For details see Chapter 2.) The process of digestion continues in the small intestines by the action of a number of other digestive enzymes and bile.

When a disease affects any organ of the digestive tract, the diet modifications prescribed are always related to promoting reversal of the affected organs to normal physiological operation.

We commonly hear about hyperacidity (generally referred to as only acidity), ulcers, gastritis, colitis, diarrhoea, dysentery, amoebiasis, hepatitis, cirrhosis of liver, constipation, etc. some of which are discussed in this chapter.

12.1 CLASSIFICATION OF DISEASES OF THE GASTRO-INTESTINAL TRACT

Diseases of the gastro-intestinal tract may be classified as:

- 1. Functional**
- 2. Organic**

Functional diseases are those disturbances that do not involve any alterations in the structure of the organs but do so in its efficiency.

Organic disturbances are those where pathologic lesions are seen as in cirrhosis of the liver, ulcers or in carcinoma.

Both types of diseases affect the secretory activity as well as motility and other physiological functions.

Some of the terms related to motility and gastric acidity are given in the Glossary. These terms are used very often in the following discussion.

12.2 INDIGESTION OR DYSPEPSIA

It may be either a functional disease or an organic one.

□ Symptoms

Heartburn, acid regurgitation, a feeling of uncomfortable fullness or bloating, especially after meals, flatulence, nausea or vomiting are some symptoms of indigestion.

□ Treatment

If the cause is functional such as unhealthy dietary habits or due to emotional stress, then individual diet counselling is required. The person has to be made to understand the importance of a balanced diet, regular meal times, sufficient time to eat in a relaxed atmosphere, proper chewing (mastication), rest after meals and avoidance of emotional tension.

If the cause is due to diseases that are affecting the digestive organs, then treating the underlying disease or diseases may alleviate the symptoms of dyspepsia.

12.3 PEPTIC ULCER

□ Etiology

Peptic ulcers are defects in the gastric or duodenal mucosa that extend through the muscularis mucosa. The epithelial cells of the stomach and duodenum secrete mucus, which is impermeable to acid and pepsin. Other gastric and duodenal cells secrete bicarbonate, which aids in buffering acid that lies near the mucosa. Prostaglandins of the E type (PGE) increases the production of both bicarbonate and the mucous layer. A balance must occur between gastric acid secretion and gastroduodenal mucosal defense. Aggressive factors, such as NSAIDs, H pylori infection, alcohol, bile salts, acid, and pepsin, can alter the mucosal defensive mechanisms such as tight intercellular junctions, mucus, mucosal blood flow, cellular restitution, and epithelial renewal.

The gram-negative spirochete *Helicobacter pylori* was first linked to gastritis in 1983 and is now well established as a causative agent of PUD in adults and children. In patients infected with *H. pylori*, high levels of gastrin and pepsinogen and reduced levels of somatostatin are found. Now *H. pylori* has been identified as a major part of the triad, which includes acid and pepsin, that contributes to primary peptic ulcer disease. This organism produces urease which allows it to alkalinize its microenvironment and survive for years in the hostile acidic environment of the stomach, where it causes mucosal inflammation and, in some individuals, worsens the severity of peptic ulcer disease. In infected patients, exposure of the duodenum to acid is increased. Virulence factors produced by *H. pylori*, include urease, catalase, vacuolating cytotoxin, and lipopolysaccharide.

PUD is commonly known as a disease of “*Hurry, Worry & Curry*”..

□ Symptoms

Gastric and duodenal ulcers usually cannot be easily differentiated since epigastric pain is the most common symptom of both. It is characterized by a gnawing or burning sensation and occurs after meals—classically, shortly after meals with gastric ulcer and 2-3 hours later in case of duodenal ulcer.

“Alarm features” include bleeding, anemia, early satiety, unexplained weight loss, progressive difficulty in swallowing, recurrent vomiting, and family history of gastro intestinal cancer. Patients with perforated Peptic Ulcer Disease (PUD) usually experience a sudden onset of severe, sharp abdominal pain.

Most patients with PUD are treated successfully with cure of H pylori infection and/or avoidance of nonsteroidal anti-inflammatory drugs (NSAIDs), along with the appropriate use of antisecretory therapy.

It has been seen that patients with gastric ulcers are also at risk of developing gastric malignancy.

□ Management of Peptic Ulcer

Although, gastric acid does not play a primary causal role in the development of most cases of peptic ulcer disease, inhibition of gastric acid secretion has been found to be therapeutic. Avoidance of secretagogues such as spices, tea, coffee, and alcohol are not of much help in healing ulcers. But alcoholic beverages like beer and wine even in modest amounts do induce near maximal gastric acid secretion without providing any significant buffering capacity. Dietary fibre does play a significant role in the prevention of recurrence of peptic ulcer disease since recurrence of peptic ulcer in patients on a low fibre diet is higher than those on a high-fibre diet.

Two surgical procedures, are performed, namely truncal vagotomy and piloroplasty, and truncal vagotomy and antrectomy. The procedures are aimed at reducing the stimulation for gastric acid secretion, thereby relieving the patient of the symptoms commonly associated with peptic ulcers. However, since, both these surgical procedures result in rapid entry of liquids, or liquids and solids into the intestine, patients suffer from “ Dumping Syndrome”, which is characterized by abdominal distension and pain. Diarrhoea results mainly from the inability of the intestine to deal with the sudden load of volume and osmoles. Early symptoms may be weakness, tachycardia, and palpitations. Late phase may be characterized by hypoglycaemia.

The diet should be aimed at avoiding “Dumping Syndrome”, i.e. avoiding sudden entry of large volumes of solids and liquids into the proximal intestine. It is advisable to have frequent small meals—avoid drinking liquid with meals, eating food which is low in osmolality; therefore, simple sugars must be avoided. Supplementation with calcium and iron is required to avoid deficiency.

□ Treatment of Peptic Ulcers

1. Drugs Drugs such as anticholinergic drugs, i.e. those which decrease the acid secretion in the stomach may be given by the physician. Other types of drugs that may be given are antacids and antispasmodics.

2. Rest As far as importance of this aspect in treatment of peptic ulcers is concerned, not only physical rest but also mental rest is important for the patient. Complete relaxation of the mind and body and control of emotional stress helps the patient a great deal. In this respect, *yogasanas*, practised correctly and regularly, are claimed to have a profound effect in gaining control over the mind and emotions.

3. Diet The diet ideally advised in case of a peptic ulcer patient is a bland and fibre-restricted diet. The main objective is to avoid mechanical, chemical and thermal irritation. Peptic ulcer has four stages, progressively acute to mild with treatment.

Stage I is the acute stage in which the patient suffers tremendous pain. Milk in this stage brings a lot of relief because of the excellent buffering action of milk proteins; hence, it is specially recommended. All liquids which encourage neutralization of the acid formed are advised. All fibre-containing foods are restricted, such as leafy vegetables, fruits with skin, seeds and whole-grain cereal flours. One can take 50–60 grams of milk and cream mixture once in every hour. The total feeding per hour must be about 100 grams. As pain subsides, small feedings of easily-digested foods such as soft-cooked egg, custards or simple puddings, toast, crackers and tender cooked fruits and vegetables may be given. A gradual progression in the amount as well as type of food is made as the patient's condition improves.

Stage II In this stage, six to eight feedings per day may be given. Milk, either plain or with cream, should be given. All milk products are also permitted.

Mechanically irritating foods such as those containing high amounts of plant fibres like green leafy vegetables, fruits, nuts, oilseeds and gas-forming vegetables such as cauliflower and cabbage should be avoided.

Thermally irritating foods such as those which are either too hot or too cold should also be avoided. They irritate the lesion by their effect on the surface blood vessels near the ulcer. Hence, all iced beverages, frozen desserts, soups and hot beverages are to be avoided.

Chemical irritation can be eliminated by excluding all types of foods which stimulate the flow of gastric juices, such as tea, coffee, broths, clear soups, gravies, highly seasoned, fried or spiced foods.

Stage III In this stage, the total amount per feeding may be increased. About six feedings per day should normally be sufficient. More liberalization towards a normal diet may be done in this stage.

Stage IV The total amount per feeding may be as in Stage III. Gradual introduction of well cooked and mashed pulses, whole-wheat flour may be done.

Foods that should be avoided and included when planning a diet for a peptic ulcer patients are given in Table 12.1.

A typical day's diet for a peptic ulcer patient in Stages II and III (moderate to mild) may be planned on the following guidelines (see Table 12.2) to provide adequate nutrients.

12.4 DIARRHOEA

In India, majority of the gastro-intestinal diseases are water-borne. Children in particular are prone to diseases such as jaundice, cholera and typhoid. One of the most common and dangerous ailments which small children suffer from is diarrhoea, which frequently causes dehydration through the passage of loose watery stools; in other words, it is a morbid evacuation of the bowels, the stools being fluid in nature, with increased frequency. The number of stools varies from several per day to one every few minutes. It often accompanies conditions such as ulcerative colitis, various infections of the bowel and most forms of gastro-enteritis.

The colon normally receives 400–500 ml of undigested material daily from the small intestine. From this it usually produces 350 g faeces per day. Of this, 70% is

Table 12.1 Foods allowed and avoided in peptic ulcers

<i>Foods allowed</i>	<i>Foods avoided</i>
Beverages—all milk beverages, weak tea	Alcohol, carbonated drinks, coffee and strong tea
Cereals—Bread, rice, refined cereals like <i>maida</i> , double-sieved flour, puffed rice, etc.	Whole—grain bread, <i>chapatis</i> , etc.
Eggs—anyway except fried	Fried eggs
Fats—in moderate amount	All fried, spiced and preparations containing chillies
Emulsified fats like butter are preferred	
Fruits—preferably canned or cooked.	Raw fruits
Banana can be peeled and consumed as such	
Meat, fish and poultry—lean, tender, boiled, baked, stewed or minced	All fatty meats, salted, smoked or fried or skewered
Pulses—well cooked and mashed, especially <i>mung dal</i> preferred (without skin)	Legumes with skin on (such as <i>mung, chana, tuvar masur</i>)
Milk—permitted in any form	Nuts—all
Sweetmeats—in moderate amounts	All sweets containing rich amounts of chocolate, nuts and sugar
Vegetables—gourds, brinjals, potatoes, lady's fingers, etc.	All strongly-flavoured vegetables such as cabbage, cauliflower and peas.

water. The faeces component plays a minor role in terms of water loss in a normal situation. In diarrhoea, the water and electrolyte loss comes from the small intestine. The small intestine receives more than ten litres of water per day, secreted by the various organs such as stomach, liver, pancreas, and the intestine itself. If this water is either not absorbed or if excess is secreted by these organs, then it is fast sent to the colon whose water-holding capacity is limited. Thus, the urge to defecate comes often in diarrhoea.

□ Causes

Overeating or eating foods difficult to digest, infection in intestinal tract, fermentation caused by incomplete carbohydrate digestion, nervous irritability and excess intake of laxatives are some causes. Other causes are parasites, bacteria, or toxins through food and water. Allergies to certain substances or foods such as milk, wheat, eggs and sea foods, emotional strain or stress in adults and fright in children; antibiotics and some drugs can cause diarrhoea.

Diarrhoea occurs as a symptom of some functional or organic disease. It may be acute or chronic in nature.

1. Acute Diarrhoea This is characterized by the sudden onset of frequent stools of watery consistency accompanied by abdominal pain, cramps, weakness and sometimes fever and vomiting. Acute diarrhoea may also be due to some infection such as gastro-enteritis or ulcerative colitis.

Table 12.2 Diet in peptic ulcer (stages II and III)

Food Exchange List				
	<i>Exchange</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Energy (kcals)</i>
1.	Milk	4	20.0	400
2.	Legumes and pulse	2	12.0	200
3.	Flesh food	1/2	5.0	50
4.	Vegetable A	2	—	—
5.	Vegetable B	2	—	100
6.	Fruit	2	—	100
7.	Cereals	8	16.0	800
8.	Fats	4	—	400
9.	Sugar	25 g	—	100
			53.0	2150

Menu Plan				
<i>Tea</i>	:	1 cup light tea	<i>Afternoon</i>	:
<i>Breakfast</i>	:	2 slices of bread with butter		2 biscuits
		1 glass plain milk	<i>Late evening</i>	:
		1 poached/boiled egg	<i>Dinner</i>	:
<i>Lunch</i>	:	2 <i>phulkas</i> or 1 <i>chapati</i> 1/2 cup rice 1 cup <i>mung dal</i>		1 cup <i>masur dal</i>
		1 cup <i>dudhi</i> potato curry	<i>Bedtime</i>	:
		1/2 cup curds		1 cup pumpkin curry 1 bowl rice porridge
				: 1 glass apple or <i>chiku</i> milk-shake

2. Chronic Diarrhoea Diarrhoea can be termed chronic when it persists for two weeks or sometimes even longer. The food is passed very rapidly through the small intestine thereby not allowing any time for the nutrients to be absorbed. This results in nutritional deficiencies.

Dehydration is one of the most common and dangerous outcome of diarrhoea, whether acute or chronic. Dehydration, especially in infants, can set in very suddenly. These water and electrolyte losses can be fatal and, hence, must be restored immediately.

□ Symptoms of Dehydration

Severe thirst, very little output of urine, drying up of the mouth, loss of skin-elasticity.

□ Treatment

An effective preventive measure would be to start Oral Rehydration Therapy (ORT). Oral rehydration therapy based on the administration of correct oral fluids while allowing food intake, provides a balanced water and electrolyte replacement at low cost and saves lives.

It can be administered not only in hospitals, health centres, health stations or clinics but also by community-based health workers and by mothers and relatives, with some guidance. Rehydration with fluids improves appetite, allowing better feeding and continued weight gain.

The WHO/UNICEF recommended formula of the oral rehydration powder is as follows:

Sodium chloride	3.5 g
Sodium bicarbonate	2.5 g
Potassium chloride	1.5 g
Glucose	20.0 g
Water	one litre

At the first sign of diarrhoea, a simple formula can be made at home (see Table 12.3).

Table 12.3 Oral rehydration formula for prevention and cure of dehydration*

In one litre boiled and cooled water mixed with 20 g glucose or 40 g sugar

OR

In one litre of water, add 50 g (or 2 heaped tablespoons) rice powder and boil for 4–5 minutes.

ADD

Sodium chloride—3.5 g (or 1/2 teaspoon common salt)

Sodium bicarbonate—2.5 g (or 1/2 teaspoon soda-bicarb)

Potassium chloride—1.5 g (or a little lemon juice)

Give at least 4–6 glasses per day. The rice formula can be kept at room temperature for 5–6 hours and in a refrigerator for 24 hours.

* Copied from the booklet *Dehydration During Diarrhoea*, published by Glindia (Glaxo Laboratories India Ltd).

After the patient stabilizes, he can be given water, coconut water, tea, buttermilk, and rice water (prepared by cooking rice in a lot of water and draining the water to which salt is added to taste). If the patient is able to eat, he can be given ripe bananas, soft-cooked rice, curds, bread, mashed potatoes and arrowroot biscuits. Breast feeding of the infant should be continued throughout.

In adults or in infants, no drugs should be used to arrest diarrhoea because they relieve the symptoms only temporarily. On the contrary they hamper the bowels protective function to rid the body of harmful contents. However, the infection that has caused the diarrhoea must be treated with appropriate drugs. Adequate supply of fluids containing electrolytes is vital. Juices of pomegranate, orange, buttermilk or coconut water, barley water with milk and sugar can be given.

Certain natural remedies have been found to be effective. They are carrot soup, banana, peeled apple, turmeric powder, cultured milk/sour milk (curd/butter milk) and garlic. Carrot soup supplies water to combat dehydration, replenishes sodium, potassium, phosphorus, calcium, sulphur and magnesium, supplies some pectin and coats the intestine to allay inflammation. It can be prepared by cooking 1/2 kg carrots with about 150 ml water until soft. It is then strained through a sieve and the resulting pulp mixed with boiled water to make one quarter. About

3/4 tbsp salt may be added. Bananas contain pectin and encourage the growth of beneficial bacteria. Acidified milk (*dahi* or curd) overcomes intestinal flora and re-establishes the normal, benign flora. Acid in the soured milk also fights bacteria. Garlic kills parasites. It is a powerful, effective and harmless antibiotic and aids digestion.

Substances like pectin and kaolin bind stools but they have very little therapeutic value in severe infant diarrhoea.

□ Chronic Diarrhoea

Diarrhoea that persists beyond two weeks in particular is nutritionally disturbing since it causes significant nutritional deficiencies. Diet modification in such diarrhoea depends upon the nature of the underlying defect. Treatment of this defect, along with an adequate intake of fluids and electrolytes, as in acute diarrhoea, normally helps. Gradual progression from liquid to a soft diet can be done as severity of diarrhoea decreases and appetite increases.

If diarrhoea in the chronic state is due to functional or organic defect, such patients are unable to tolerate foods rich in fat, fibre and milk, which are best avoided.

Generally, a soft diet, rich in protein and calories, with liberal amounts of vitamins and minerals and large amounts of fluids is recommended.

Table 12.4 shows the diet recommended for a chronic diarrhoea patient.

Table 12.4 Diet in chronic diarrhoea (calories—2000; protein—50–60 g)

Food Exchange List				
	<i>Exchange</i>	No. of exchanges	Protein (g)	Calories
1.	Milk	3	15.0	300
2.	Legume and pulse	3	18.0	300
3.	Flesh food	—	—	—
4.	Vegetable A*	2	—	—
5.	Vegetable B*	2	—	100
6.	Fruit	2	—	100
7.	Cereals	8	16.0	800
8.	Fats	3	—	300
9.	Sugar	40 gm	—	160
			49.0	2060

Menu Plan

<i>Tea</i>	: 1 cup	<i>Afternoon</i>	: 1 glass orange juice/
<i>Breakfast</i>	: 1 cup tea/coffee		coconut water
	1 slice bread with butter		1/2 cup <i>suji upma</i>
	1 banana or peeled apple	<i>Dinner</i>	: 2 <i>phulkas</i> or <i>chapati</i>
<i>Lunch</i>	: 2 <i>phulkas</i> or 1 <i>chapati</i>		1 and 1/2 cup rice and
	1 cup rice		<i>mung dal khichdi</i>
	1 cup <i>dal</i> (<i>tur/mung/masur</i>)		1 cup red pumpkin
	1 cup <i>dudhi</i> curry		curry
	1 cup curd		1 cup curd

* Vegetables such as *dudhi*, potato, red pumpkin can be used. Omit green leafy vegetables and other vegetables containing excessive fibre. These can be soft-cooked and pureed and then used.

12.5 CONSTIPATION

Constipation has been described in terms of both the character and frequency of stool. Normal bowel frequency ranges between three bowel movements per day to one movement every three days. A constipated stool is hard, dry, and difficult to pass. Many symptoms are attributed to constipation, such as headache, malaise (a general feeling of illness), bad taste in the mouth, foul breath and coated tongue.

Constipation may be acute or chronic. An acute change in bowel habits, particularly over the age of 40, is a cause for concern because it may be a symptom of a colonic neoplasm. Other acute causes are a sudden decrease in physical activity, change in diet, particularly reducing fiber, medications, and anal pain.

Fecal impaction refers to a huge accumulation of hard stool, usually in the rectum, that cannot be passed because of its size and consistency.

Megacolon is constipation carried to the extreme, with a hugely dilated and atonic colon, containing massive amounts of stool. The colon musculature is hypotonic, allowing huge fecal accumulations. Congenital megacolon, or Hirschsprung's disease, is due to an aganglionic segment of the colon destroying the normal neurologic defecatory reflex. Acquired megacolon is due to factors such as psychosis or senility.

□ Causes of Constipation

The commonest causes of constipation are:

- Decreased stool weight or bulk, usually from a lack of dietary fiber. Certain fibers, such as bran or psyllium (isabgol), are hygroscopic, increasing stool water content and weight.
- Decreased propulsive activity, usually from medication but occasionally from intrinsic muscle disease such as scleroderma, amyloid, and certain neurologic disorders.
- Medications include those with anticholinergic properties, such as the antidepressants and some antiarrhythmic drugs, the opiates, certain antacids, calcium channel blockers, and laxatives. Initially, laxatives stimulate the musculature of the bowel through irritant properties, but with repeated use induce a hypotonia that responds only to more potent irritants, ultimately resulting in an atonic colon. It can be referred to as "Laxative addiction".
- In some cases such as thrombosed hemorrhoid or anal fissure, the person may suppress the normal defecatory rectal stimulus by voluntarily contracting the external anal sphincter. Sometimes lack of proper toilet facilities especially for women may lead to constipation in the long run.
- Depression.
- Lack of exercise / little or no physical activity since exercise stimulates colonic motility. Sometimes an illness forcing bed rest, frequently leads to constipation.
- Anorexia and insomnia.
- Lack of sleep or rest
- Change in surroundings
- Irregular eating and elimination habits
- Organic diseases such as diverticulosis

□ Treatment

Chronic constipation is more common and often more difficult to remedy. Once organic causes such as hypothyroidism are ruled out, chronic constipation often falls into two categories: the older patient with a well-established laxative habit and the younger patient who is constipated because of lifestyle and is often headed toward laxative dependence. Sigmoid spasm often contributes to constipation by interfering with normal colonic motility so that colonic contents are held proximal to the sigmoid, resulting in overdesiccation or hardened stools.

Once readily diagnosable conditions (e.g., neoplasm, medication, hypothyroidism) have been excluded, functional and dietary factors must be considered. Treatment involves establishing regularity in habits of eating, sleeping (rest), exercise and elimination. A large intake of dietary fibre and plenty of fluids is recommended to correct most cases of constipation.

□ Dietary Modification

This is based on increasing the intestinal bulk by increasing the fibre content of the diet. This can be achieved by including plenty of raw green vegetables and fruits. So also, bran as found in whole-grain cereals and pulses is an immensely useful aid. All refined cereals should be substituted with their wholesome counterparts.

Additional information on a high residue diet is given at the end of this chapter.

All foods containing fat such as bacon, butter, *ghee*, cream, oils, etc. must be included since, fatty acids present in them stimulate the mucosal movements.

Castor oil or mineral oil (such as paraffin) if medically advised, must be taken long after the meals since it interferes with the absorption of fat-soluble vitamins.

A large amount of fluids in the form of liquids or high-fluid foods help in some cases. Tea and coffee may be taken but in moderation. Soups, whether clear or with cream, are nourishing and supply a good amount of electrolytes and water.

Table 12.5 shows a typical diet for a patient suffering from constipation.

12.6 ULCERATIVE COLITIS

It means inflammation and ulceration of mucosa of the large intestine (colon).

□ Symptoms and Clinical Findings

This disease is predominantly found in young adults. Initially, it may present itself as a need to defecate several times a day or diarrhoea with rectal bleeding.

Severe loss of water, electrolytes and bleeding cause weight loss, dehydration, fever, anaemia and general weakness. If necrosis of the tissue is localized without any external symptoms, the case may be severe and remedy must be given immediately.

□ Dietary Modification

This disease demands that the diet must be modified as per the individual's needs. Patients with this disease must be constantly assured and directed as to what they should eat, since they are generally very apprehensive about foods that cannot be eaten and try to avoid most foods.

Table 12.5 Diet in constipation (high residue diet with plenty of fluids)

Food Exchange List				
	Exchange	No. of exchanges	Protein (g)	Calories
1.	Milk	4	20.0	400
2.	Legume and pulse	3	18.0	300
3.	Flesh food	1/2	5.0	50
4.	Vegetable A	3	—	—
5.	Vegetable B	2	—	100
6.	Fruit	3	—	150
7.	Cereals	9	18.0	900
8.	Fat	5	—	500
9.	Sugar	30 g	—	120
			61.0	2520

Menu Plan				
<i>Tea</i>	:	1 cup	<i>Afternoon</i>	:
<i>Breakfast</i>	:	1 glass egg nog 1 medium orange/lime 2 slices of brown bread with butter		1 cup light tea 1/2 cup <i>kanda pohe</i> 1 orange/lime
<i>Lunch</i>	:	2 <i>chapatis*</i> 1 cup <i>Alu palak</i> 1 bowl tomato soup with 5 gm butter 1 cup whole <i>mung usal</i> 1/2 cup <i>dal</i> 1/2 cup rice 1 cup curds	<i>Dinner</i>	1 bowl cream of <i>palak soup</i> 1/2 cup vegetable <i>rice pulao**</i> 1 cup <i>matki/chana usal</i> 2 <i>chapatis/I bhakri</i> 1 cup cucumber <i>raita</i>
<i>Green salad</i>	:	(lettuce, radish, carrot, leeks, beet, tomato, and cucumber)	<i>Green salad</i>	:
				(lettuce, radish, tomato, carrot, beet and onion)

* Do not sieve the flour. Use whole-meal flour and not *maida*.

** Use cabbage, cauliflower, french beans, carrot.

The entire meal should be divided into five to six small and frequent feedings.

Nutritionally, the diet must be adequate by supplying more proteins. Tender meats, poultry, soft-boiled eggs and fish cooked with very little spices for non-vegetarians is ideal. Milk can be restricted initially and intake increased as tolerance improves. Protein supplements like proteinex or protinules can be used if necessary. A very low-residue diet may be given initially, which may progress to a moderate-fibre diet.

All raw vegetables and fruits and other similar foods which irritate the bowels must be avoided. Supplementation with vitamins and minerals is essential, especially iron supplementation is necessary if anaemia is prevalent and calcium supplementation required, if milk is not tolerated.

Table 12.6 shows a diet for an ulcerative colitis patient.

Table 12.6 Diet in ulcerative colitis

Food Exchange List				
	<i>Exchange</i>	<i>No. of Exchanges</i>	<i>Protein (g)</i>	<i>Calories</i>
1.	Milk	1	5.0	100
2.	Legume and pulses	3	18.0	300
3.	Flesh food	1/2	5.0	50
4.	Vegetable A	1	—	—
5.	Vegetable B	1	—	50
6.	Fruit	2	—	100
7.	Cereals (Refined)**	11	22.0	1100
8.	Fat	3	—	300
9.	Sugar	30 g	—	120
			50.0*	2120

Menu Plan				
<i>Breakfast</i>	: 1 cup weak tea	<i>Tea</i>	: 1 cup weak tea/coffee or	
	: 2 slices bread (remove edges)		1 glass lemon juice	
	with butter and 10 g cheese.	<i>Late</i>	: 1/2 small banana	
	1/2 small banana	<i>evening</i>		
	1 poached/boiled egg	<i>Dinner</i>	: 4 <i>phulkas</i> or 2 <i>chapatis</i>	
<i>Lunch</i>	: 4 <i>phulkas</i> or 2 <i>chapatis</i>		prepared with <i>maida</i>	
	prepared with <i>maida</i>		1 cup pumpkin curry	
	1 1/2 cup plain <i>dal</i>		1 and 1/2 cup <i>mung dal</i>	
	1 cup rice		1 cup rice	
	1 cup <i>dudhi</i> potato curry			
	1/2 cup curd			

* Protein supplements such as proteinex, protinules may be used. Sieved soya flour may be incorporated in *maida* to be used for *chapatis*.

** Sieve all flours before using.

12.7 CELIAC DISEASE

It is a disease of the digestive system that damages the small intestine and interferes with the absorption of nutrients from food.

Celiac disease occurs when the body reacts abnormally to gluten, a protein found in wheat, rye, barley, and possibly oats. The person's immune system causes an inflammatory response in the small intestine, which damages the tissues and results

in impaired ability to absorb nutrients from foods. The inflammation and malabsorption create other problems in many systems of the body. Since, the damage is caused by the body's own immune system, celiac disease is classified as an "autoimmune" disorder. Celiac disease may also be called sprue, nontropical sprue, gluten sensitive enteropathy, celiac sprue, and adult celiac disease.

Celiac disease can occur at any age, from infancy through adulthood. The disorder is more commonly found among white Europeans or in people of European descent. It is very unusual to find celiac disease in African or Asian people. The prevalence of celiac disease is not known. It is under-diagnosed, since, the symptoms may be attributed to another problem. Also there is a lack of knowledge about celiac disease.

Because celiac disease has a hereditary influence, close blood relatives have a higher risk of being affected with the condition.

□ Lactose Intolerance

Lactose intolerance is the inability of a person to digest lactose, the principal sugar in milk, that gives rise to gastrointestinal symptoms. Lactose intolerance is caused by a deficiency of the intestinal enzyme lactase that acts on lactose to convert it into glucose and galactose which are then absorbed from the intestine.

The primary symptoms of lactose intolerance are diarrhea, flatulence (passing gas), and abdominal pain. Abdominal bloating, abdominal distention, and nausea may also occur.

Lactose intolerance is treated with dietary changes, supplements of lactase enzyme, and adaptation to increasing amounts of milk. It may be necessary to avoid milk and milk containing products. The main challenge would be a dietary deficiency of calcium and vitamin D which could lead to diseases of the bones.

Lactase deficiency may be:

1. Congenital: Lactase deficiency may occur because of a congenital absence of lactase, the symptoms of this type of lactase deficiency begin shortly after birth.
2. Secondary: This type of deficiency is due to diseases that destroy the lining of the small intestine along with the lactase. Eg. celiac sprue.
3. Adult-type hypolactasia: A decrease in the amount of lactase that occurs after childhood and persists into adulthood. This decrease in lactase is genetically programmed, and the prevalence of this type of lactase deficiency varies in different ethnic groups.

It is important to understand that lactase deficiency is not the same as lactose intolerance. Persons with milder or moderate deficiencies of lactase often have no symptoms after the ingestion of milk.

12.8 DIETS MODIFIED IN RESIDUE CONTENT

Residue means the amount of food left behind after the process of digestion is complete. *Food residue* is that part of food which the body cannot digest and, therefore, it is ultimately thrown out of the body in the form of faeces. If there is less residue in the bowels, there is less of the faeces formed for the body to evacuate and if more residue is present in the bowels then the body evacuates more.

Residue mainly comprises indigestible matter in food, which is fibre, obtained abundantly from green leafy vegetables, raw fruits and other vegetables, whole-grain preparations like brown bread, *chapati* made from whole-meal flour, etc.

□ Indication

A *high residue* or fibre diet is prescribed in constipation and diverticulosis.

□ Diverticulitis

Diverticulitis refers to the development of inflammation and infection in one or more *diverticula*. Diverticula are outpouching or bulges which occur when the inner lining layer of the colon bulges out through the outer, muscular layer. It is characterized by the inflammation of one or more of the pouches or sacs that sometimes form in the wall of the large intestine. If the diverticulitis obstructs the bowel, it can be very painful. Diverticula tend to occur most frequently in the sigmoid colon. The great majority of people with diverticulosis will remain symptom-free.

This disease is linked to poor dietary habits such as intake of highly refined foods and is made worse by inactivity. A well-balanced diet with plenty of fibre combined with regular exercise, can alleviate uncomplicated diverticulitis by improving mobility of the gut and easing the passage of stools.

1. Causes and Symptoms Diverticula are said to be caused by overly forceful contractions of the muscular wall of the large intestine which cause areas of the wall to become weaker allowing the inner lining to bulge through. Diverticula commonly occur next to the blood vessels.

The elderly have the most serious complications from diverticulitis, but it can also occur in patients under the age of 50. The symptoms are characterized by severe pain and fever. When a diverticulum weakens it may cause peritonitis, which is an infection and inflammation of the lining of the abdominal cavity, the peritoneum. Other complications of diverticulitis are the formation of abnormal connections called fistulas, between two organs which normally do not connect (for example, the intestine and the bladder), and scarring outside of the intestine that squeezes off and obstructs a portion of the intestine.

2. Prevention There is no certain way to prevent the development of diverticula. However, it is believed that high-fibre diets may help. Foods that are recommended for their a high residue or fibre diet is prescribed in constipation and diverticulosis content include whole grain breads and cereals, and all types of fruits and vegetables. Individuals must take in 20–35 grams of fibre daily and plenty of water.

□ Indication

A *low* or *restricted residue* diet is prescribed in peptic ulcers and ulcerative colitis. It may also be advised by the doctor before a surgery is performed. The restricted residue is meant to decrease the normal work of the large intestines by reducing food residue. Hence, it may also be prescribed in the form of a *minimum residue* diet for post-operative patients or for people suffering from chronic colitis or

ileitis. The important point to consider in a low-residue diet is that since, several foods are not allowed, supplementation with vitamins and minerals is necessary.

The foods allowed in a minimum residue diet are similar to those in the restricted residue diet except milk, tea, or coffee and spices which are not permitted. Milk is avoided as far as possible in a diet which is termed minimum residue or residue-free diet since milk encourages the process of fermentation, which delays the emptying of the stomach. Vegetables and fruits can be consumed in the form of unseasoned and strained juices.

Table 12.7 Sample menu for a restricted residue diet (chronic colitis)

Food Exchange List				
	<i>Exchange</i>	<i>No. of exchanges</i>	<i>Protein (g)</i>	<i>Calories</i>
1.	Milk	1	5.0	100
2.	Legume and pulses	2	12.0	200
3.	Flesh food	1	10.0	100
4.	Vegetable A	—	—	—
5.	Vegetable B	1	—	50
6.	Fruit	2	—	100
7.	Cereals (Refined)	8	16.0	800
8.	Fats	2	—	200
9.	Sugar	25 g	—	100
			43.0	1650

Menu Plan				
<i>Tea</i>	:	1 cup very light tea with milk	<i>Snacks</i>	:
				1 cup tea with little milk
<i>Breakfast</i>	:	2 slices bread		2 biscuits
		5 gm butter		1/2 banana, 1 boiled egg
		1 poached egg	<i>Dinner</i>	:
		1 banana		2 <i>chapatis</i> or 4 <i>phulkas</i> prepared with <i>maida</i>
		1/2 cup coffee using milk		3/4 cup rice
<i>Lunch</i>	:	1 cup clear tomato soup		1 cup <i>dudhi</i> curry
		2 <i>chapatis</i> or 4 <i>phulkas</i>		1 cup <i>masur dal</i>
		prepared with <i>maida</i>		
		3/4 cup rice		
		1 cup <i>mung dal</i>		

Table 12.8 Foods allowed and avoided in restricted residue diets and minimum residue diets

<i>Foods allowed</i>	<i>Foods avoided</i>
Restricted Residue Diet	
Milk, buttermilk (limited to two glasses daily)	Fibrous meat
Cottage cheese	Fresh fruits and vegetables
Butter and margarine	Fried foods
Eggs (all types, except fried)	Coarse breads and cereals
Tender chicken, fish, ground beef and lamb prepared either by baking, boiling or broiling.	Nuts and olives
Soup broth	Coconut, garlic
Cooked, mild-flavoured vegetables such as bottle gourd, pumpkin, vegetable juices fruit juices, bananas, peaches, pears, plums and prunes, citrus fruits without membranes.	Pickles, jams and marmalades
Refined breads and foods, cereals, macaroni, spaghetti and noodles, <i>mung dal, masur dal</i>	Whole legumes like mung, <i>matki, urad</i>
Custard, juice, ice-creams, plain gelatin jelly, sponge cake, and plain cakes and biscuits. (If any cereal puddings are prepared, they may be considered as a part of the two glasses of milk allowed)	
Tea, coffee, cocoa, carbonated beverages	
Salt, sugar and small amounts of spices permitted.	
Minimum Residue Diet	
Boiled or evaporated milk, if any milk allowed.	Fruits and vegetables
Cottage cheese, if tolerated.	Fried foods
Butter and margarine	Coarse, whole-grain breads and cereals, quick breads
Eggs, except fried.	Fibrous meats
Minced chicken and fish	Milk (sometimes)
Scraped beef	Salad
Soup broth	
Small amounts of plain, unseasoned vegetable juice	
Refined breads and cereals, white crackers, macaroni, spaghetti and noodles.	
Juice, gelatin, plain cake and cookies.	
Tea, coffee (if physician permits)	
Small amounts of salt and sugar	



SUMMARY

The entire nutritional supply of the body is totally dependent on the normal functioning of the digestive system. Problems with this system can jeopardize nutritional status

of the whole body and call in emergency supplementation with intravenous supply of water, electrolytes and sugar. Therefore, the therapeutic diet is planned to give rest to the digestive organs, ensuring the necessary supplies to the body through almost predigested foods. Diarrhoea is one of the most common, at times dreaded, disorders of this system. It drains the body of water and electrolytes, causing death due to dehydration, particularly in children.



CASE STUDY

Sex	:	female
Age	:	62 years
Height	:	5 feet 4 inches
Weight	:	46 kg
Activity	:	sedentary lifestyle
Symptoms and diagnosis	:	severe pain in the stomach and suffering from chronic colitis.
Other problems	:	Has intolerance for milk, refined wheat flour (maida), cauliflower, <i>chana dal</i> and most leafy vegetables. She has lost most of her teeth, hence she cannot chew.
Clinical picture	:	Haemoglobin: 10.1 mg/dl

What is your advice to her regarding:

1. Foods which she can eat.
2. Foods which she should avoid.
3. Foods she should consume to improve her weight and haemoglobin.



REVIEW QUESTIONS

1. What is a peptic ulcer? What is the recent scientific explanation given as the cause of ulcers?
2. List five foods commonly allowed and five foods avoided in peptic ulcers.
3. What is dehydration? What are its causes? What are the symptoms of dehydration? Why should dehydration be treated as early as possible, especially in case of infants and children?
4. What is ORT? How can you prepare it at home? Make a list of oral rehydration mixtures available.
5. Explain the role of fluid and fibre intake in constipation.
6. Diets are modified in residue contents for which diseases. Plan one low residue diet and one high residue diet.
7. Name five foods prescribed in low residue diets.
8. Name five foods advised in high residue diets.

Chapter

13



Diet for Liver Diseases

13.1 LIFE DEPENDS UPON THE LIVER

It is a saying that we have been hearing since ages. The liver is a complex and the largest gland associated with the digestive system in our body. It has several functions in our nutritional well-being.

The large size of the liver is matched by its functional complexity and involvement in a diverse array of regulatory mechanisms. It performs about 100 functions, which may be broadly classified into seven major categories, shown in Fig. 13.1.

1. Carbohydrate Metabolism Glucose is converted to glycogen in the liver, which is used later to derive energy in the intervals between ingestion of food. Glycogen is stored in the liver.

It converts the non-carbohydrate metabolites like amino acids, fats, glycerol, etc. into glucose to maintain the glucose level of blood.

2. Interconversion of Metabolites The liver is a major organ where the production of both fatty acids and neutral fats (triglycerides) takes place. Excess intake of carbohydrates will be converted to fatty acids and neutral fat.

Synthesis of phospholipids takes place in the liver.

Ketone bodies produced by the liver represent partial oxidation products of fatty acid degradation which are utilized as a rapid, short-term energy source by extrahepatic tissues.

Cholesterol is synthesized by the liver although small amounts are ingested. Cholesterol is excreted in the faeces following its conversion to bile salts but considerable recycling of these sterol compounds may occur between the intestine and liver. Steroid hormones, which resemble cholesterol in their chemical structure, are degraded in the liver and may be excreted in the bile.

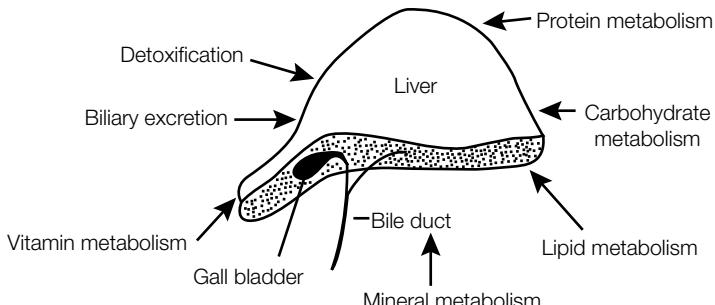


Fig 13.1 Liver and its functions

Amino acids which reach the liver via portal circulation may in a small portion be incorporated into hepatic structural protein to serve as labile reserve. During gluconeogenesis, the amino acids are stripped of their nitrogen and the remaining molecule is used for production of glucose. The process of transamination also occurs here.

3. Blood Protein Manufacture The liver manufactures plasma cholinesterase, albumin, prothrombin and fibrinogen. The liver thus, plays a significant role in maintaining the osmotic pressure of blood, preventing haemorrhage, providing a reserve of protein.

4. Erythropoietic Function The liver is the predominant source of embryonic red blood cells and is also involved in production of thrombocytes (platelets).

5. Detoxification Many poisons are rendered harmless by degradation reaction in the liver. Many harmful drugs like barbiturates, tranquillizers and hallucinogens such as LSD are detoxified. Detoxification mechanisms are also involved in the formation of bile pigments, the esterification of cholesterol and conjugation and oxidation of steroid hormones.

6. Bile Formation Bile is formed in the liver. It consists of bile pigments, bile salts, protein, cholesterol and inorganic salts. The pigments bilirubin and biliverdin are conjugated with glucuronic acid by the liver.

7. Vitamin Storage The liver stores Vitamins A and D as well as iron. Carotene in the liver is converted into vitamin A. Some water-soluble B vitamins are also found in high levels in the liver.

The functions of liver have been summarized in Table 13.1.

From this table, one can envisage the importance of liver. It is a vital organ involved in the metabolism of all the nutrients. Besides processing nutrients, the other most important function is to detoxify bacterial decomposition products, mineral poisons, drugs and dyes, deamination of amino nitrogen and to reprocess metabolic wastes for excretion, and to decompose waste haemoglobin to bilirubin. It will be interesting to note that all the absorbed water-soluble material from the digestive system is sent

Table 13.1 Functions of liver

<i>Detoxification</i>	<i>Protein Metabolism</i>
bacterial decomposition products, mineral poisons, drugs and dyes and such other foreign substances	deamination of amino acids; synthesis of plasma proteins; formation of urea
<i>Biliary Excretion</i>	<i>Carbohydrate Metabolism</i>
reprocessing of metabolic wastes in the form of bile pigment and bile salts	synthesis, storage and release of glycogen; synthesis of heparin
<i>Vitamin Metabolism</i>	<i>Lipid Metabolism</i>
storage of Vitamins A and D; some conversion of carotene into Vitamin A; role of Vitamin K in prothrombin formation	synthesis of lipoproteins, cholesterol and phospholipids; formation of bile; conjugation of bile salts; oxidation of fatty acids
<i>Mineral Metabolism</i>	
storage of iron, copper and other minerals.	

to the liver through the hepatic portal circulation, where it is screened and processed before being circulated to the other parts of the body.

13.2 CAUSES OF LIVER DISEASES AND DISORDERS

These comprise the following:

1. Infectious agents—bacteria, viruses, parasites,
2. Toxins and toxic chemicals—phosphorus, halogenated hydrocarbons, chloroform, carbon tetrachloride
3. Alcoholism—excessive intake of alcohol over a long period of time
4. Metabolic or nutritional factors—impaired nutrition as in protein calorie malnutrition
5. Biliary obstruction—as in bile stone formation
6. Carcinoma—hepatoma
7. Decreased mass of functioning cells—due to damaged liver cells
8. Decreased blood supply.

Several organs in the body show reactions to liver damage, such as brain, kidney, pancreas, adrenal and gonads. Basic changes take place in liver tissue and these involve accumulation of fat in the liver (fatty degeneration), wasting or atrophy of the tissue, fibrosis and necrosis.

13.3 LIVER FUNCTION TESTS

For biochemical clinical evaluation of the status of liver function, a special set of laboratory tests are conducted on blood and urine of the patient and are called *liver function tests*. These include:

In Blood

1. Total and conjugated serum bilirubin test.
2. Serum glutamic oxalacetic transaminase test (SGOT).
3. Serum glutamic pyruvic transaminase test (SGPT).
4. Serum alkaline phosphatase test.
5. Serum total proteins test.
6. Serum albumin test.
7. Serum globulin test.
8. Serum albumin-globulin ratio.
9. Serum cholesterol.
10. Serum cephalin cholesterol flocculation test.
11. Thymol flocculation test/thymol turbidity test.
12. Bromsulfalein test.

In Urine

1. Bile salts
2. Bile pigments
3. Urobilinogen

Alterations in these factors in the blood and urine give an indication of the likely liver disease.

13.4 CLINICAL SYMPTOMS

Jaundice is the symptom common to many liver diseases. It is apparent from the yellow pigmentation of the skin and body tissues because bile pigments accumulate in the blood. It could be manifested in several forms.

Jaundice

<i>Obstructive</i> due to obstruction of bile by stones (gallstones), tumours, or swelling of the mucosa of the ducts.	<i>Hemolytic</i> due to yellow fever, pernicious anaemia, etc.	<i>Toxic</i> due to poisons, drugs, or viral infections, protozoal infections causing hepatitis.
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Common symptoms seen in liver diseases are lassitude, weakness, fatigue, anorexia, weight loss; other symptoms may be pain in the abdominal region, flatulence, nausea and vomiting, hepatomegaly (enlargement of the liver) externally seen as enlarged abdomen, ascites, oedema and portal hypertension.

13.5 NUTRITIONAL CONSIDERATIONS IN LIVER DISEASES

The diet of a person affected by a liver disease should be nutritious, since it is an important part of therapy. It ensures protection of liver cells from stress and enables the liver to perform to its normal capacity.

A high-protein diet, except in hepatic coma, is essential to provide for tissue repair and for preventing fatty infiltration of the liver. Proteins contain lipotropic factors such as choline and methionine. A high carbohydrate intake ensures that there is an adequate quantity of glycogen, which along with adequate proteins has a protective effect. The fat intake may be restricted since its mobilization from the liver is affected. Medium-chain triglyceride therapy is then advocated.

Medium-chain triglycerides (MCTs) contain only fatty acids with 6–12 carbon atoms. They are rare in nature. They have been fractionated from coconut oil. They are composed of:

- 75% caprylic acid (8 C)
- 22–23% capric acid (10 C)
- 1% caproic acid (6 C)
- 1% lauric acid (12 C)

Traces of other fatty acids such as linoleic, stearic, and palmitic acids are also present.

□ Importance of MCTs

Since MCTs are liquid at room temperature, they are more soluble in water than natural triglycerides. MCTs are easily digested by pancreatic lipase and do not require bile salts for absorption. Once absorbed, they enter the portal vein and into the liver as fatty acids and do not go through the lacteal system.

Synthetic MCTs are also popular in the treatment of intestinal diseases, especially malabsorption such as steatorrhoea, sprue and pancreatic insufficiency. They are a ready source of energy and prevent starvation from lack of absorbed calories.

□ Uses of MCTs

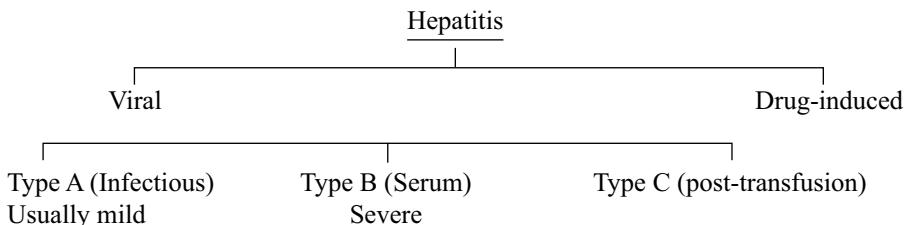
1. When pancreatic enzymes and/or bile salts are either absent or present in very small amounts.
2. When the lymphatic system has an obstruction especially in the branches leaving the intestinal walls.
3. When the intestinal mucosa is infective.

□ Problems of MCT Therapy

Because MCTs are easily absorbed, any excessive consumption forces their increased degradation. As a result, formation of acetone, acetoacetic acid and hydroxybutyric acid may increase and acidosis may occur. Patients susceptible to hepatic encephalopathy may react adversely to MCTs that reach the liver directly from the gut.

Overall in liver diseases all vitamins, especially the B-complex vitamins, should be given in plenty. Sodium may be restricted if swelling is seen. There are restrictions on spices, chillies and oily preparations.

13.6 HEPATITIS



Hepatitis is a common liver disease.

□ Causes of Hepatitis

The two types of hepatitis that one comes across are viral and drug-induced. Viral hepatitis may be of Type A or B. Type A or infectious hepatitis is transmitted either by faecal contamination of water or food or it may be transmitted parenterally. Type A hepatitis is usually mild and rarely progresses to chronic hepatitis.

Type B may be transmitted chiefly through improperly sterilized surgical needles etc. It is more severe and may potentially progress to a serious disorder.

Type C may be transmitted by blood transfusion. It is also frequently seen in male homosexuals.

Drug- or chemical-induced hepatitis may be due to addiction to alcohol, heroin, marijuana or hashish or due to hypersensitivity to sulpha compounds or penicillin, or due to toxic substances like carbon tetrachloride, chloroform, etc.

□ Symptoms

Anorexia, fatigue, nausea, vomiting, diarrhoea, fever, weight loss and abdominal discomfort are some of the common symptoms characterizing all types of hepatitis. Generally, jaundice follows after these symptoms appear.

1. Treatment Involves adequate rest, a nutritious high-protein, high-carbohydrate, moderate fat diet and withdrawal of any external causative factors such as alcohol or the drug causing hepatitis to avoid any further damage to the liver. Fat should be restricted and is given with due consideration to the quality of the protein and the state of the liver disorder.

2. Diet A high-protein high-carbohydrate, moderate fat diet divided into six to eight small meals which will encourage the patient to eat well and recover fast is advised. If the patient is made aware of the prevention of a relapse by eating a proper diet, the objective of dietary modification will be achieved effectively. About one gram good quality protein per kilogram body weight is recommended. Spices and condiments may be used judiciously to stimulate appetite.

The food must be initially of liquid consistency since, the initial acute stage is that of anorexia. As convalescence progresses, a wider selection of foods with texture and consistency changes may be made. High-protein beverages such as protinules and protinex in milk may be given in between meals. No foods are specifically contraindicated in hepatitis. However, if the patient complains of intolerance towards strongly-flavoured vegetables, rich desserts, fried and fatty foods, nuts, chocolate and highly-seasoned foods, then these may best be avoided.

Table 13.2 shows a typical diet plan for a hepatitis patient in the convalescent stage.

Table 13.2 Diet in hepatitis (high-protein, moderate fat, high-carbohydrate diet)

Food Exchange List				
Exchange	No. of exchanges	Carbohydrates (g)	Protein (g)	Calories
1. Milk	5	—	25.0	500
2. Legumes and pulses	3	45.0	18.0	300
3. Flesh food	1/2	—	5.0	50
4. Vegetable A	2	—	—	—
5. Vegetable B	2	20.0	—	100
6. Fruit	4	40.0	—	200
7. Cereals	10	200.0	20.0	1000
8. Fats	2	—	—	200
9. Sugar	50 g	50.0	—	200
		355.0	68.0	2550

Menu Plan					
Tea	:	1 cup	Afternoon	:	1 banana
Breakfast	:	1 glass milk with protinules 2 slices of bread with 5 g butter 1 poached egg	Tea	:	1 cup
Lunch	:	2 <i>chapatis</i> or 4 <i>phulkas</i> 1 cup medium-thick dal 1 cup <i>palak</i> curry 1 cup parwar-potato curry 1 cup rice 1 cup curd 1 roasted <i>papad</i>	Dinner	:	4 <i>phulkas</i> or 2 <i>chapatis</i> 1 cup medium-thick <i>dal</i> 1 plateful mixed vegetable salad 1 cup rice 1 cup curd
			Bedtime	:	1 bowl fruit salad

13.7 CIRRHOSIS OF THE LIVER

1. Causes Cirrhosis of the liver may be due to infectious hepatitis, chronic alcoholism along with malnutrition, metabolic-disturbances such as haemochromatosis or Wilson's disease, hepatotoxins present in certain plants and fungi and biliary stashes over a long period of time.

2. Symptoms Gastro-intestinal disturbances accompanied by anorexia, nausea, vomiting, pain and distension are some symptoms which develop gradually. As the disease progresses, jaundice and other serious changes occur.

Ascites in cirrhosis is due to a combination of liver failure and portal hypertension. In addition, there may be lymphatic obstruction in the liver, which predispose to the localization of fluid in the abdomen.

Jaundice is seen mainly due to failure of bilirubin metabolism. It may be generally mild or absent. Increasing jaundice implies progressing liver failure.

In advanced liver failure, the patient may develop haemorrhagic failure.

Oesophageal varices and varicose veins in the upper part of the stomach may develop. This symptom should be regarded as serious since, there is an ever-present danger of irritating the oesophageal lining resulting in haemorrhage, which may be fatal.

Hepatic encephalopathy characterized by mental changes, progressing from confusion to stupor to coma, results from sudden severe impairment of hepatic function. It indicates deterioration in chronic liver disease.

Renal failure can occur in cirrhosis of the liver or it may be present as hepatorenal syndrome.

3. Diet The diet plays a key role if it is started at the appropriate time, that is before the disease is well advanced. A high-carbohydrate, high-protein diet given in infectious hepatitis may be adequate in most cases. However, if hepatic coma is suspected (indicated by elevated levels of plasma aromatic amino acids, i.e. phenylalanine and tyrosine, as well as methionine, while isoleucine, leucine and valine levels are lowered), then dietary protein levels must be controlled. Generally, a protein intake of 35–50 g per day is considered adequate and low enough to prevent hepatic coma. The fat content of the diet must be very low, less than 10 grams. Fibre in the diet may be increased in the diet as much as can be tolerated.

Adequate calories should be supplied. About 35 to 50 kcals per kilogram body weight are found to be sufficient.

Vitamins may be supplemented in the diet to replenish liver stores and repair tissue damage, especially if there is anorexia.

If swelling and ascites are seen, then sodium in the diet may be restricted. Generally, a 500–800 mg sodium diet is prescribed.

The consistency of the diet should be liquid to soft with small and frequent meals, accompanied by a reduction in the fibre content of the diet.

Table 13.3 shows a typical diet in cirrhosis of the liver.

Table 13.3 Diet in cirrhosis of the liver (low-protein, high-carbohydrate, low-fat and fibre restricted diet)

Food Exchange List					
Exchange	No. of exchanges	Carbohydrate (g)	Protein (g)	Fat (g)	Calories
1. Milk	2	—	10.0	—	200
2. Legumes and pulses	1	15.0	6.0	—	100
3. Flesh food	—	—	—	—	—
4. Vegetable A	2	—	—	—	—
5. Vegetable B	4	40.0	—	—	200
6. Fruit	6	60.0	—	—	300
7. Cereals	8	160.0	16.0	—	800
8. Fats	2	—	—	22.0	200
9. Sugar	80 g	80.0	—	—	320
		355.0	32.0	22.0	2120

Menu Plan					
<i>Tea</i>	:	1 cup	<i>Afternoon</i>	:	1 glass fruit juice with sugar
<i>Breakfast</i>	:	1 glass fruit juice with 10 grams glucose/sugar	<i>Tea</i>	:	1 cup 2 arrowroot biscuits
		1 slice bread with jam	<i>Late evening</i>	:	1 bowl fruit custard (with peeled and cored apples, bananas and chikus using a little milk, custard powder and sugar)
<i>Mid-morning</i>	:	1 bowl tomato soup			
<i>Lunch</i>	:	1 <i>chapati</i> or 2 <i>phulkas</i>	<i>Dinner</i>	:	2 <i>phulkas</i> or 1 <i>chapati</i>
		1 cup rice			1 cup rice
		1 cup <i>potaio-dudhi</i> curry			1 cup red pumpkin curry
		1 cup thin <i>dal</i>			1 cup thin <i>dal</i>
		1/2 cup curd with 10 grams sugar			1/2 glass buttermilk with sugar (<i>sweet lassi</i>)
			<i>Bedtime</i>	:	1 medium glass milk with sugar

13.8 HEPATIC COMA

1. Causes As mentioned under cirrhosis of the liver, some cases advance to hepatic coma which is a syndrome of severe liver disease. There are several neurological disturbances due to entrance of nitrogen-containing substances like ammonia into the cerebral circulation without being metabolized by the liver.

2. Symptoms Clinically, the blood plasma amino-acid pattern is altered and electrolyte imbalance occurs. The period before coma is characterized by severe mental confusion, restlessness, hyper-irritability, delirium and drowsiness. The breath has a foetid odour and the person goes into coma and may have convulsions.

3. Dietary Modification Restriction of dietary protein to a minimum level is the first essential step. The diet should be rich in calories to prevent tissue breakdown, about 1500–2000 kcal should be supplied. About 300–400 g glucose should be given per day. In the initial stage, protein is restricted severely, i.e. 20–30 g per day, but as the condition improves, the protein intake is gradually improved to supply 1 g/kg body weight.

After the condition of the patient stabilizes, about 40–50 g high biological value protein per day may be given. It may be necessary to restrict fluid intake to 1000–1500 ml per day. Vitamin supplementation, especially of Vitamin C and B-complex, is necessary. If electrolyte imbalance is noticed, it must be corrected to prevent worsening of neurological status. Table 13.4 shows a typical diet in hepatic coma.

Table 13.4 Diet in hepatic coma*

Food Exchange List						
<i>Exchange</i>	<i>No. of exchanges</i>	<i>Carbohydrate (g)</i>	<i>Fat (g)</i>	<i>Protein (g)</i>	<i>(Energy kcal)</i>	
1. Milk (skim)	2	24.0	—	10.0	200	
2. Legumes and pulses	—	—	—	—	—	
3. Flesh food	—	—	—	—	—	
4. Vegetable A	1	—	—	—	—	
5. Vegetable B	1	10.0	—	—	50	
6. Fruit	4	10.0	—	—	200	
7. Cereals	2	40.0	—	4.0	200	
8. Fats	1	—	11.0	—	100	
9. Sugar (Glucose)	300 g	300.0	—	—	1200	
		384.0	11.0	14.0	1950	

Menu Plan	
Early morning	: orange juice or sweet lime juice—150 ml with 4 tbsp. sugar
8.00 a.m.	: Sugarcane juice—150 ml with 2 tbsp glucose
10.00 a.m.	: Rice or <i>rava suji</i> (porridge)—150 ml with 3 tbsp. sugar
12.00 noon	: Mashed banana with barley water—150 ml with 2 tbsp. sugar
2.00 p.m.	: Tomato juice—150 ml with 3tbsp. sugar
4.00 p.m.	: Fruit juice—150 ml with 2 tbsp sugar
6.00 p.m.	: Vegetable soup (pureed and sieved)—150 ml with 2 tbsp. sugar
8.00 p.m.	: Rice or <i>rava</i> porridge—150 ml with “ tbsp. sugar
10.00 p.m.	: Barley water—150 ml with 2 tbsp. sugar or honey.

* Small and frequent meals every two hours should be given if the patient is not in coma. If he is in coma, it should be given by intra-gastric route.

13.9 MALABSORPTION SYNDROME

Malabsorption is a state which arises from an abnormality in the digestion or absorption of food nutrients in the GI tract. There may be an impairment of single or multiple nutrients depending on the abnormality. This may lead to malnutrition and anaemia.

Malabsorption can be classified into three basic categories:

1. selective, as seen in lactose malabsorption;
2. partial, as observed in Beta-lipoproteinaemia, and
3. total as in celiac disease.

Malabsorption can be due to:

1. Mucosal damage
2. Acquired or congenital reduction in absorptive surface
3. Defects of specific hydrolysis
4. Insufficiency of the pancreas

Causes

1. **Infective agents** such as intestinal tuberculosis, HIV related malabsorption, parasites, etc.
2. **Mucosal abnormality** such as intolerance to soya milk and cow's milk.
3. digestive failure due to cystic fibrosis, chronic pancreatitis, malabsorption of bile salts.
4. **Structural defects** such as inflammatory bowel diseases like Crohn's disease, gastro-jejunostomy, fistulae, diverticulae, etc.
5. **Enzyme deficiencies** such as lactase deficiency in lactose intolerant persons, intestinal disaccharidase deficiency, etc.
6. **Systemic diseases** such as hypothyroidism, hyperthyroidism, diabetes mellitus, etc.

Clinical features occur such as diarrhoea, often steatorrhoea, characterized by watery, diurnal and nocturnal, bulky, frequent stools. Bloating, flatulence and abdominal discomfort, cramping pain are some symptoms. Weight loss can be significant despite increased oral intake of nutrients. Growth retardation, anaemias can also be seen in this disease.

Treatment is directed largely towards management of the underlying cause. Besides this, replacement of nutrients, electrolytes and fluid may be necessary. In severe deficiency, parenteral administration may be required. Dietary modification is important in some conditions. Lifelong avoidance of particular food or food constituent may be needed as in celiac disease or lactose intolerance.

13.10 CHOLELITHIASIS OR GALLSTONES

Cholelithiasis involves the presence of gallstones, which are hard solid masses that form in the biliary tract, usually in the gallbladder. Choledocholithiasis refers to the presence of one or more gallstones in the Common Bile Duct (CBD). Gallstones can migrate to other parts of the digestive tract and cause severe pain with life-threatening complications. Most gallstones are composed of cholesterol, calcium and bilirubin, with either cholesterol or bilirubin being predominant. Sometimes mixed stones may also occur. Women are more prone to develop gallstones than men.

There are four stages of the disease:

1. *Lithogenic state*, in which conditions favour gallstone formation
2. *Asymptomatic gallstones*
3. *Symptomatic gallstones*, characterized by episodes of biliary colic
4. *Complicated cholelithiasis*

Characteristics of biliary colic include pain that may be sporadic and the episodes are unpredictable. It may begin postprandially, as intense and dull, may last for 1–5 hours steadily increasing, and then wane gradually. Pain due to gallstones may be constant and not relieved by emesis, antacids, defecation, flatus, or positional changes. Sometimes it may be accompanied by sweating, nausea, and vomiting. Other nonspecific symptoms are indigestion, dyspepsia, belching or bloating.

Uncomplicated biliary colic may be identified by pain that is poorly localized and visceral. There may be absence of fever.

Acute cholecystitis characterized by well-localized pain in the right upper side of the abdominal region and frequently there may be fever. Hence, the presence of fever, persistent tachycardia, hypotension, or jaundice may be indicative of gallstones or pancreatitis.

Medical treatments may be used individually or in combination such as

1. Oral bile salt therapy (ursodeoxycholic acid)
2. Contact dissolution
3. Extracorporeal shockwave lithotripsy
4. In some cases, it may be necessary to remove the gallstones surgically.

Cholecystitis

When the gallstone is lodged in the cystic duct which transports bile from the gallbladder to the liver, it causes pain. If the condition persists for a long period of time, it can cause thickening of the walls of the gallbladder and the organ shrinks and becomes hard. Its function is disrupted and it does not store and release bile. This condition is known as chroniccholecystitis.

13.11 PANCREATITIS

Pancreatitis is an inflammation of the pancreas, an organ that is important in digestion. Pancreatitis can be acute (beginning suddenly, usually with the patient recovering fully) or chronic (progressing slowly with continued, permanent injury to the pancreas).

The pancreas are located in the midline of the back of the abdomen, closely associated with the liver, stomach, and duodenum. The pancreas is an unique gland since, it performs both, the endocrine function as well as the exocrine function. Its endocrine function produces three hormones of which two, namely insulin and glucagon, are central to the carbohydrate metabolism. The third hormone called *Vasoactive Intestinal Polypeptide (VIP)* affects the GI functioning. The exocrine function of the pancreas produces a variety of digestive enzymes (trypsin, chymotrypsin, lipase, and amylase, among others). These enzymes are passed into the duodenum through a channel called the pancreatic duct. In the duodenum,

the enzymes begin the process of breaking down a variety of food components, including proteins, fats, and starches. In pancreatitis these vital functions are affected.

Acute pancreatitis occurs when the pancreas suddenly become inflamed but improve. Patients recover fully from the disease, and in almost 90% of the cases the symptoms disappear within about a week after treatment. The pancreas return to its normal architecture and functioning after healing from the illness. After an attack of acute pancreatitis, tissue and cells of the pancreas return to normal. With chronic pancreatitis, damage to the pancreas occurs slowly over time. Symptoms may be persistent or sporadic, but the condition does not disappear and the pancreas are permanently affected.

For dietary management of other liver disorders, similar indications as discussed above are applicable with minor changes to suit the individual requirements.



SUMMARY

Liver is one of the most important and metabolically highly active glands of the body which first receives the digested and absorbed nutrients. The processing of nutrients, as well as the metabolic wastes and foreign substances, keeping the safety of the body as prime consideration, is carried out here. An inefficient or malfunctioning liver risks all the other systems of the body. The dietary management of the liver disease calls for a very nourishing diet high in calories, good-quality protein, B-complex, and C vitamins for regeneration of the liver tissue so that the liver is not put to strain in its functions.



CASE STUDY

Sex	:	female
Age	:	25 years
Height	:	5 feet 4 inches
Weight	:	52 kg
Activity	:	sedentary

Clinical picture

Her blood picture is (values are in mg/dl):

Haemoglobin	11.8
Serum bilirubin	2.04
Serum bilirubin (direct)	1.49
SGOT	128.16
SGPT	179.09
Alkaline phosphatase	837
GGPT	202.78

1. Plan a diet and justify the dietary principles involved.
2. Which foods should she avoid and why?
3. Which foods should she consume in large amounts?
4. What are the do's and dont's that you would advice her for complete recovery?



REVIEW QUESTIONS

1. Why is it said, "Life of person depends upon the liver"?
2. Briefly outline the functions of the liver.
3. What are MCTs? In which disease do they play an important role? Why?
What are the accompanying problems of MCT therapy?
4. List out the types of hepatitis. What are the general symptoms of hepatitis?
5. Plan a diet for a boy aged 13 years who is convalescing from hepatitis.
Outline the nutritional considerations for his diet regime.

Chapter

14



Diet for Infections and Fevers

Infection as defined by the medical dictionary is the successful invasion, establishment and growth of micro-organisms in the tissues of the host. A healthy person has adequate resistance to infections. This ability is hampered by a poor nutritional status. Such a person falls an easy prey to infections frequently either in the form of cough and cold or marginal fever, feeling of weakness and other minor complaints. In other words, an infection weakens the immune response of a person.

14.1 DEFENCE MECHANISMS IN THE BODY

The body has two types of defence mechanisms: specific and non-specific. These are listed below.

Table 14.1 Specific and non-specific defence mechanisms of the human body

<i>Specific</i>	<i>Non-Specific</i>
• Cell mediated immunity— T-lymphocytes	• Skin • Mucous membranes
• Humoral immunity— Beta lymphocytes	• Collagen • Various body secretions
• Plasma accessory cells	• Fever (High temperature)
• Antibodies	• Intestinal flora • Hormonal influences
	• Iron-binding protein
	• Certain nutrients like Vitamin A, ascorbic acid (Vitamin C), protein, zinc
	• Leukocytes (WBC)

14.2 ROLE OF NUTRITION IN INFECTIONS

People with poor nutritional status are prone to infection, and they also take a longer time to recover. In our country, infants and preschoolers form the most vulnerable group. Immunity is a complex result of many components, some native and heritable, others acquired. Specific antibodies check the infection. These antibodies are made up of proteins, hence, if the protein status of an individual is good, these antibodies will be present in adequate number to resist the invading infection. Poor nutritional status will result in lowered resistance to infections.

14.3 EFFECTS OF INFECTION ON BODY MECHANISMS

Infection affects the nutritional status of the body adversely and significantly. The extent to which it will be affected depends upon the following:

1. Nature of the infection or infectious disease
2. Severity of the disease
3. Period for which it persists
4. Presence or absence of fever
5. Nutritional status of the person before the setting in of the infectious disease.

The effects of infection are seen as follows:

1. There are increased losses of nitrogen, some electrolytes like potassium and phosphates and other elements such as magnesium and zinc.
2. If there is fever along with an infection, then the energy needs are increased since the metabolic rate also increases.
3. There is decrease in food intake due to nausea and loss of appetite.
4. Loss of nutrients is increased due to increased perspiration, vomiting and diarrhoea.
5. There is a decrease in the absorption of nutrients especially in case of enteric infections.

14.4 EFFECTS OF INFECTION ON NUTRIENTS

1. Even in the absence of fever, protein catabolism increases.
2. The needs for energy are increased by 10 to 30 % during and after acute infections.
3. Vitamin requirements are increased if infection is accompanied by swelling and necrosis of the tissue. Many readers may be familiar with megadoses of Vitamin C advocated by Dr Linus Pauling in the prevention and cure of common cold. It was suggested that supplements of Vitamin C have an effect in reducing the incidence and severity of symptoms of cold.
4. Requirement of zinc and iron increases since both are involved in the immunity process. Infected patients show a decreased blood zinc level because of its migration to tissues and organs. Zinc excretion in urine also increases. Iron losses occur due to increased destruction of the red blood cells.

14.5 DEFINITION OF FEVER

Fever is elevation in the body temperature above the normal which may occur in response to an infection, inflammation or due to unknown causes.

The normal body temperature is 98.4 °F or 37 °C .

The agents that cause fever may be micro-organisms, especially bacteria, viruses and fungi or antigen-anitbody reactions, malignancy of a tissue or rejection of a graft by the body, malaria, etc.

□ Duration of Fevers

1. *Short duration*—such as in acute infection like colds, tonsilitis, influenza, etc. which last for a few hours or a few days.
2. *Long duration*—such as in malaria, tuberculosis, typhoid, etc. which last from several days to several months.

□ Effects of Fever on Metabolic Processes in the Body

Fever damage envisages all the metabolic processes of the body. They can be summed up as follows:

1. The metabolic rate increases by 13% for a rise of every degree Celsius in body temperature or 7% for a rise of every degree Fahrenheit in body temperature. This increases the caloric needs of the body during fever.
2. Glycogen stores of the body are depleted as also are the fat stores since they are burnt up to meet the increase in the caloric needs.
3. There is an increase in the breakdown of proteins, especially in typhoid fever, malaria, typhus fever, poliomyelitis. This causes an increase in excretion of the protein wastes by the kidneys.
4. There is an excessive loss of body fluids due to increase in excretion of body wastes through perspiration and evaporation.
5. There is increased excretion of the electrolytes, sodium and potassium.

14.6 DIETARY MODIFICATION IN INFECTION AND FEVERS

1. Energy The intake of energy should be increased by almost 50% in case of high fevers lasting for a longer period. However, due to fever, the patient's appetite is poor and digestion may be hampered, hence the maximum number of calories that can be tolerated by him should be given.

2. Carbohydrates They should be high and as liberal as possible. It is advisable to add glucose in all liquids and fruit juices given to the patient, since it is well tolerated in large amounts and is easily assimilated by the body.

3. Protein Just as the caloric need increases, so does the need for protein. A high-protein diet supplying about 1.25 to 1.5 g protein per kg body weight should be fed. Protein supplements which can be incorporated in beverages may be given. When digestion is affected adversely, predigested protein beverages may prove useful.

4. Fats These can be used liberally as in case of rich sweetmeats and foods which contain large amounts of fats.

5. Minerals Loss of the two electrolytes, sodium and potassium, should be replaced. Sodium in the form of salt in soups, dals, curries and broths should be given liberally. Potassium, which is also needed in greater amounts, should be given through fruit juices and milk which are good sources of potassium.

6. Vitamins All vitamins may be given as supplements to the patient.

7. Fluids Since loss of body fluids through perspiration and excretory wastes is high, plenty of water, coconut water, fruit and vegetable juices and soups are advised. These help to flush out excretory products from the kidneys.

8. Texture and Consistency of the Diet Soft texture and fluid to semi-solid consistency are desirable to promote appetite and help the patient to consume a diet which is nutritionally adequate. The feedings should be small and as frequent as possible.

Generally, six to eight feedings should be sufficient. A diet recommended in fevers of short duration is shown in Table 14.2.

□ Diet in Typhoid

Fever in typhoid is of a long duration. The rise in temperature is very high, thus causing significant damage to the nutritional status of the person. Antibiotic therapy helps a lot to curb the fever but however short the period may be, protein losses are very high, glycogen stores of the body are depleted to a very large extent and the water balance too may be affected severely. The antibiotic therapy also kills the beneficial symbiotic bacterial flora of the intestines.

In this disease, the intestines are the worst affected part of the body. They become inflamed and irritated and in several cases diarrhoea may be a frequent complication. If sufficient care is not taken, ulceration of the intestines may take place which may lead to bleeding, and the intestine may perforate in worst cases resulting in death.

Dietary Modifications Dietary modifications are similar to those given in case of fevers of short duration. However, caution must be exercised in preventing inclusion of irritating dietary fibres. All whole-grain cereals and cereal products, leafy vegetables, raw vegetables and fruits should be eliminated from the diet. Tender meat, fish and poultry, potatoes, soft-cooked vegetables and simple preparations

Table 14.2 Diet in Fevers of Short Duration

<i>Tea</i>	:	1 cup	<i>Mid-afternoon</i>	:	Custard with banana
<i>Breakfast</i>	:	<i>Rawa or suji upma</i> <i>sweet lime (mosambi) juice</i>	<i>Snacks time</i>	:	Tea with biscuits Red pumpkin or
<i>Mid-morning</i>	:	Egg-nog with honey and cream	<i>Dinner</i>	:	spinach curry Rice
<i>Lunch</i>	:	Cream of spinach or tomato soup <i>Phulkas</i> <i>Dudhi curry</i> Rice <i>Mung usal or dal</i> Buttermilk or curds		:	<i>Mung dal or tur dal</i> Buttermilk or curds Orange
			<i>Bedtime</i>	:	Milk with protinules or protinex

restricting the use of excessive fat and spices are advised. Table 14.3 shows a typical diet in typhoid.

Table 14.3 Diet in typhoid calories-2000; protein—50—60 g

Food Exchange List			
<i>Exchange</i>	<i>No. of Exchanges</i>	<i>Protein (g)</i>	<i>Calories</i>
1. Milk	3	15.0	300
2. Legumes and pulses	3	18.0	300
3. Flesh food	1/2	5.0	50
4. Vegetable A	2	—	—
5. Vegetable B*	2	—	100
6. Fruit	2	—	100
7. Cereals	8	16.0	800
8. Fats	3	—	300
9. Sugar	40 g	—	160
		54.0**	2110

Menu Plan			
<i>Tea</i>	— 1 cup	<i>Tea</i>	— 1 glass orange juice or coconut water
<i>Breakfast</i>	— 1 cup tea/coffee		1/2 cup <i>suji upma</i>
	1 slice bread with butter		
	1 egg	<i>Dinner</i>	— 1 <i>chapati</i> or 2 <i>phulkas</i>
	1 banana		1 and 1/2 cup rice and <i>mung dal khichdi</i>
<i>Lunch</i>	— 1 <i>chapati</i> or 2 <i>phulkas</i>		1 cup red pumpkin curry
	1 cup rice		1 cup curds
	1 cup <i>dal</i> (<i>tur/mung/masur</i>)		
	1 cup <i>dudhi</i> curry 1 cup curd	<i>Bedtime</i>	— 1 cup milk **

* Vegetables such as *dudhi*, potato and red pumpkin can be used. Omit other vegetables containing excessive fibre and green leafy vegetables. These can be soft-cooked and pureed and then used.

** Improve protein value of the diet by using protein supplements such as protinex, protinules, trophox, resource, spert, etc.

□ Diet in Tuberculosis

Tuberculosis in our country is associated with poverty and unhygienic living conditions. Generally, the lungs are affected but other organs such as lymph nodes, bones, kidneys may also be affected. One crore people suffer from tuberculosis in India today. More than five lakh people die due to tuberculosis every year. Tuberculosis is particularly dangerous to infants and young children.

Pulmonary or lung tuberculosis is accompanied by persistent, worsening cough, spitting of phlegm, fever, exhaustion, wasting of tissue, etc. In many cases it leads to pneumonia which can be fatal, or to a slow wasting disease in the bone causing deformities. Tubercular meningitis (of the brain) can be fatal.

In the acute stage of all types of tuberculosis, the fever may be very high but in the chronic stage the patient's temperature may be only slightly higher than the normal, thereby the rate of metabolism is lower than that in high fevers. So, if there is a persistent loss of weight, cough, rise in body temperature in the evening or

spitting of blood, visit your doctor immediately. It is vital to establish the diagnosis of tuberculosis as quickly as possible, for the earlier the treatment begins, the quicker will be the cure. Tuberculosis can be prevented by taking the following important steps:

1. Administer BCG vaccination to infants.
2. Always eat a balanced diet which need not be an expensive one. It will help enhance the person's resistance to tuberculosis.
3. Personal hygiene, sanitation and keeping the surroundings clean are important.
4. When a person contracts tuberculosis, his personal belongings should be kept separate. Feeding utensils should be kept aside for the sole use of the patient. Great care should be taken of personal hygiene. Medical treatment should be promptly begun and regularly followed. **Tuberculosis is completely curable with proper treatment.**

Dietary Modification The energy needs are markedly increased due to wasting of tissues. A diet providing 3000 to 3500 kcal, about 75–100 g protein and large amounts of calcium and iron (if there is bleeding) and vitamins A and C are advised for fast recovery and quicker tissue regeneration. B-complex vitamins, especially pyridoxine and folic acid, are prescribed in larger amounts. This is so because the drug, isoniazid, which is commonly used in the treatment of tuberculosis, is an anti-metabolite of pyridoxine and prevents folate-dependent reactions. A very widely available natural drink, *neera*, freshly collected and consumed before sunrise everyday is supposed to have beneficial effects for all, and patients of tuberculosis in particular. It is also supposed to help gain weight.

A typical diet for a TB patient (chronic stage) is shown in Table 14.4.

Table 14.4 Diet in tuberculosis (high-calorie, high-protein diet)
(calorie—3000–3500 kcals; protein—75–100 g)

Food Exchange List			
Exchange	No. of Exchanges	Protein (g)	Calories
1. Milk	5	25.0	500
2. Legumes and pulses	3	18.0	300
3. Flesh food	1	10.0	100
4. Vegetable A	2	—	—
5. Vegetable B	2	—	100
6. Fruit	4	—	200
7. Cereals	12	24.0	1200
8. Fats	5	—	500
9. Sugar	50 g	—	200
		77.0	3100

(Contd.)

(Contd.)

Menu Plan

<i>Tea</i>	:	1 cup*	<i>Tea</i>	:	1 cup tea
<i>Breakfast</i>	:	1 glass egg-nog 1 medium banana	<i>Evening</i>	:	1 egg sandwich 1 glass fruit milkshake
<i>Mid-morning</i>	:	1 cheese sandwich 1 glass sweet lime/ orange juice	<i>Dinner</i>	:	1 bowl cream of tomato soup Green salad (lettuce, carrot, beet, radish)
<i>Lunch</i>	:	2 <i>chapatis</i> or 4 <i>phulkas</i> 1 cup rice 1 cup dal 1/2 cup <i>matki/mung usal</i> 1/2 cup parwar-cabbage curry 1 cup curd			1 cup vegetable <i>pulao</i> 2 <i>chapatis</i> or 4 <i>phulkas</i> 1 cup <i>palak paneer</i> 1/2 cup <i>alu chana</i> 1 cup curd

* Fresh neera (unfermented toddy) may be included.

□ DOTS (Directly Observed Treatment, Short Course)

The WHO-recommended Directly Observed Treatment, Short Course (DOTS) strategy was launched formally as the Revised National TB Control programme (RNTCP) in India in 1997 after pilot testing from 1993–1996. Since then, DOTS has been widely advocated and successfully applied.

The Five Elements of DOTS

- Political commitment with increased and sustained financing
- Case detection through quality-assured bacteriology
- Standardized treatment, with supervision and patient support
- An effective drug supply and management system
- Monitoring and evaluation system, and impact measurement

In 2006, the new *StopTB* strategy was recommended internationally by WHO. The components of the new Stop TB strategy are as follows:

- Pursue high-quality DOTS expansion and enhancement.
- Address TB/HIV, MDR-TB and other challenges.
- Contribute to health system strengthening.
- Engage all healthcare providers.
- Empower people with TB, and communities.
- Enable and promote research.

RNTCP is already addressing almost all components of the Stop TB strategy.

DOTS is the most effective strategy available for controlling TB.

More information can be obtained on www.who.int/tb/dots/whatisdots/en/



SUMMARY

Infection with fever is a very common occurrence in our country. Our body is constantly under attack by infectious agents, which are fought back. It is when the

infection overrides the fighting capacity of the body that infection or fever appears. The body has immune systems and other defence mechanisms. Failure of these precipitates infection. The role of nutrition is to maintain and strengthen these defense mechanisms of the body to fight the invading germs.

Precipitated infection, however mild it may seem, can play havoc on the body resources, increasing the need for several nutrients, especially fluids, energy, proteins, vitamins and electrolytes. In case the infection is accompanied by fever, it adds to the nutritional stress since fever increases the metabolic rate, enhancing the energy needs. Fevers of either long or short durations are caused by influenza, typhoid, tuberculosis, malaria, etc.

Easily digestible, nutritionally-rich diet, divided into small servings, taken at frequent intervals during the day is advisable under these conditions.



CASE STUDY

Sex	:	male
Age	:	33 years
Height	:	5 feet 7 inches
Weight	:	47 kg
Activity	:	executive
Diagnosis	:	typhoid

Advise the patient about the following:

1. His diet plan
2. Foods he should avoid
3. Diet during convalescence.

*For the solution, just scan the QR code given here
OR visit <http://qrcode.flipick.com/index.php/238>.*



*Also check out the MCQ's related to this case in the next
QR code OR visit <http://qrcode.flipick.com/index.php/312>.*



REVIEW QUESTIONS

1. List out five non-specific defence mechanisms of the body.
2. What are the effects of infection on the body?
3. Define fever. Why do caloric-needs increase during fever?
4. During typhoid, it is much essential to take care of the texture and consistency of the diet. Why?
5. A tuberculosis patient must be given a high protein diet. Why?
6. Visit the chemist's store and make a list of drugs used in the treatment of T.B. Also list out the protein supplements available in the market.

Chapter

15



Nutrition in HIV and Aids

India is in the early stages of a demographic transition. There appears to be a shift from high birth rates and high death rates to low birth rates and low death rates. This also implies that today, the Indian population is young with a median age of 25.1 years and the mortality and fertility rates are high (WHO, 2008). Due to improvements in basic health care, education, and technologies in several fields, the life expectancy in India has increased with five years in the period 1996 till 2006 to 63 years. There is still an imbalance between the mortality and fertility rates, which results in an estimated 1.6 percent growth annually.

15.1 HIV/AIDS IN INDIA

In 1986, the first case of HIV was diagnosed in Chennai, Tamil Nadu, two years after the start of the epidemic in South-East Asia. India is one of the five countries with the highest HIV burden in this region. The HIV Sentinel Surveillance Report 2005 of the National AIDS Control Organization (NACO) estimated the overall adult HIV prevalence in India to be 0.91%, of which more than half of the adults were living in rural areas and 38% of them were females. In the six states with the highest HIV prevalence it varied from 1.25 to 2.00%.

Although an HIV prevalence of 0.91% seems low, due to the large population, this prevalence translates to the largest number of people living with HIV in the world. Official numbers for children living with HIV in India are not available, although it has been estimated by WHO that it must be more than 170,000 children.

15.2 RELATION OF NUTRITIONAL STATUS AND HIV/AIDS

The relationship between HIV and nutrition is multifaceted and multidirectional. HIV can either cause or worsen malnutrition, which may be due to decreased food intake, increased energy requirements and poor absorption of nutrients. Besides this, malnutrition also weakens the immune system thereby increasing susceptibility of the patient to infections and worsens the impact of this disease.

Figure 15.1 depicts the relationship between Nutrition and HIV.

This vicious cycle can be broken by helping the patients to improve, maintain or slow down the decline of the nutritional status. Malnutrition and HIV are driven by the same factors, such as poverty, conflict and inequality. These are also determinants of food insecurity. Food security plays an important role in the individual's nutritional status.

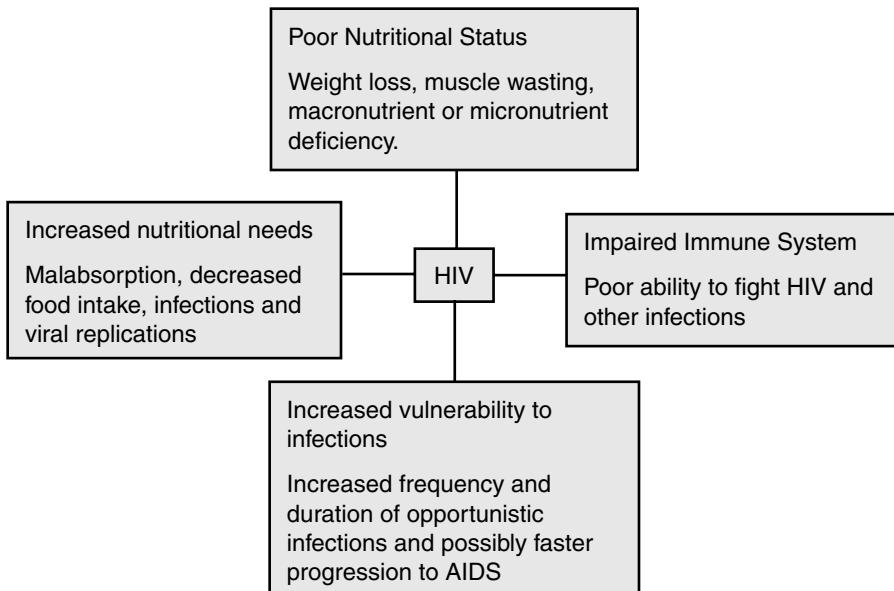


Fig. 15.1 HIV/AIDS and health impacts

* Adapted from Regional Centre for quality of Health Care and FANTA, *Handbook: Developing and Applying National Guidelines on Nutrition and HIV/AIDS*, March 2003. Semb RD and AM Tang, "Micronutrients and the pathogenesis of human immunodeficiency virus infection" *British Journal of Nutrition*, Vol. 81, 1999.

"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

Nutritional status affects the maintenance and optimal functioning of the immune system and therefore, the health status and progression of HIV/AIDS in the patient are closely related. The affected individual can manage his symptoms, boost immune responses and improve adherence and response to Anti Retroviral Therapy (ART) and other medical treatment. Good nutrition can strengthen the immune system and increase the resistance to (opportunistic) infections related to HIV/AIDS whereas poor nutrition has the opposite effect.

On the other hand, HIV/AIDS affects nutrition in the following ways:

1. Reduction in food intake (caused by pain during eating and vomiting, for example)
2. Nutrient malabsorption
3. Metabolic alterations
4. Increased energy and protein requirements

All of these can lead to wasting and other complications. Wasting has long been established as a strong predictor of mortality in HIV-infected patients. In addition, malnutrition can reduce effectiveness and acceptance of medications and other therapies. CD4-T-lymphocytes play an important role in the human immune system. The severity of the HIV infection is often expressed in number of CD4-cells: CD4-count. When available, an HIV infected person is recommended to take Anti Retroviral therapy (ART) when the CD4-count is 200 or less.

A key indicator of chronic malnutrition in children is stunting. A child is too short for his/her age compared to the WHO child growth standards. The cause of stunting can be lack of sufficient, nutritious (including micronutrients) food and recurrence of diseases. Not only is growth impaired, but brain development also slows down. Another type of version is wasting, caused by acute food shortages and worsened by diseases. Globally, approximately 1.5 million children die annually due to wasting. The problems of malnutrition start long before the child is born. The nutrition of the mother, her health status and education and often her status within her family and community determine whether the child will be malnourished or not. Nutritious and healthy food decreases rates of stunting.

Twenty percent of the population in India is undernourished according to FAO, 2006. India has a high prevalence of low birth weight, high morbidity and mortality in children and poor maternal nutrition as indicated by WHO, 2007. The prevalences for stunting and being underweight in Indian children under the age of five years were respectively 47.9 and 43.5 percent in the period 2000–2006. These figures are more than the prevalence for the South East Asian region (respectively 42.0 and 32.8 percent). Combined with the data on prevalence of HIV/AIDS, this is truly a large burden.

The Major and Minor Signs of AIDS classified by WHO are as follows:

Major Signs

- Weight loss greater than 10 percent of body weight;
- Fever longer than one month, intermittent or continuous; and
- Chronic diarrhoea for longer than one month, intermittent or constant.

Minor Signs

- Persistent cough for longer than one month,
- General itchy dermatitis (skin irritation),
- Recurrent Herpes zoster,
- Oropharyngeal candidiasis (fungus infection in the mouth/throat),
- Chronic progressive and disseminated herpes simplex infection, and
- Generalized lymphadenopathy (swelling of lymph glands).

If a person has two major and two minor signs, she or he is diagnosed as having AIDS. It is important to note that these symptoms are also fairly common in various non-AIDS conditions.

Ref: Pathfinder International Technical Guidance Series Number 5, April 2007

15.3 OPPORTUNISTIC INFECTIONS (OI's)

The patient finds himself susceptible to *Opportunistic Infections (OI's)*. OI's are a group of infections that usually affect people with weakened immune systems.

Some common and/important opportunistic infections are:

1. Recurrent, spreading herpes simplex (cold sores)
2. Cuts and grazes that become red, discharge pus and do not heal.
3. Candidiasis (thrush) in the mouth, throat, oesophagus and vagina.

4. Chronic infectious diarrhoea or dysentery (Giardia, which normally affect adults in developing countries, can cause chronic debilitating diarrhoea in HIV-infected adults.)
5. TB is a common co-infection in persons diagnosed with AIDS. HIV co-infection is also common in persons diagnosed with TB.
6. Pneumocystis pneumoniae and other pneumonias
7. Toxoplasmosis
8. Fungal infections such as Cryptococcal meningitis.

15.4 ANTI RETROVIRAL DRUGS (ARV'S)

These are powerful drugs that fight viral infections. They can be used to treat people whose HIV infection has progressed to AIDS via clinical staging or who have a CD4 count less than 200. To be effective, these drugs must be taken for life without a break. The 3 main classes of ARVs are:

1. *Nucleoside Reverse Transcriptase Inhibitors:* Examples are Abacavir, Lamivudine, Stavudine and Zidovudine.
2. *Non-Nucleoside Reverse Transcriptase Inhibitors:* Examples are Efavirenz and Nevirapine.
3. *Protease Inhibitors:* These are used to slow down the reproduction of HIV in newly infected cells and those that have been infected for a long time. Thus, they are used as a second line of treatment, e.g. Saquinavir.

Due to the ARVs, AIDS is no longer a rapidly fatal condition. Instead it can extend the lives of those infected if carefully managed along with multi-faceted support. But it must be remembered that they are powerful drugs that have side effects and can cause damage to the body.

□ Side Effects of Anti-Retroviral (ARV) Drugs

The NRTI class of ARVs can cause

1. Disturbance of the body's chemistry;
2. Liver damage;
3. Peripheral nerve damage leading to "pins and needles," pain, and loss of feeling;
4. Inflammation of the pancreas, and
5. Anaemia.

The ARV drug *Abacavir* can cause a severe hypersensitivity or allergic reaction resulting in a severe lumpy red rash, swelling of the mouth and eyelids, and widespread skin peeling that requires the drug to be stopped immediately. Abacavir must not be used again in people who have previously experienced hypersensitivity to the drug.

Zidovudine may cause flu-like symptoms when first used. It may also cause anaemia and muscle weakness.

ARVs in the NRTI class can cause rashes and liver damage. Efavirenz can cause insomnia (sleeplessness) and vivid dreams, especially in the beginning. Nevirapine can damage the liver and, rarely, cause Stevens Johnsons Syndrome—a severe skin reaction that creates big, fluid filled blisters all over the body.

The PI class of drugs can cause kidney stones, nausea, diarrhoea, and disturbance of the body's chemistry. Serious adverse effects must be recognised in their early stages, such as severe anaemia and neutropenia, neuropathy, pancreatitis, hepatitis and serious hypersensitivity dermatitis with bullae or blisters.

Table 15.1 gives some management techniques for common conditions experienced by patients on ART

Table 15.1 Management of common conditions of patients on ART

Coughing	<ul style="list-style-type: none"> Soothe the throat by drinking tea with sugar or honey.
Diarrhoea	<ul style="list-style-type: none"> Eat small meals more times per day. Try not to eat greasy, spicy, and fatty foods. Try foods such as bananas, and biscuits. Drink a lot of clean water, weak tea, or lemon water. Use oral rehydration solution made according to local guidelines, from sachets of oral rehydration salts, or from salt and sugar, or other starches or sweeteners.
Nausea	<ul style="list-style-type: none"> Eat smaller meals, more times in the day. Try not to eat greasy, spicy, and fatty foods. Try foods like rice, soup, bananas, and biscuits. Drink a lot of clean water, weak tea, lemon water, or fresh ginger tea.
Sore mouth and throat	<ul style="list-style-type: none"> Rinse mouth with clean warm water and salt. Avoid sweets. Avoid things with caffeine such as coffee, strong tea, and some sodas. Eat soft foods rather than hard or crunchy foods. Eat bland, not spicy foods. Use a straw for liquids and soups. This may help when taking in the food needed while preventing it from touching the sore areas. Cold foods, drinks or ice, if available, may help numb the mouth and relieve discomfort.

15.5 MOTHER-TO-CHILD TRANSMISSION AND PAEDIATRIC AIDS CARE

Pregnant women who have symptoms of AIDS or a CD4 count of 200 or less need ART. Today, there is an emerging evidence that if a pregnant woman having CD4 count of 350 is started on ART there is a better chance that the transmission of the virus to the embryo may not take place than when her CD4 count is 200 or less.

Generally, women who are infected with HIV before pregnancy and whose CD4 count is 500 or more have very low rates of transmission of HIV to their child. Besides ART, good nutrition, avoiding infection, and a healthy lifestyle can extend health of the new born.

All infants born of HIV infected mothers are followed up after birth. Up to 18 months of age the infant's blood shows the presence of antibodies to HIV, since they have been passively transfused through the placenta and hence diagnosis of the

child's HIV status can be done only after 18 months of age. However, a virological test known as PCR (Polymerase Chain Reaction) is 98% accurate if done at the infant's 4 to 6 weeks age.

15.6 WHO CRITERIA FOR PRESUMPTIVE DIAGNOSIS OF SEVERE HIV DISEASE IN INFANTS

A presumptive diagnosis of severe HIV disease should be made in infants if these three criteria are present:

1. Confirmed HIV-antibody positive;
2. Aged under 18 months; and
3. Symptomatic with two or more of the following:
 - (a) Oral thrush,
 - (b) Severe pneumonia,
 - (c) Severe wasting/malnutrition, or
 - (d) Severe sepsis.

Other factors that support the diagnosis of severe HIV disease in an HIV-positive infant include:

1. Recent HIV-related maternal death,
2. Advanced HIV disease in the mother, or
3. CD4 < 25%,[@]

15.7 NUTRITION IN HIV

The importance of good nutrition cannot be underestimated in HIV/AIDS. It is necessary to:

1. Delay the onset of opportunistic infections.
2. Boost immunity.
3. Avoid morbidity.

Since, a lot of precautions need to be taken to observe cleanliness and hygiene in the care of an HIV+ person, all possible precautions must be taken by the family and care givers. Since most cases are found in limited resource settings, efforts must be made to maximise the available resources. It is necessary for the person to be active and participate in making a positive contribution to society.

All the nutrients are important in maintaining good health. The energy and protein requirements are met by the staple foods and their products. Of greater importance are the micronutrients, especially. vitamins A and C and trace elements selenium and zinc. Table 15.2 highlights the need for various micronutrients:

[@] Paediatric CD4 counts are given as a percentage of total lymphocyte counts because in children under five years of age the absolute CD4 count tends to vary within an individual child more than the percent CD4. Currently, therefore, the measurement of percent CD4 is thought to be more valuable in children under five years of age. Absolute CD4 counts and, to a lesser extent, percent CD4 values, fluctuate within an individual and values can vary with inter-current illness, physiological changes, timing of test or test variability. Serial measurements are therefore more informative than individual values and also reflect trends over time.

Table 15.2 Important vitamins and minerals for people living with HIV/AIDS

Micronutrient	Role	Source
Vitamin A	Makes white blood cells—essential for vision, healthy skin and mucosa, teeth and bone development. Protects against infection associated with accelerated HIV progression, increased adult mortality, increased mother to child transmission, higher infant mortality and child growth failure	All yellow and orange fruits and vegetables, dark green leafy vegetables, alfalfa, liver, oily fish, dairy products and egg yolk
Thiamine (Vitamin B1)	Important for energy metabolism, supports appetite and nervous system functions	Whole-grain cereals, beans, meat, poultry and fish
Riboflavin (Vitamin B2)	Important for energy metabolism, supports normal vision, health and integrity of skin	Milk, yoghurt, meat, green leaves and whole-grain cereals
Niacin (Vitamin B3)	Essential for energy metabolism, supports health and integrity of skin, nervous and digestive systems	Milk, fish, eggs, meat, poultry, peanuts, whole-grain cereals
Pyridoxine Vitamin B6	Facilitates metabolism and absorption of fats and proteins, helps to make red blood cells	Sweet potatoes, white beans, maize, avocados, cabbage, whole-grain cereals, seeds, Brazil nuts, walnuts, eggs, leafy green vegetables, alfalfa, bananas, legumes, meat and fish
Folate	Required for building new cells, especially red blood cells and gastrointestinal cells	Liver, red meat, green leafy vegetables, fish, oysters, legumes, groundnuts, nuts oilseeds, whole-grain cereals, egg yolks and avocados
Cyanocobalamin (Vitamin B12)	Important for new cell development and maintenance of the nerve cells	Red meat, fish, poultry, seafood, sardines, cheese, eggs, milk, whole-grain cereals and seaweed
Ascorbic acid (Vitamin C)	Helps the body to use calcium and other nutrients to build bones and blood vessel walls. Increases non-haem iron absorption. Increases resistance to infection and acts as an antioxidant. Important for protein metabolism	Citrus fruits (such as baobab, guava, oranges and lemons), tomatoes, sweet peppers, cabbage, green leaves, yams and plantains. Vitamin C is lost during cooking when food is cut up, reheated or left standing after cooking

(Contd.)

(Contd.)

Micronutrient	Role	Source
Vitamin E	Protects cell structures and facilitates resistance to disease	Leafy vegetables, vegetable oils, peanuts, egg yolks, dark green vegetables, nuts and seeds, whole-grain cereals.
Calcium	Builds strong teeth and bones. Aids heart and muscle functions, blood clotting and pressure and immune defences	Milk, green leaves, shrimps, dried fish (with bones), nuts, beans and peas
Iodine	Ensures the development and proper functioning of the brain and the nervous system	Fish, seafood, milk and salt with iodine
Iron	Transports oxygen to the blood, eliminates old red blood cells and builds new cells	Red meat, poultry, liver, fish, beans, some cereals, green leafy vegetables, seeds, whole-grain cereals, dried fruit and alfalfa.
Magnesium	Strengthens the muscles and is important for proper functioning of the nervous system. Involved in bone development and teeth maintenance	Cereals, dark green vegetables, seafood, nuts and legumes
Selenium	Prevents impairment of the heart muscle	Seafood, liver, meat, carrots, onions, milk, garlic, alfalfa, mushrooms and whole-grain cereals
Zinc	Reinforces the immune system, facilitates digestion and transports vitamin A	Meat, chicken, fish, cereals, leafy green vegetables, seafood, oysters, nuts, pumpkin seeds, milk, liver, whole-grain cereals, egg yolks, garlic and legumes

Source: Adapted from Network of African people living with HIV/AIDS [NAP+] (1996).

Besides supplying adequate macro- and micronutrients, the importance of imparting nutrition education is much more necessary.

Table 15.3 specifies the role of Nutrition Education as HIV infection develops.

Healthy and Balanced Nutrition is Important for People Living with HIV/AIDS

Nutritional care and support promotes well-being, self-esteem and a positive attitude to life for people and their families living with HIV/AIDS. Healthy and balanced nutrition should be one of the goals of counselling and care for people at all stages of HIV infection. An effective programme of nutritional care and support will improve the quality of life of people living with HIV/AIDS by:

Table 15.3 Impact of nutrition education in HIV/AIDS

HIV+ Individual	Nutrition education promotes:
No symptoms	<ul style="list-style-type: none"> • positive nutrition practices • practical measures to grow/prepare appropriate foods/protect food security and food hygiene
Immune system weakening	<ul style="list-style-type: none"> • awareness of the importance of recognizing signs of weight loss and the need for prompt action • continued positive nutrition practices
Progression to clinical AIDS	
Weight loss	<ul style="list-style-type: none"> • actions to prevent weight loss and to regain lost weight
Diarrhoea	<ul style="list-style-type: none"> • early treatment of infection
Opportunistic infections	<ul style="list-style-type: none"> • continued eating during infection
Weakening	<ul style="list-style-type: none"> • home remedies for common problems, e.g. loss of appetite, sore mouth, diarrhoea

1. Maintaining body weight and strength;
2. Replacing lost vitamins and minerals;
3. Improving the function of the immune system and the body's ability to fight infection;
4. Extending the period from infection to the development of the AIDS disease;
5. Improving response to treatment; reducing time and money spent on health care;
6. Keeping HIV-infected people active, allowing them to take care of themselves, their family and children; and
7. Keeping HIV-infected people productive, able to work, grow food and contribute to the income of their families.

Sustainable livelihoods and food security are essential to ensure that HIV/AIDS-affected households can face the nutritional needs of affected/infected persons (to face the HIV infection and delay the development of fully-blown AIDS, as they grow weaker and less productive), as well as the needs of the other household members (malnourished individuals are more at risk of infection).

□ Nutrition Requirements for People Living with HIV/AIDS

(Information below is based on WHO Technical Consultation 2003)

Energy Requirements at a Glance

1. Energy requirements are likely to increase by 10% to maintain body weight and physical activity in asymptomatic HIV-infected adults, and growth in asymptomatic children.
2. During symptomatic HIV, and subsequently during AIDS, energy requirements increase by approximately 20% to 30% to maintain adult body weight.
3. Energy intakes need to be increased by 50% to 100% over normal requirements in children experiencing weight loss.

(a) Adults Studies point to low energy intake combined with increased energy demands due to HIV infection and related infections as the major driving forces behind HIV-related weight loss and wasting.

WHO recommends:

- (i) Increased energy intake by 10% to maintain body weight in asymptomatic HIV-infected adults.
- (ii) Increased energy intake by 20% to 30% for adults during periods of symptomatic disease or opportunistic infection. NOTE: This increase may not be feasible during periods of acute infections or illness and might not be necessary due to reduced physical activity.
- (iii) Increased energy intake by 30% during the recovery period. NOTE: Efforts should be made to aim at the maximum achievable to compensate for losses during periods of infections and illness.

Maintaining physical activity is highly desirable for preserving quality of life and maintaining muscle tissue.

(b) Children Energy requirements in children can vary according to the type and duration of HIV-related infections and whether there is weight loss along with acute infection.

WHO recommends:

- (i) Increased energy intake by 10% to maintain growth in asymptomatic HIV-infected children
- (ii) Increased energy intake by 50% to 100% for HIV-infected children experiencing weight loss over established requirements for otherwise healthy uninfected children

(c) Pregnant and Lactating Women

- (i) **Energy** The suggested energy intake for HIV-infected adults should also apply to pregnant and lactating HIV-infected women until updated evidence-based recommendations are provided.
- (ii) **Protein** There is insufficient data at present to support an increase in protein intake for PLWHA above normal requirements for health, i.e. 12% to 15% of total energy intake.
- (iii) **Fat** There is no evidence that total fat needs are increased beyond normal requirements as a consequence of HIV infection.

However, special advice regarding fat intake might be required for individuals undergoing anti retroviral therapy or experiencing persistent diarrhoea.

❑ Breastfeeding Guidelines by WHO (2010)

(Reference: <http://www.who.int/hiv/pub/mtct/PMTCTfactsheet/en/>)

In 2010, WHO released new guidelines on PMTCT and infant-feeding practices. These guidelines aimed to provide the basis for more effective PMTCT interventions in resource-limited settings, and to reduce new paediatric HIV infections. The elimination of Mother-To-Child Transmission of HIV (MTCT) is the public health goal to be achieved through:

- Early anti-retroviral therapy (ART) for a larger group of HIV-positive pregnant women to benefit both, the health of the mother and, prevent HIV transmission to her child during pregnancy and breastfeeding.
- Longer provision of anti-retroviral (ARV) prophylaxis for HIV-positive pregnant women with relatively strong immune systems who do not need ART for their own health. This would reduce the risk of HIV transmission from mother to child.
- Provision of ARV prophylaxis to the mother or child to reduce the risk of HIV transmission during the breastfeeding period. There is enough evidence now for WHO to recommend ARVs while breastfeeding.

In many countries both the available health services and individual mothers are not able to adequately support and provide safe replacement feeding. HIV-positive mothers face the dilemma of either giving their babies all the benefits of breastfeeding but exposing them to the risk of HIV infection, or avoiding all breastfeeding and increasing the risk of death from diarrhoea and malnutrition.

National health authorities should decide whether health services will principally counsel and support HIV-positive mothers to either: breastfeed and receive ARV interventions, or alternately avoid all breastfeeding, which is likely to give infants the greatest chance of HIV-free survival.

According to WHO, in settings where national authorities recommend HIV-positive mothers to breastfeed and provide ARVs to prevent transmission, mothers should exclusively breastfeed their infants for the first 6 months of life, introducing appropriate complementary foods thereafter, and should continue breastfeeding for the first 12 months of life.

Given the importance of breastfeeding as a child-survival intervention, the availability of ARV interventions could make a major contribution to reducing child mortality in the entire community.

□ Micronutrient Requirements at a Glance

- (i) To ensure micronutrient intakes at Recommended Daily Amount (RDA) levels, HIV-infected adults and children are encouraged to consume healthy diets including vegetables and/or fruits.
- (ii) Nevertheless, dietary intake of micronutrients at RDA levels may not be sufficient to correct nutritional deficiencies in HIV-infected individuals.
- (iii) There is evidence that some micronutrient supplements, e.g. vitamin A, zinc and iron can produce adverse outcomes in HIV-infected populations.

1. Adults HIV-infected adults and children should consume diets that ensure micronutrient intakes at RDA levels. However, this may not be sufficient to correct nutritional deficiencies in HIV-infected individuals.

Results from several studies raise concerns that some micronutrient supplements, e.g. vitamin A, zinc and iron, can produce adverse outcomes in HIV-infected populations. Safe upper limits for daily micronutrient intakes for PLWHA still need to be established.

2. Children In keeping with WHO recommendations, 6 to 59-month-old children born to HIV-infected mothers living in resource-limited settings should receive

vitamin A supplements every six months (100,000 IU for infants 6 to 12 months and 200,000 IU for children >12).

3. Pregnant and Lactating Women Iron-folate supplementation: In keeping with WHO recommendations, HIV-infected women should receive daily iron-folate supplementation (400 µg of folate and 60 mg of iron) during six months of pregnancy to prevent anaemia and twice-daily supplements to treat severe anaemia.

However, in view of iron's potential adverse effects (due to its pro-oxidant activity which might accelerate disease progression) research on the safety of iron supplementation in adults and children with HIV infection is recommended.

(a) Vitamin A In keeping with WHO recommendations for areas of endemic vitamin A deficiency, HIV-infected women should receive a single high-dose of vitamin A (200,000 IU) as soon as possible after delivery, but not later than six weeks after delivery.

Research is currently under way to further assess the effect of single dose, postpartum vitamin A supplementation on HIV-infected women.

(b) Multiple Micronutrient Supplements Micronutrient deficiencies are common in resource-limited settings where HIV infection is prevalent. Some studies show that different multiple micronutrient supplements may have produced a broad range of beneficial outcomes.

Pending additional information, micronutrient intakes at the RDA level are recommended for HIV-infected women during pregnancy and lactation.

□ Nutrition and Anti-Retroviral Therapy

ART is an essential component of care for PLWHA but there are a number of metabolic complications associated with the use of certain treatments.

Nutritional interventions should be an integral part of all HIV treatment programs so that improved diet may enhance ART acceptability, adherence and effectiveness.

Resources for Nutrition requirements for people living with HIV/AIDS:

Nutrient Requirements for People Living with HIV/AIDS Report of a technical consultation 31 pages 274 kb

"Recommended Daily Caloric Intake to Help in the Estimation of Additional Caloric Needs"

World Health Organization, Geneva, 13–15 May 2003

□ Conclusion

A range of food and nutrition interventions can be used to address the disease such as strengthening the livelihood activities, giving food assistance, micronutrient supplementation, and nutrition assistance and education counselling which leads to changes in knowledge and availability of resources at the individual and household levels. These in turn influence dietary practices and access to food which would finally lead to improvement of the nutritional status of the affected individual.

Thus, improving food security and nutritional status of HIV affected households, will improve quality of life. In infected children, good nutrition is critical to delaying disease progression of AIDS.



SUMMARY

With cases of HIV and AIDS rising in the country, this is the newer scourge which has affected our society. Victims of this disease are people from all strata of the society, and worst affected are the children, who are the “future” of a country. Malnutrition, starvation and deprivation have already dented the fabric of our society. Social ostracism causes further damage by preventing the infected and affected persons to be productive members of the society.

The relationship between HIV and Nutrition is multi-faceted and multi-directional. Nutrition plays an important role in reducing morbidity and mortality in HIV and AIDS. It can also help in preventing the advancement of Opportunistic Infections (OIs).

The main focus of nutrition in HIV is to strengthen the immune system by providing food security, ensure a clean, healthy and wholesome diet as well as encourage hygienic and sanitary practices.

Since symptoms of malnutrition and emaciation are seen in patients affected by this disease, these should be tackled first. It must be borne in mind that HIV can worsen the symptoms to a point of no return.

Advances in the medical field have produced Anti Retro Virals (ARVs) which can help fight this dreaded disease. However, no medicine can cure a patient unless his nutritional intake is taken care of. ARVs also produce side effects which can be tackled by the nutritionist. Some simple remedies can help alleviate these.

All nutrients play an important role in the management of a disease. However, of particular importance are proteins, vitamins (especially A and C), and trace minerals selenium and zinc.

The role of nutrition education can never be underestimated, more so in helping the survival of an HIV patient. Not only does the patient himself need to know how nutrition can improve his condition but also the caregiver must be well equipped to take good care of the patient.

Ultimately the role of nutrition is to ensure ‘good health’ in an individual so that he continues to be a productive member of the society and does not become a burden on it or the country as a whole.



CASE STUDY

Sex	:	male
Age	:	35 years
Height	:	5 feet 4 inches
Weight	:	43 kg
Activity	:	carpenter, carries his tiffin to work.
Clinical picture	:	Intolerant to high fat foods, undergoing ARV therapy.

How will you help him to:

1. Increase his weight
2. Improve his protein status
3. Prevent opportunistic infections.



REVIEW QUESTIONS

1. Expand the following acronyms: HIV, AIDS, NACO, and ARV.
2. List out the effects of HIV on the health of a person.
3. Why is wasting commonly seen in HIV patients?
4. What are CD4-T lymphocytes? Why are they used as indicators of treatment with ARVs?
5. Why is TB a common co-infection in HIV?
6. What are opportunistic infections? Describe any 2 OIs.
7. Classify ARVs and give examples of each class. Which ARVs are used as second line of treatment?
8. Describe briefly the side effects of ARVs.
9. How will you treat the following side effects:
 - a) Sore mouth and throat
 - b) Nausea
10. Describe the role played by the following nutrients and their food sources:
 - a) Vitamin A
 - b) Vitamin E
 - c) Selenium
 - d) Zinc

References

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3. www.fao.org/docrep/005/y4168e/y4168e00.HTM
4. motherchildnutrition.org/nutrition-hiv-aids/nutrition-living...hiv-aids/nutrition-requirements-for-people-living-with-hiv-

Chapter

16



Diet in other Health Conditions

There are several health conditions in which it is necessary to apply therapeutic benefits of a controlled and planned diet. The scope of this aspect of dietetics is very vast but each and every aspect cannot be discussed here. However, certain health problems like (i) pre- and post-operative care, (ii) gout, (iii) arthritis, (iv) cancer, (v) skin care, (vi) allergies, etc. which are very common have been listed in this chapter. A broad outline of some do's and don'ts will serve as a guideline to the reader.

16.1 TRAUMA

Trauma can be described as the body's response to injury. Examples of trauma are wounds, fractures and burns.

Stress is defined as physical or emotional tension resulting in altered homeostasis with a definitive physiological action.

It is now known that the physiological response to an injury may not be localized but may cause responses which may be in two phases:

1. The ebb or the shock or the acute phase.
2. The flow phase or the adaptive phase.

The body has to attain homeostasis and the faster it does so the quicker is the recovery.

In the ebb phase the neuroendocrine system responds to the injury. It may last between 24 to 72 hours after injury. The characteristics of this phase are that the oxygen consumption decreases, blood glucose levels rise due to hepatic glycogenolysis, lactic acid in the blood rises due to lack of oxygen in tissues, ketogenesis rises markedly, and such other catabolic responses take place.

The flow phase may last between one to three days after injury, depending on the severity of the injury and measures used during the ebb phase. Some characteristics are hypermetabolism such as increased oxygen uptake, increased gluconeogenesis and hepatic glucose output, increased lipolysis and free fatty acid utilization, increased protein breakdown and increased urinary nitrogen excretion, etc.

In general, there is a loss of lean body mass in the flow phase. The cardiac output which was below normal in the ebb phase, increases in the flow phase. Negative nitrogen balance in the patient must now be balanced by proper nutritional input.

Sepsis is not just an exaggerated response to trauma but has quite different effects on energy substrate metabolism. The variability in metabolic and physiologic responses is related partly to the patient's age, previous state of health, preexisting disease, and previous stresses, site of infection, and specific pathogens. Mortality and morbidity rates due to septicemia is as high as 50%.

Starvation is marked by deprivation of the body to nutrients primarily due to lack of availability of nutrients.

The differences in metabolic response to trauma, starvation and sepsis can be seen in Table 16.1.

Table 16.1 Differences in metabolic response to trauma, starvation and sepsis

Parameter	Normal	Trauma	Starvation	Sepsis
Oxygen consumption ml/kg/min	7.0	10.0	6.0	5.0
Serum albumin, g/l	40.0	30.0	42.0	20.0
Urinary nitrogen loss, g	5.0	9.0	3.0	10.0
Ketone body conc. nmol/l	0.2	1.5	2.0	0.05

Nutrition support plan must take into account the following factors:

1. Type and extent of malnutrition
2. Degree of hypermetabolism
3. Protein or calorie requirements
4. Gastrointestinal function
5. Appetite
6. Delivery route
7. Organ dysfunction affecting nutrition restrictions

16.2 NUTRITION IN PRE- AND POST-OPERATIVE CARE

Surgery involves loss of blood and breakdown of tissues. The postoperative period involves rebuilding all that is lost. Survival of a seriously injured person, burn victim or post-surgical patient depends upon the body's ability to handle physical stress, minimize weight loss, overcome mental trauma and meet increased nutritional needs.

□ Prognostic Nutritional Index (PNI)

Overview The Prognostic Nutritional Index (PNI) is a measure of the risk that a patient has of developing a complication such as sepsis or death related to malnutrition.

Parameters:

- (1) serum albumin in g/dL
- (2) triceps skinfold in mm
- (3) serum transferrin in mg/dL
- (4) DH value

$$\text{PNI (percent)} = 158 - (16.6 \times \text{albumin in g/dL}) - [0.78 \times (\text{triceps skinfold in mm})] - [0.20 \times (\text{serum transferrin in mg/dL})] - [5.8 *(\text{DH value})]$$

where:

* DH value is the cutaneous delayed hypersensitivity reaction to a recall antigen (usually mumps, Candida, or streptokinase-streptodornase): 0 if nonreactive, 1 if < 5 mm induration, 2 if ≥ 5 mm induration

Interpretation:

<i>PNI</i>	<i>Risk</i>
< 40	low risk
40 – 49.99	intermediate risk
= 50	high risk

□ Pre-operative Care

Ability of a surgery patient to recover and lead a normal life is much greater, if adequate nutritional care is taken before and after the surgery. When surgery is performed in an emergency situation there is no time to build up adequate reserves before the surgery but when an operation is planned well in advance, the dietitian (if in a hospital) or the person taking care of the patient at home can take adequate measures to ensure a healthy patient before the surgery.

It is seen in several patients that a poor pre-operative nutritional status results in increase of actual morbidity and mortality risk.

A pre-operative diet should provide optimum reserves for the period of surgery itself and for the time immediately following it, when the patient may be unable to take any oral feedings. These nutrient stores must be especially those of protein, calories, vitamins and minerals. In other words, the patient getting ready for surgery must have optimum nutrition.

In general, the patient for surgery should be neither underweight nor overweight, having sufficient glycogen stores in the liver, in positive nitrogen balance (a protein intake of 1.0–1.5 g/kg body weight is sufficient) and devoid of any deficiency of vitamins and minerals. Anaemia, if any, should be corrected. Diabetes should be controlled.

Just before the surgery, i.e. at least eight hours before surgery, the doctor usually advises NBM (Nil-by-mouth). This is done because by the end of eight hours the stomach is completely empty and ensures that the patient does not vomit to bring up food when anaesthesia is administered to him at the time of operation. Moreover, any food present in the stomach and intestines at the time of operation increases the possibility of post-operative gastric retention or expansion or it may interfere with the surgical procedure itself.

□ Post-operative Care

(Post-surgical complications increase with):

1. Pre-surgical malnutrition
2. Underweight 20–30%
3. Obesity
4. Alcoholism
5. Gastrointestinal disorders
6. Increased metabolism due to fever, etc.
7. Fistulas or abscesses
8. Inability to ingest adequate proteins or calories after a week or more

A post-surgery patient is:

1. In negative nitrogen balance
2. Dehydrated with low intravenous fluid volumes
3. Water intoxication if water is replaced without sodium
4. Dumping syndrome (difficulty in tolerating osmotic loads)

The diet in this case has to be limited in carbohydrates; fluids may be given 30 minutes before or after feeding. At least six small feedings may be given.

Vitamin C supplementation may be done but no vitamin E supplementation must be done, since tissue may be repaired in a weakened state.

In this period, nutrition becomes vital in healing and helping the patient recover completely and quickly from the effects of surgery.

This period needs special attention since, loss from the body increases tremendously during surgery and immediately after surgery, food intake is reduced or sometimes even absent for a while.

All the nutrients need special attention. The tissue demands carbohydrates for sparing both protein for tissue synthesis and liver from damage due to depletion of glycogen stores. As in cases of severe burns, the protein requirement may be as high as 250 g per day, which raises the caloric requirement to as much as 4,000–6,000 kcal.

The protein demands are high since it is required for tissue synthesis in healing wounds, to avoid shock, to control swelling, especially at the surgical site, to enhance bone-healing, to resist infection (that is, to form antibodies, blood cells, hormones and enzymes) and to transport lipids.

Fluid requirement may be high. Water loss may be greater during the postoperative period due to vomiting, haemorrhage, exudates (leakage of wounds), diuresis or fever.

Vitamin requirements are increased, especially those of vitamins A and C, for tissue-healing. The requirement for B-complex vitamins thiamine, riboflavin and niacin, which are co-enzyme factors, is increased since the energy needs are increased. Vitamin K is necessary for blood-clotting mechanism, hence, its requirement, too, is increased.

Minerals, especially potassium and phosphorus, sodium and chloride need to be focussed upon since, large areas of tissue as well as water may be lost. Iron deficiency anaemia may develop due to blood loss or from faulty iron absorption.

1. Dietary Management In some surgery cases, if the gastro-intestinal tract cannot be used, intravenous feeding may be resorted to. In such cases, solutions of hydrolyzed protein or amino acids, dextrose and a fat emulsion are available in the market for peripheral intravenous feeding. However, it is important that the patient returns to oral feeding as soon as possible, since it will provide adequate nutrition and stimulate the gastro-intestinal tract. Intravenous feeding cannot replace food in all respects, it can only prevent starvation temporarily.

When oral feedings may not suffice to meet the increased nutrient needs as in the cases of major tissue damage, then hyperalimentation or Total Parenteral Nutrition (TPN) may be used. This means intravenous nutritional support with concentrated solution of the nutrients is needed.

This type of intravenous feeding may continue until the patient is able to consume food and other types of nutrition to obtain adequate nourishment for his increased needs.

When the patient once begins oral feedings, the diet should rapidly progress from clear to full liquid and then to a soft and finally a regular one. (For details see Chapter 7.)

2. Tube Feedings These are indicated in patients who cannot chew or swallow normally at all. Such a condition may arise in the following cases:

- (a) Surgery of head or neck
- (b) Oesophageal obstruction
- (c) Gastro-intestinal surgery
- (d) Severe burns
- (e) Anorexia nervosa
- (f) Comatose condition

Usually, a nasogastric tube is inserted through the nose. In case of oesophageal obstruction, the tube is inserted into an opening made in the abdominal wall which is known as gastrostomy. About two litres of the formula either in the form of a preparation or a food mixture calculated according to the patient's needs may be blended and used. The formula is divided into six to eight feedings at three to four hour intervals in which each feeding should not exceed eight to twelve ounces (250 ml–350 ml).

Prepared formulae are those which are commercially available and need to be simply diluted with water or milk. This type of formula is easy to prepare and administer, but if the concentration of formula is increased to meet the increasing caloric demands of the patient, it may cause diarrhoea. The main requirement of these prepared formulae is that they should be smooth, free-flowing, having controlled viscosity. Hence, they often need to be prepared with enzymes such as amylase. A formula prepared by calculating the desirable ratio of nutrients in a diet may be better accepted by the patient since he feels that he is being fed his regular food. Usual ingredients include a milk base, with addition of egg, strained meat, vegetable, fruit, fruit juice, non-fat dry milk, cream, brewer's yeast and ascorbic acid.

16.3 NUTRITION IN GOUT

Gout is a disease generally observed in middle-aged and older men and postmenopausal women. It is characterized by high levels of uric acid in the blood and sodium salts of uric acid in joints, cartilages and kidneys.

Plasma level of uric acid in normal individuals is 2–5 mg% but in those susceptible to gout it is more than 7 mg% and may even go up to 20 mg%. There may be attacks of acute inflammatory arthritis which is often the reason for which they approach the doctor. Inflammation and severe pain of the joints especially the metatarsal, knee and toe joints may be experienced.

Dietary Treatment

During acute attacks, a low purine diet is often recommended. Sometimes, purine intake may be restricted even during the quiescent period. In the body purines are oxidised to uric acid which is normally excreted in urine.

Foods containing purines are shown in Table 16.3. Foods that need to be especially controlled are all flesh foods and extractives prepared from them such as gravies and soups.

Table 16.2 Foods rich in purines

Sweet breads*	Dried beans	Mushroom	Alcoholic beverages
Anchovies	Dried peas	Cauliflower	Chocolate
Sardines	Dried lentils	Spinach	Cocoa
Liver			Tea
Kidney			Coffee
Brain			
Pancreas			
Lamb, Bacon			
Pork, Beef			
Meat extracts			
Meat gravies			

Foods Containing Insignificant Amount of Purines

Vegetables	Cereals	Miscellaneous
Beetroot	Maize	Butter, oil
Brinjal	Rice	Cheese
Cabbage	Wheat	Cream
Calabash cucumber		Egg
Carrot		Fruits of all kinds
Cucumber		Gelatin
Lady's finger		Milk
Lettuce		Nuts
Potato		Sugar and sweets
Pumpkin		Tapioca
Sweet potato		Yeast
Tomato		
Turnips		

* Means thymus gland or pancreas of animal.

The general nutrient control should be the following:

1. Energy Obese patients suffer the acute symptoms of gout more severely. It is necessary to control weight. However, weight loss regime should be discontinued

during acute attacks since, catabolism of adipose tissue reduces the excretion of uric acid. A gradual weight loss on a 1,200 kcal diet for women and 1600 kcal diet for men is generally satisfactory.

2. Protein, Fat and Carbohydrate Protein in diet must be about 1g per kg body weight. Fat may be supplied not more than 60 g daily. High amounts of carbohydrates may be supplied so that the fatty tissue of the body is not excessively catabolized.

3. Fluids Daily fluid intake may be a little more than normal, i.e. about three litres. More fluid intake may help flush out uric acid. Tea and coffee may be given in moderate amounts. Fruits and vegetables may be consumed in liberal amounts so that the urine is neutral or near alkaline.

16.4 NUTRITION IN ARTHRITIS

This disease experienced by middle-aged and elderly persons, mainly affects the joints and restricts their movements.

The most common form of arthritis is osteoarthritis or rheumatoid arthritis. Joint stiffness is the characteristic of this illness. Pain in joints, especially when in motion or when bearing weight, is experienced. Generally, joints of the fingers, knees, hip and spine are affected.

Several types of anti-inflammatory treatments ranging from aspirin to steroid therapy have been found to bring relief. However, no single cure can be pinpointed for this debilitating illness.

Dietary Modification If the patient is obese, he may be required to decrease his weight in order to reduce the weight stress on his joints.

Side effects of the drugs taken to reduce the pain such as aspirins or steroids are seen in many patients, such as gastric irritation or even ulceration. In such cases protein and alkali mineral foods may be given to abate these side effects.

If sodium retention is seen, then mild sodium restriction in the form of a 1,000 mg sodium diet may be prescribed. Milk may be taken in liberal amounts. Acid foods should be avoided.

16.5 NUTRITION IN CANCER

Today, all over the world cancer is a dreaded disease. Every cancer is different. Studies on animals show that diet plays an important role in preventing cancer. Fibre, which has been described under the topic of Cellulose in Chapter 3, is an apt example. Its role in preventing colon cancer cannot be underestimated. Cancer means neoplasm and malignant tumour. There is growth disturbance with excessive and unnecessary cell proliferation. When localized, it might not produce serious illness or invade other tissues, and is said to be *benign*. If the cells multiply rapidly and invade other tissues it is said to metastasize and the cancer is termed *malignant*. Incidence of cancer of the lung, large intestine and breast has increased. High intake of fat has been indicated as a risk factor in the incidence of breast and colon cancer. A high intake of meat is also known to increase the risk of colon cancer.

Drinking alcohol regularly in large amounts and smoking are two habits which are associated with cancers of the mouth, pharynx, larynx, oesophagus and lungs. In our country, chewing the *paan* or *paan supari* tobacco habitually is said to lead to oral cancer. There are several nutrients like vitamins C and A, factors in pure *ghee* and scores of other substances which have been known to exert anti-cancer effects and hence help to protect the body from cancer.

Spices such as garlic and mustard seeds are said to have anti-cancer properties. Cruciferous vegetables such as horseradish, kale, collard greens, Chinese broccoli, cabbage, Brussels sprouts, kohlrabi, broccoli, cauliflower, Chinese cabbage, turnip root (*shalgam*), rutabaga, garden cress, watercress, radish, wasabi contain glucosinolates which in turn are converted into a number of chemicals which may have anti-cancer properties. For example, 3,3'-diindolylmethane (DIM) in Brassica vegetables is found to protect against human prostate cancer cells. Cruciferous vegetable consumption correlates with low cancer rates and are found to promote cell death in breast, prostate, endometrium, colon, and white blood cancer cells.

It is thus felt that a diet consisting of large amounts of fresh fruits and vegetables, providing plenty of anti-oxidants, vitamin C, lycopene, beta carotene and also including lean meat, fish in a wholesome, balanced meal will help prevent and fight cancer.

Cancer is a degenerative disease, frequently complicated by anorexia and resulting in malnutrition. Metabolic disorders and side effects of medications and treatments such as chemotherapy, radiotherapy and surgery result in depletion of nutrient stores and poor nutritional status. Improving the nutritional status can reduce morbidity and mortality. A well-balanced, nourishing diet is necessary to maintain the strength and resistance required to combat the disease and enhance the effects of treatment. Aggressive nutrition therapy can mean the difference between life and death, since several patients die from starvation than from the disease itself.

1. Effects of Cancer A cancer patient needs careful handling since his physiologic, psychologic, and emotional state is imbalanced. The fast growing malignant tissue extracts maximum nutrition from the available nutrient food, thus starving the body. In addition, the general food intake is reduced, he suffers from depression and morbidity and his digestive and absorptive functions may be impaired. His nutritional status may be further degenerated by treatments such as surgery, radiation therapy, chemotherapy and immunotherapy. The cancer patient is generally malnourished and difficult to treat.

2. Dietary Modification The diet of a cancer patient must be tailored according to the type of therapy being given. Every therapy has its side effects which may lead to impairment, either to the patient's ability to eat, chew or swallow, or absorption of the nutrients. There are several side effects which may be avoided by some diet modifications and are listed in Table 16.3.

Nutrition management is highly individualized depending on the type and degree of the disease. Increased taste threshold for sweets or dislike for certain foods needs special care in meal management.

Granulocytopenic patients have increased susceptibility to infections. They are advised to consume a reduced bacteria diet. No fresh fruits and vegetables are

Table 16.3 Some side effects of cancer therapy and suggested diet modifications

<i>Side effects</i>	<i>Diet modifications</i>
Nausea and Vomiting	Clear, cold and carbonated beverages Sipping beverages slowly using straw Small and frequent meals Low fat in the diet Salted dry foods Arrowroot biscuits before rising Cold food especially desserts like fruit salad, jelly Fluids half-an-hour to one hour before meals.
Loss of appetite	Small, frequent feedings. High-calories, high-protein foods and beverages.
Sore mouth and throat	Soft, neutral or low acid foods. Blended and liquid foods. All foods and beverages at room temperature. Use straw for liquids. No highly seasoned foods and <i>masala</i> preparations.
Swallowing problems	Liquid feeds, tube feeds in some cases. Frequent feeds Addition of fats like oil, <i>ghee</i> , butter and margarine to foods to aid swallowing. Food finely chopped.
Early feeling of satiety or fullness	Small frequent meals. No liquids half-an-hour to one hour before meals. Foods high in fats and rich sauces must be omitted from diet. Chewing foods slowly and eating well.
Dry mouth	Increase in fluid intake. Vegetables and other preparations with gravy.
Alterations in taste of food	Delicate use of spices and condiments and mild seasonings.

allowed. They can consume only processed foods, cooked foods, and sterile water served in disposable dishware.

Parenteral and enteral support is required for patients with increased needs for energy and protein that cannot be met by oral intake. Product taste, osmolality, digestibility and specific disease taste determine the use of formula.

In parenteral feedings:

1. The caloric intake must be 40–45 calorie per kg per day.
2. The protein intake must be 1.5 g per kg per day, to achieve a positive nitrogen balance.
3. Fat emulsions are isotonic which give 1.1 calories/gram and the essential fatty acids.
4. Long-term TPN requires an intake of vitamins K, B12, folic acid and iron via another route of administration. There must be no abrupt change in the modalities of route of feeding, but it must be gradual, progressing from parenteral to parenteral + enteral to enteral + food and then to food.

The advantages of nutritional and dietary therapy are many.

1. It can improve and maintain the nutritional status.
2. It prevents weight loss.
3. It reduces the risk of infection and decreases morbidity and mortality.
4. It minimises the side effects of drugs and increases its effectiveness.

The most important aspect to be remembered is maintenance of weight. Modifications in texture and composition of food may be made. Various modifications in the texture, consistency or composition are outlined in Chapter 7 which may be the basis of these alterations.

Generally, attention needs to be paid to protein which may be incorporated through high protein formulae as well as by use of protein-rich foods like meat, fish, eggs and poultry, milk and pulses.

16.6 NUTRITION AND SKIN CARE

A child has a glowing and clear skin. As it grows older and approaches teenage, the skin shows several changes and at this juncture, if adequate diet and rest are not taken, the teenager develops acne and pimples which mar his appearance.

The relationship between diet and skin health and appearance is well seen by the urticarial eruptions which occur due to the circulation of a foreign or toxic protein in the blood stream. Foods that are particularly associated with urticaria especially in susceptible individuals are shellfish, strawberries, eggs, meat, etc. This reaction may be due to their decomposed products or due to penetration of protein material into the blood stream without proper digestion or to allergy on the part of the individual concerned. In this case, the skin has been the first to indicate that all is not well with the functioning of the body.

Many a times skin is first and sometimes the only indicator of a deficiency in the diet. Vitamins and certain food factors are associated with skin health.

Vitamin A deficiency is seen by hyperkeratosis involving deposition of keratinous material in the hair follicle and on the skin in general.

Vitamin A avitaminoisis is much more common than is supposed and various skin lesions that are classified under hyperkeratosis are invariably associated with sub-optimal supply of vitamin A.

Riboflavin or vitamin B₂ is of value in treatment of eczema of the scrotum and of the angles or the mouth. Reddened lesions of the lips and fissures in the angles of the mouth are symptoms of riboflavin deficiency.

Niacin is useful in prevention and treatment of dermatitis of the disease pellagra wherein skin becomes inflamed and eczematous. These lesions are usually symmetrical. All these three vitamins are constituents of enzymes, hence their relationship to the skin and mucous membranes is not surprising.

Pyridoxine or vitamin B₆ is found to be amazingly effective in treating seborrhoeic dermatitis, atopic eczema with seborrhoeic features and eczematous eruptions of unknown etiology.

Of all the vitamins, pantothenic acid or the chick anti-dermatitis factor has been of *cosmetical* prominence because of its claimed properties as an *anti-grey hair*

vitamin. In rats and mice, either pantothenic acid or para amino benzoic acid can cure achromotrichia. However, there is no evidence that human beings too can be treated in the same way.

Vitamin C or ascorbic acid is a clinical necessity for the rapid and healthy healing of wounds and to prevent scurvy which is also manifested on the skin.

Vitamin D has given dramatically favourable results in the treatment of cutaneous TB and hence shows for the first time that a vitamin therapy may cure a condition which is not due to a vitamin deficiency.

Calcium is also believed to be associated with certain forms of urticaria.

Magnesium deficiency in the rat produces vasodilation and hyperaemia of exposed skin areas.

Essential fatty acids have also been found to play an important role in skin health.

From all these observations, one can realize the importance of good nutrition for a healthy skin. It is important to maintain a good and clean skin. Teenagers generally ignore a good diet and eat all types of junk foods, oily, spicy, appealing to the tongue but repugnant to a clean and glowing skin. This affects their intake of a well-balanced diet. Changes occurring in the hormones of their body also cause pimples to appear on their skin.

Acne and pimples make their way as eruptions on the cheeks, and the forehead. Such eruptions can be minimized if the diet contains plenty of fresh fruits and vegetables, wholesome cereals and pulses, and moderate intake of fat foods.

A glowing skin reflects the condition of physical fitness of a well-nourished individual.

16.7 FOOD ALLERGY, INTOLERANCE AND SENSITIVITY

Allergy, a word coined by V Pirquet in 1906, means altered reactivity. The term *allergy* is now used to denote a condition of hypersensitivity in human beings attributable to some underlying antigen-antibody reaction.

1. Definitions

- (a) *Food allergy* or *hypersensitivity* means an adverse immunological response to a specific substance in food which produces the characteristic symptoms after the food is eaten.
- (b) Food sensitivity is a slightly broader term applied to conditions in which an abnormal reaction occurs after the consumption of specific foods. In such cases an immunological etiology is likely but not proven.
- (c) Food intolerance is different from the former two in that it does not involve an immunologic mechanism. It may be due to an enzyme deficiency or other factors.
- (d) Allergen is the substance which is responsible for initiation of the allergy. Usually, it is a protein but sometimes it is seen that a polysaccharide or a substance that binds to a protein to form a complex becomes the active allergen.
- (e) Common food allergens are present in milk, eggs, wheat, citrus fruits, chocolate, cola, legumes, corn, fish, shellfish and some spices.

- (f) Antigens are large molecular compounds, either proteins or polysaccharides. When small molecules become antigenic they probably first react chemically with body proteins, which in this way are rendered *foreign* to the body.
- (g) Antibodies are formed in the body in response to the introduction of an antigen.

Mostly all globulins are antibodies. They are manufactured in the spleen, lymph-node cells and in bone marrow by special cells rich in RNA, called plasma cells.

The following are the predisposing factors:

- (a) Heredity.
- (b) Physical or emotional stress. This increases the severity of the allergic reaction.
- (c) Frequency of eating the food containing the allergen.
- (d) The amount of allergen-containing food eaten.
- (e) The physical state of the food.

2. Reactions Allergic reactions may often be sub-divided according to the time taken to manifest symptoms of the reaction. They are: (i) immediate and (ii) delayed hypersensitivity.

In most people, food antigens are destroyed in the gastro-intestinal tract. In atopic (familial allergy) individuals, i.e those with a predisposition to allergy, repeated exposure to the allergen causes the allergen to be absorbed intact from the gastro-intestinal tract and enter the blood circulation.

Four types of immunoglobulin reactions are seen—I, II, III and IV or IgA, IgE, IgG and IgM, respectively.

Type I This is an immediate reaction to food allergy or hypersensitivity. It is observed that symptoms are produced within minutes, or a few hours following consumption of food and such a reaction occurs everytime that the allergen-containing food is eaten.

Effects are generally seen on blood vessels, smooth muscle and mucous glands to produce symptoms immediately after exposure to even a small quantity of the allergen. They usually clear up within 24–48 hours.

Types II and III The reactions are not due to food hypersensitivity. Other allergens like inhalants (dusts, pollens, fungi, smoke, perfumes, odours of plastics), drugs (aspirins, antibiotics, serums), infectious agents (bacteria, virus, fungi, animal parasites), contactants, (chemicals, animals, plants, metals) and physical agents (heat, cold, light, pressure, radiations) cause these.

Type IV It is a delayed cell-mediated response. The reaction occurs 24–72 hours after exposure to the allergen and may last for several days. This type may be involved in some cases of gastro-intestinal food sensitivity or intolerance. It is more difficult to diagnose a delayed food allergy than an immediate one.

It is important to note that the reaction time of an individual towards a given substance always remains the same.

Local anaphylactic reactions are asthmatic attacks produced by ingestion of certain foods such as strawberries or shell-fish.

Systemic anaphylactic reactions usually begin with itching and flushing of the skin, followed by severe dyspnoea due to laryngospasm and bronchospasm, and a profound fall in blood pressure. These reactions can be fatal. Rapid relief may often be obtained by administration of adrenaline and i.v. antihistamine drug.

□ Symptoms

These may be produced in any part of the body, on the skin, on the gastrointestinal or respiratory tract or may even be neurologic.

1. Skin Canker sores, dermatitis, oedema, rash, fever, blisters, pruritus, urticaria and flushing of the skin are seen.

2. Gastro-Intestinal Tract Cheilitis, stomatitis, colic in infants, abdominal distension and pain, constipation, diarrhoea, dyspepsia, nausea and vomiting may be seen.

The symptoms are suggestive of appendicitis, colitis, gall bladder disease or ulcers and due to these symptoms there may be confusion in the diagnosis.

3. Respiratory Tract Allergic rhinitis, asthma, bronchitis, and nasal polyps may be seen.

4. Neurologic It is indicated by anxiety, fatigue, headache, irritability, muscle and joint aches, restlessness, stomach pains and others.

5. Miscellaneous Anaphylactic reactions (described earlier), arthralgias and oedema have been seen to be due to food allergy.

As seen earlier, food allergy is more commonly seen in children than in adults. Many adults who complain of food allergy claim that they had suffered from allergy in their childhood as well. A person with a food allergy also tends to be allergic to one or more of the following:

Pollen dust, mould, wool, cosmetics, and other inhalable items.

□ Testing a Food Allergy

A food allergy may be diagnosed by the Case history of the patient, Skin tests, other tests, and Restricted diet.

1. Case History of the Patient This is the most important of all the methods of diagnosis of an allergy. If the allergic reaction is an immediate one, the patient finds no difficulty in locating the allergen. However, in case of delayed reactions this is not so easy and it is necessary to evaluate the physical status and the circumstances preceding the attack.

For this, the patient is asked to keep a detailed diary to note all the foods eaten and the occurrence of any symptoms of allergy. The details should include all the foods liked or disliked by the patient. This is because a liked food which may be causing allergy in a patient may be eaten while another patient may exclude a food from his diet because he dislikes it.

2. Skin Tests These tests are not so relevant in food allergies as they are in respiratory allergies.

- (a) *Scratch tests* in which a minute quantity of allergen is applied into scratches made on the skin.
- (b) *Patch tests* in which the antigen applied on a filter paper is placed on a prepared area of skin and covered.
- (c) *Intradermal tests* in which the diluted antigen is injected under the skin.

Reactions to all the above skin tests are checked immediately and at intervals of 24–48 hours.

These tests are not very reliable in detecting food allergies since, symptoms of a food allergy may be manifested not in the skin but in other tissues.

3. Other Tests Measuring the immunoglobulin levels in the body is another way of testing and diagnosing an allergy. It has been observed that serum IgE levels of an individual allergic to milk are elevated.

4. Restricted or Elimination Diets In this type of diagnosis, a restricted diet is fed for about three weeks in which the different foods to which the patient may be allergic are eliminated from the diet and included at an interval of three days, one by one simultaneously, observing for symptoms.

A number of elimination diets have been developed such as diets from which cereals, fruits, wheat, eggs, milk, corn, soya, etc. are excluded.

16.8 BURNS

A burn is a damage to the body's tissues caused by heat (dry or wet), chemicals, electricity, sunlight or radiation. The most common causes of burns are scalds from hot liquids and steam, fires in buildings, and inflammable liquids and gases. Breathing smoke can cause inhalation injury which can damage the respiratory system.

There are three types of burns:

1. *First-degree burns* which damage only the outer layer of skin
2. *Second-degree burns* which damage the outer layer and the layer underneath
3. *Third-degree burns* which damage or destroy the deepest layer of skin and tissues underneath

According to Body Surface Area (BSA) affected, burns may be classified as:

1. Small: less than 15 to 20% of BSA is affected (First degree)
2. Intermediate: 20 to 40% BSA is affected (Second degree)
3. Severe: more than 40 to 50% BSA is affected (Third degree)

According to the thickness of the skin, burns may be classified as:

1. *Partial thickness*: In this condition, the epithelial layer is still present which can spontaneously re-epithelialize.
2. *Full thickness*: In this condition, all epithelial remnants are destroyed; hence, it is necessary to use skin grafts.

The damage due to burns can vary from being relatively mild, namely swelling, blistering, scarring, but in serious cases, can result in shock and even death. Burns can also lead to infections because they damage the skin's protective barrier.

Treatment for burns depends on

- (a) the cause of the burn,
- (b) how deep it is, and
- (c) how much of the body it covers.

Antibiotic creams can prevent or treat infections. But for more serious burns, treatment under continuous medical supervision would be needed to keep the wounds clean, replace the skin, and ensure that the patient has enough fluids and nutrition.

The purpose of diet management is:

1. To support respiration and circulation until skin cover is restored, BMR is normal, fluid and electrolyte balance is normal, blood volume is normal and ultimately the nutritional status is normal.
2. To prevent infection.

If the burns are extensive and the person is malnourished prior to trauma then the energy requirements may be 30 to 300% more, especially while grafting is underway. Patients, whose burns are in small area and are in good health prior to trauma, would have no nutritional problems.

Nutritional Management

A severe burn is not only painful and traumatizing for the patient but puts a lot of stress on the body. The increased metabolic response associated with a severe burn surpasses that of any other disease state. A burn patient needs a high-calorie, high-protein diet to promote wound healing, minimize the risk of complications and maintain a normal nutritional level.

1. Calories Calorie needs increase significantly after a burn. The average, healthy adult needs about 1,800 to 2,000 calories per day, but after a burn, this same adult may need at least 2,500 calories. If a burn patient is unable to consume enough food to meet these calorie needs, liquid nutritional supplements may be needed. These supplements should be taken between meals so as not to decrease the patient's appetite during the meals.

2. Protein After a burn, the body breaks down muscles to obtain energy for the healing process. Protein is also lost through the burn wounds. The breakdown of protein can exceed 150 grams per day. Lack of adequate protein in the patient's diet can lead to decreased wound healing, loss of muscle mass and decreased immune function. Burn patients require a minimum of 1.5 to 2 grams of protein per kilogram of body weight, which would be approximately 100 to 130 grams of protein per day for a 65 kg man. The dietitian must preferably provide a diet rich in Class I proteins.

3. Carbohydrates Carbohydrates should be the main source of energy for burn patients, since wounds use glucose for energy, which is provided by carbohydrates.

Increasing carbohydrate intake will ensure the body does not turn to protein for energy. Instead, the amino acids from protein are spared and used to rebuild muscle instead. Carbohydrates also provide glucose for increased metabolic demands of the body as a whole.

4. Fat Fats should provide essential fatty acids needed for healing as well as extra calories required to compensate for increased metabolic demand. Too much fat can compromise the immune system, making healing more difficult. Fat intake should not exceed 30 percent of calories.

5. Other Nutrients In addition to increased calorie and protein needs, a burn patient may need additional vitamins and minerals— specifically iron, zinc, selenium and vitamins A, C and D. Low levels of these vitamins and minerals have been linked to decreased wound healing and suppression of the immune system. Beef, spinach and nuts provide zinc, iron and selenium. Sweet potatoes, spinach, red pumpkin and carrots are high in vitamin A, and vitamin D needs can be met through consumption of fish like swordfish, salmon and fortified food products. Citrus fruits like lemon, oranges, sweet lime, berries, amla, provide good amounts of vitamin C.

Nutritional requirements are as follows:

1. Calories: $25 \times \text{body weight (kg)} + 40 \times \% \text{ BSA affected}$.
2. Protein: 2–4 g/kg of body weight per day.
3. Supplements are required; especially requirement for vitamin C and zinc increase in burns.
4. Serum potassium must be monitored or else hypokalemia can occur. Calcium intake must be high.

16.9 DIET IN INBORN ERRORS OF METABOLISM

More than 3000 inherited metabolic disorders have been described in literature. Several of them are rare, but a substantial number make significant contribution to morbidity and mortality, especially in childhood. A few of them can be treated with therapeutic diets. An attempt has been made to enable the nutritionist to understand some of the more common hereditary metabolic disorders.

□ Diet Therapy for Genetic Diseases—Dietary Restrictions

1. Amino Acid Disorders

- Phenylketonuria (PKU)
- Urea cycle disorders
- Arginosuccinic acidurias
- Organic acidurias
- Maple syrup urine disease
- Homocystinuria
- Hereditary tyrosinaemia type I
- Branched-chain amino acid disorders

2. Carbohydrate Disorders

- Galactosemia
- Hereditary fructose or lactose intolerance
- Glycogen storage disorders
- Carbohydrate malabsorption diseases

3. Others

- Favism
- Hyperlipidaemia

Dietary intervention can help by:

- Preventing the accumulation of a substrate and its derivatives, e.g. a low phenylalanine diet in PKU.
- Providing a metabolite, which becomes rate limiting due to a metabolic block, e.g. arginine is given in argininosuccinase deficiency.
- Provide a cofactor or precursor, e.g. pyridoxine is given for a type of homocystinuria.
- Provide a metabolite whose deficiency is dangerous, e.g. hypoglycaemia can be prevented with dietary modifications in glycogen storage disease.

The skill of the dietitian in planning these diets is to plan and prepare diets, which will be consumed by the patient in spite of some everyday items being absent, and some unfamiliar substitutes in their place.

□ Amino Acid Disorders

1. Phenylketonuria Successful management of a genetic disorder by dietary manipulation is best illustrated by the classic example of phenylketonuria (PKU). It has been shown by the North American Collaborative study that elimination of phenylalanine from an infant's diet with defect even up to 65 days after birth, leads to near normal mental development (IQ of 100 for PKU patients compared to normal siblings at eight years of age). It has revolutionized the practice of clinical genetics.

PKU is a single gene determined by autosomal recessive disorder. It occurs with a frequency of approximately 1 in 12000 births. The biochemical defect is either an absence or marked deficiency of the enzyme phenylalanine hydroxylase, which is responsible for conversion of phenylalanine into tyrosine. Because of deficiency of the enzyme, there is marked increase in blood levels of phenylalanine. The accumulated phenylalanine is catabolized into phenyl pyruvic acid, phenyl acetic acid and phenyllactic acid, which are excreted in urine, hence, the name of the disease. However, a better term, now more popular, is hyperphenylalaninaemia since it may exist without phenylketonuria. In reality, it is a group of disorders.

In most developed countries, infants are screened for PKU by measurement of blood phenylalanine level during newborn period either by a fluorometric or a microbiological assay.

An affected patient presents with mental retardation, eczema, hypopigmentation (fair complexion) and neurological deficits (hypertonia, irritability, agitated behaviour, tremors, hyperactivity and occasionally seizures). Exact mechanism that

causes neurological abnormalities and mental retardation is not known. It is believed to be related to interference with functioning of metabolic pathways within the nervous system by raised levels of phenylalanine and its metabolites.

Dietary therapy in the form of reduced phenylalanine intake, if instituted very early in life, has been shown to be effective in preventing mental retardation in PKU patients. Ideally, phenylalanine restricted diet should be started within 30 to 90 days of birth. Long-term studies from USA, UK and Canada have shown that continuation of such a diet for six to eight years results in significant improvement in intelligence, comparable to normal siblings.

A phenylalanine blood level of 2–10 mg% is considered satisfactory for achieving normal mental development without affecting growth.

Maternal hyperphenylalaninemia during pregnancy results in offspring who may suffer from mental retardation, microcephaly and congenital heart disease. A majority of mothers with blood phenylalanine concentration above 20 mg during pregnancy have at least one mentally retarded child. It is recommended that dietary treatment should be started prior to proposed conception.

Although, theoretically management of PKU by diet appears simple, yet it is quite difficult in practice. Ideally, monitoring of blood levels is essential to keep phenylalanine levels optimally low.

One has to use synthetic protein substitutes (amino acids and peptides) to achieve exclusive limits; on the other hand, various natural sources of food are preferable to make the diet more palatable and acceptable. It has also to be ensured that the diet is adequate in essential and non-essential amino acids, fatty acids, calories, minerals and vitamins, and trace elements according to age-related requirements. Aspartame, an artificial sweetener, is known to be hydrolyzed into phenylalanine in the gut and should be avoided.

2. Maple Syrup Urine Disease It is rare with an incidence as low as 1:1,00,000. It is inherited as an autosomal recessive disorder. There is a genetic deficiency of the dehydrogenase complex.

There is accumulation of branched chain alpha keto acids and leucine, isoleucine and valine. Patients present with severe acidosis and hypoglycaemia.

Treatment involves use of high caloric diet with limited amounts of leucine, isoleucine and valine. Thiamin (10–100 mg/day) may be helpful in stabilizing dehydrogenase complex.

3. Homocystinuria This is another amino acid disorder characterized by mental subnormality, lens displacement, skeletal abnormalities and thrombocytic disorders. It is caused by deficient activity of cystathione synthetase causing impaired conversion of homocystine to cystathionine, resulting in accumulation of homocystine, methionine and other sulphur containing metabolites, accompanied by low level of plasma cystine. Other amino acid disorders are listed in Table 16.5.

□ Carbohydrate Disorders

Galactosemia This is another genetic disorder, which is correctable by dietary manipulation. Classic galactosemia occurs due to deficiency of galactose-1-phosphate uridyl transferase, which metabolises galactose to glucose. There is

elevation of galactose-1-phosphate in blood and tissues, which causes hepatic damage. There is also elevation of galactose, galactitol and galactonic acid in blood and urine. Galactitol elevation is considered responsible for cataracts. This disease is transmitted as an autosomal recessive trait. Newborn screening programmes have shown its prevalence to be 1:60,000.

Table 16.4 *Organic acidurias*

<i>Disorder</i>	<i>Dietary Therapy</i>
Isovaleric aciduria	Low protein/leucine, high glycine
3 Methyl-crotonyl glycinaemia and combined carboxylase deficiency	Large doses of biotin, i.e. 10 mg/24 hrs.
3 Hydroxy-3 methylglutamic aciduria	Low protein/leucine
2 Methyl-3 hydroxybutyric aciduria	Low protein diet
Glutamic aciduria	Riboflavin restrict protein/glutarogenic amino acids
Pyroglutamic aciduria	Treatment with bicarbonate
Medium and Long Chain Acyl-Coa Dehydrogenase Deficiency	Carbohydrate snacks prior to bed time
Propionic aciduria	Biotin 10 mg/24 hrs. Dietary restriction of propiogenic amino acids or proteins
Methyl malonic aciduria	Vitamin B ₁₂ restriction of proteins or propiogenic amino acids

Clinical manifestations are distinctive in that they develop after feeding is started. The child may refuse the food, there is vomiting and diarrhoea and the child fails to thrive. Other manifestations are hypotonia, lethargy, jaundice, hepatomegaly, susceptibility to infection with gram-negative organisms, cataracts and physical and mental retardation. Haemolysis may occur. The child may develop acidosis and there is secondary renal aminoaciduria. Clinical course is usually fulminant.

Treatment consists of excluding milk-containing product from diet, which are the main sources of lactose and galactose. Various milk substitutes are available in the form of caesin hydrolysates and soyabeans formulae. The diet may be relaxed after puberty but the restrictions need to be reinstated during pregnancy. The adequacy of treatment is monitored by red blood cell galactose 1-phosphate levels, which are acceptable up to 100 ug/g of haemoglobin. Galactose restriction is highly effective in preventing early death due to hepatocellular damage and sepsis. It is compatible with good general health and normal physical development.

Deficiency of a second enzyme galactokinase also causes galactosemia and galactosuria but the clinical course is much milder. Major manifestations are cataract and pseudo-tumour cerebri. Treatment is the same, i.e. exclusion of lactose and galactose from the diet. It should be instituted early to avoid cataract.

□ Glycogen Storage Disease

This is a group of disorders resulting from deficiency of different enzymes in the catabolic pathway of glycogen metabolism. It leads to severe hypoglycaemia, even

after brief periods of fasting. Other manifestations include hyperlactic acidaemia, hyperuricaemia, and raised levels of triglycerides and cholesterol (hyperlipidaemia). The children are short statured, have hepatomegaly and may have bleeding diathesis. Treatment is aimed at maintaining euglycaemia by frequent carbohydrate feeds during daytime and an infusion of concentrated glucose or high carbohydrate formula at night via naso-gastric tube.

16.10 NUTRIGENOMICS

Nutrition research is investigating on how nutrition can optimize and maintain cellular, tissue, organ and whole-body homeostasis. This requires an understanding of how nutrients act at the molecular level which in turn involves a multitude of nutrient-related interactions at the gene, protein and metabolic levels. As a result, nutrition research has shifted from epidemiology and physiology to molecular biology and genetics giving birth to "Nutrigenomics".

There is growing interest in *nutrigenomics* or *nutritional genomics* due to its potential for modifications of food or diet to support health and reduce the risk of diet-related diseases. This is an emerging field that tends to unfold the role of nutrition on gene expression and is based on the science of bioinformatics, nutrition, molecular biology, genomics, epidemiology and molecular medicine.

Nutrigenomics brings along with it, its terminology, novel experimental techniques and a fundamentally new approach to nutrition research, which requires technologies that enable the global study of gene expression in a cell or organism.

Nutritional genomics is the study of diet-gene interactions on a whole genome scale. It aims at developing innovative solutions to disease prevention, diagnosis and treatment. Nutrigenomics involves the characterization of gene products, their physiological function and interactions. It focuses on the effect of nutrients on genome, proteome, metabolome and explains the relationship between specific nutrients and nutrient-regimes on human health.

Since a long time, examples of diet-gene interactions affecting human health have been known such as lactose intolerance, phenylketonuria, galactosemia, gluten-sensitive enteropathy and familial hypercholesterolemia. In these classic inborn errors of metabolism, disease-specific genetic polymorphisms have been identified, their population distributions are known and clinical dietary guidelines are developed in order to prevent the disease as well as treat it. Other than these diseases, many common chronic diseases such as obesity, diabetes, cardiovascular disease, breast cancer and prostate cancer, are also associated with diet as a risk factor. However, the genetic background of these polygenic diseases is much more complex and the explanations of the diet-gene interactions will be possible only with the recent advances in post-genomic technologies. For example, the chemopreventive properties of a soy-based polypeptide are being investigated on human cells and small animal models. It has been shown to remodel chromatin structure and to affect genes which are related to tumour suppression, apoptosis, cell-cycle control and DNA repair. Hence, it gives humankind hope that diet could help prevent cancer. The ultimate aim of this emerging field of science is prevention rather than cure.



SUMMARY

In this chapter, diets in various conditions such as pre- and post-operative care, gout, arthritis, etc. are dealt with. There are many such illnesses which may be treated by a therapeutic diet but only a few important ones have been illustrated.

Importance of diet therapy cannot be underestimated whether it is restricting purines in the diet to give some relief to a gout patient, or minimizing the symptoms of a patient being treated for cancer.

Problems which may seem trivial but which cannot always be ignored, such as acne and pimples, may also be controlled by a proper diet.



CASE STUDIES

Sex	: female
Age	: 58 years
Height	: 5 feet 6 inches
Weight	: 53 kg
Activity	: sedentary
Diagnosis	: breast cancer
Symptoms	: anorexic and has difficulty in swallowing
Treatment	: undergone mastectomy, chemotherapy and radiation therapy
Clinical picture	
Blood protein level	: 5.3 g/dl
Serum albumin	: 3.7 g/dl

What measures will you take to improve her nutritional status and prevent cancer cachexia?



REVIEW QUESTIONS

1. What is lactose intolerance? What are its causes? How is it detected?
2. Name five metabolic disorders.
3. What role does diet play in pre- and post-operative care of patients?
4. Name five foods which are rich in purines. Which foods will you advise as substitutes for those foods?
5. What are the side-effects of cancer therapy? How does diet help to alleviate them?
6. What are the predisposing factors of food allergy?
7. Which are the most common allergies that you have come across in your own circle of friends, relatives and acquaintances?



Section 3 MALNUTRITION AND ASSESSMENT OF NUTRITIONAL STATUS

- **Chapter 17** The Assessment of Nutritional Status
- **Chapter 18** Malnutrition and Nutrition Programmes

Chapter

17



The Assessment of Nutritional Status

Nutritional assessment is essential in order to:

1. Identify the undernourished or overnourished state of an individual or a community and estimating the optimum energy and nutrient intake to promote growth and well-being.
2. To gauge the prevalence of malnutrition in the clinical setting, which is found to be high, in the range of 48 to 50%. Also it is associated with suboptimal surgical outcome, increased rate of infection, longer hospital stay, impaired wound healing, frequent hospital readmission for the elderly, more frequent post-operative complication and increased risk of death.
3. To plan health programmes.

A number of public health problems afflict a large population of the world. In order to improve the situation, several numerical measurements are required in order to act as a baseline. It is then possible to assess the progress being made in any public health programme.

17.1 NUTRITIONAL ASSESSMENT OF A COMMUNITY

There are three main aims of nutritional assessment of a community. They are:

1. To judge the magnitude and geographical distribution of malnutrition.
2. To know the effect of ecological factors that may directly or indirectly be responsible.
3. To suggest corrective measures especially with the participation of the affected community.

Besides, it is important for the community to be aware of the problem and the government may be required to make financial provision for its prevention.

17.2 METHODS OF ASSESSMENT OF NUTRITIONAL STATUS

The nutritional status can be assessed by two methods:

1. DIRECT
 - (a) Anthropometric methods
 - (b) Biochemical methods
 - (c) Clinical methods
 - (d) Dietary procedures

2. INDIRECT

Malnutrition may be manifested as four forms of pathology:

- (a) Under-nutrition—Ref. Chapter 1.
- (b) Specific deficiency-relative lack or absolute lack of an individual nutrient.
- (c) Over-nutrition—Ref. Chapter 1.
- (d) Imbalance among essential nutrients.

In the underdeveloped countries, health problems are related to malnutrition more so due to under nutrition, specific deficiency and imbalance.

17.3 NUTRITIONAL ANTHROPOMETRY

This technique is concerned with the measurement of the physical dimensions and the gross composition of the human body at different age levels and degrees of nutrition.

It requires well-organized research centres, elaborate equipment and highly sophisticated mathematical knowledge. The interpretation of findings is complex and often controversial.

The human body and its growth is influenced by various biological determinants including sex, intra-uterine development, birth order, birth weight, parental size, genetic constitution, environmental factors such as climate, socioeconomic level, etc.

The physical dimensions of the body are influenced by nutrition, especially the rapid growth period of childhood. Valuable information can be gleaned from selected body measurements particularly in case of malnutrition in which the body size and gross body composition are affected. Bacterial, viral and parasitic infections can affect growth and physique. In some cases it may be difficult to differentiate these factors from symptoms of secondary nutritional consequences. This is especially evident in kwashiorkor which is generally not exclusively dietary in origin but a complex syndrome caused by other stresses on the body such as intestinal helminthes as well as bacterial and viral infections, persistent malaria and psychological trauma associated with weaning.

It is necessary to select those methods of anthropometry depending on the purpose and objectives of the survey. It is necessary for the nutritionist to keep in mind that this tool is of greatest value in the assessment of growth failure and malnutrition.

Calibration of suitable instruments must be done before using them. The most desirable or optimal anthropometrical values or standards are not known with certainty for any community. Also the nutritionist needs to remember the general trend of the local community and prepare and use local standards for different ethnic groups with potentially different patterns of growth. Once the baseline data has been prepared, the interpretation of clinical signs becomes more accurate.

For children, the nutritionist must collect optimum data from the children of the truly well-fed, medically and socially protected families and use it for constructing local standard. In the early years of growth, standards for boys and girls may be considered together, since, except sub-cutaneous fat thickness there is not much difference in other commonly used measurements.

The Harvard standards should be used for weight and height measurements in young children. For school children, where weight or height for age are required, the Baldwin Wood Standards would be useful.

For adults the weight for height tables are derived by ICNND (1963). These are given in Appendix VIII. Tables for triceps, skin-fold, arm circumference, etc. are also given in Appendix VIII.

As far as possible, local anthropometric standards should be prepared and used as a yardstick, which would be considered as a more realistic goal.

To interpret anthropometric data accurately, it is necessary to record the age of the children accurately by a combination of dental eruption, head circumference, local calendar and presence of siblings.

The measurement techniques used are the following:

1. Weight This is the most common anthropometric method. It is useful in detecting PEM since, it is one of the best indicators of growth failure in all age groups. It is necessary to take into account length, frame size, proportions of fat, muscle and bone and the presence of pathological weight due to oedema or splenomegaly.

A sturdy, inexpensive, easily transportable and accurate scale must be used. It must be checked frequently. Beam balances must be preferred to spring balances. For weighing very small children the butcher's steelyard is an ancient, simple and inexpensive weighing apparatus.

Young children should be weighed nude. For older preschool age children who are large and more active, the mother should be weighed alone and weighed again with the child.

For school children and adults, the platform beam balance is mostly used. Weighing should be avoided after a full meal. Ordinary, simple clothes must be worn while weighing.

Weight assessment in community investigations is concerned with determining degrees of underweight mainly resulting from PEM in developing countries. One such assessment is given below.

Gomez Classification of Malnutrition in Children

Overview The child's weight is compared to that of a normal child (50th percentile) of the same age. It is useful for population screening and public health evaluations.

$$\text{percent of reference weight for age} = [(\text{patient weight}) / (\text{weight of normal child of same age})] \times 100$$

Percent of reference weight for age	Level of Malnutrition	Grade
90–110%		normal
75–89%	mild	Grade I
60–74%	moderate	Grade II
< 60%	severe	Grade III

Limitations oedema consequent to malnutrition increases the body weight, resulting in an interpretation less severe than warranted.

References Jackson A A, Golden MHN. Severe malnutrition. 8.12–8.29. IN: Weatherall D J, Ledingham J G G, Warrell D A. *Oxford Textbook of Medicine*, 2nd ed. Oxford University Press. 1987.

Interpretation of the results obtained of this anthropometric method must take into account the weight of muscle, fat, bone and internal organs as well as pathological circumstances of oedema, ascites, massive organ enlargement and even the helminthes burden in severe ascariasis.

2. Linear Measurements

Two common measurements are:

- (a) Height (or length) or the whole body
- (b) Certain circumferences especially of head and chest

(a) Height (or Length) of an individual is made up of the sum of four parts—legs, pelvis, spine and skull.

In field nutritional anthropometry, only the total weight is measured. For older children and adults, a vertical measuring rod or a scale fixed to a wall can be used. The height must be measured without shoes and the subject must stand on a flat floor by the scale. His feet should be parallel with the heels, buttocks, shoulders and back of head touching the upright portion of the scale. The head should be comfortably held erect. The arms should be relaxed and held in a natural manner. The headpiece should be either a metal bar or a wooden block and lowered slowly so as to touch the hair and make contact with the top of the head.

For infants and preschool children, the crown-heel length or recumbent length must be measured. This is usually carried out with a wooden length-board. The child is laid on the board, the head is positioned firmly against the fixed headboard, the knees are extended and feet are flexed at right angles. The upright sliding footpiece is moved to obtain firm contact with the heels. The length is then read off. Given below is the **Waterloo Classification of Malnutrition in Children**.

Waterloo Classification of Malnutrition in Children

Overview Chronic malnutrition affects a child's growth, eventually resulting in reduced stature (stunting). Malnutrition also affects the child's body proportions, eventually resulting in body wastage.

$$\text{percent weight for height} = [(\text{weight of patient}) / (\text{weight of a normal child of the same height})] \times 100$$

$$\text{percent height for age} = [(\text{height of patient}) / (\text{height of a normal child of the same age})] \times 100$$

	<i>Weight for Height (wasting)</i>	<i>Height for Age (stunting)</i>
Normal	> 90	> 95
Mild	80–90	90–95
Moderate	70–80	85–90
Severe	< 70	< 85

References: Jackson A A, Golden MHN. Severe malnutrition. 8.12–8.29. IN: Weatherall D J, Ledingham J G G, Warrell D A. *Oxford Textbook of Medicine*, 2nd edn. Oxford University Press. 1987.

(b) Head Circumference It is a standard procedure for infants and children. It can be used to detect pathological conditions with certain accuracy. It is mainly related to the brain size but it also includes the thickness of the scalp and the skull.

Nutritional status causes changes to occur in these parameters.

The chest to head circumference ratio is of value, especially in detecting PCM in early childhood. The head circumference can be used as rough guide in age assessment.

A narrow, less than 1 cm, flexible, non-stretch tape either made of steel or fibre can be used to measure. Cloth tapes stretch in use and hence, must be avoided.

(c) Chest It is of practical field use especially in the second and third year of life. At 12 months of age both these measurements are the same but later the skull grows slowly and the chest more rapidly; therefore, a chest/head circumference ratio of less than 1 may be due to failure to develop.

17.4 SOFT TISSUES

The brain, liver, heart, kidney and other internal organs make up most of the body weight but are relatively unchanged in malnutrition. Muscle and fat constitute the soft tissues that change with a deficiency of protein and calories.

These measurements are valuable in field anthropometry.

1. Subcutaneous fat can be determined using:

- (a) Physical and chemical analysis (as in whole body analysis at autopsy)
- (b) Ultrasonics
- (c) Densitometry (such as water displacement in a densitometer or underwater weighing)
- (d) Gaseous uptake of fat-soluble gases
- (e) Radiological anthropometry (using soft-tissues exposures)
- (f) Physical anthropometry

Of all the methods listed above, physical anthropometry is practicable in field circumstances. Also, the correlation between caliper measurements, radiological findings and direct measurements at surgical separations is good.

The caliper used should have a standard contact surface or 'pinch area' (20–40 mm²), should read up to 0.1 mm accuracy and exert a constant pressure (10 g/mm²) through the whole range of skin-fold thicknesses at all distances of separation of the jaws. The Harpenden calipers, the large calipers and the USAMRNL calipers are used normally.

Generally, the left side of the body must be used for this measurement. To calculate the total body subcutaneous fat: measurements can be made at the biceps, triceps, the abdomen and subcapsular and subcostal sites as well as supriliac thigh and calf regions.

2. Muscle Poor muscle development or muscle wasting are typical features of all forms of PEM, especially if one has suffered it in childhood. In older children muscle mass could be increased with exercise. Muscle may be judged using various techniques:

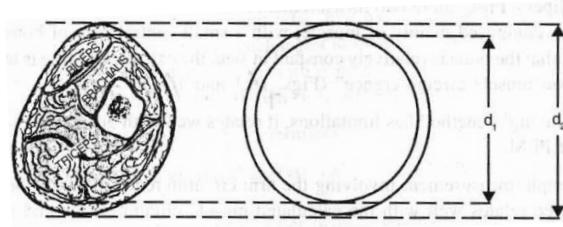
- (a) Total:**
 - (i) by body analysis (at autopsy)
 - (ii) by measuring body radioactive potassium
 - (iii) by chemically analysing urine.

- (b) *Localized:* by soft tissue radiology of the body, particularly by physical anthropometry.

The most practical method, especially in the field, is by measuring the muscle mass of a limb by direct physical anthropometry. The two portions which are used are roughly circular and heavily muscled, i.e. the mid-calf and the mid-upper arm. The latter is most convenient as this region is easily accessible. A flexible steel or fibreglass tape may be used. Two measurements are taken—one, while the mid-arm is hanging freely at its mid-point and the other while the over-lying subcutaneous fat is measured in the triceps region with skinfold calipers. From these two measurements one can calculate the inner circle, which is composed mainly of muscle, with a small central core of bone. Assuming that the bone is relatively constant in size, the calculated value is termed “mid-arm muscle circumference” (Figs. 17.2 and 17.3).



Fig 17.2 Measurement of mid-upper-arm circumference



Measurements are made of arm circumference C_1 and triceps skin-fold S . Let d_1 = arm diameter and d_2 = muscle diameter. Then skin-fold $S = 2 \times$ subcutaneous fat $= d_1 - d_2$, and arm circumference $C_1 = \pi d_1$. Now, muscle circumference $C_2 = \pi d_2 = \pi [d_1 - (d_1 - d_2)] = \pi d_1 - \pi(d_1 - d_2)$. Hence, $C_2 = C_1 - \pi S$.

Fig. 17.3 Calculation of mid-upper-arm-muscle circumference

Although, the method has limitations, it relates well with general manifestations of PEM.

A simple measurement involving the arm circumference may also be used since, it co-relates well with the calculated muscle circumference and is also reduced in all severe forms of PEM. Approximate general standards are given in Appendix VIII.

17.5 BIOPHYSICAL METHODS

1. Radiographic Examination This is not feasible in routine examination but is valuable to carry it out if the physical signs and other circumstances suggest that rickets, osteomalacia, fluorosis or beriberi may be present, e.g. active rickets can be identified with widened concave (cupped), rarefied, frayed distal ends of long bones, usually the radius and ulna.

2. Tests for Physical Function These are devised to determine deviations in visual acuity, dark-adaptation of the eyes, capillary fragility, nerve accommodation, physical performance (dynamometry, etc.), muscle coordination, etc., in different deficiency states.

The most widely used test is the dark-adaptation since vitamin A deficiency is a very common one and this test can be used objectively to evaluate the complaint of night-blindness.

3. Cytological Test Assessing the buccal smears have shown a good correlation with malnourished children. Cornified and non-cornified cells can be differentiated by the colour reaction to Schorr's Stain. The buccal smears from healthy children show 60–70% non-cornified cells while in PEM, this proportion drops to about 20% or less.

17.6 BIOCHEMICAL TESTS

Blood and urine are the two fairly easily available body fluids, which are used in biochemical assessment of the nutritional status. A wide range of tests can be used for assessing malnutrition but it is necessary to use those tests that are feasible in rural field conditions. Ideally, the samples should be easily collectable, stable during transport, not affected by a recent meal or by water load and capable of giving information which is not already available by non-biochemical techniques.

In all surveys, the expected value of results by a particular method in assessing the nutritional status must be weighed against the problems of collection, transport, laboratory analysis and interpretation. Also, it must be remembered that a few do not have set "standards" for the less advanced forms of malnutrition.

One must select the appropriate biochemical test depending on the type of survey being carried out. It is important to bear in mind that the results of biochemical tests in a community must be correlated, with all the other findings, viz clinical, anthropometric, dietary and ecological.

□ Interpretation of Biochemical Tests

The accuracy of the biochemical tests depend upon the standards of collection, methods of transport and storage, including possible exposure to ultraviolet light, heat and shaking as well as the actual technique used, including laboratory control using control sera.

It must be remembered that knowledge of the unique metabolism of each particular nutrient, including its storage in the body, the possibility of synthesis and the mode of excretion must also be taken into consideration.

1. The Nutrient Supply to the Body It is reflected by its levels in a particular tissue mostly the serum, e.g. ascorbic acid. However, it may also be reduced due to poor absorption, impaired transport, abnormal utilization or a combination of all these. While this measurement is of value in suggesting the possibility of malnutrition, it does not indicate the presence or define the degree of nutritional disease.

2. The Metabolic Changes These could be resulting from tissue malnutrition due to inadequate levels of essential nutrients of long duration. These biochemical tests indicate a state of deficiency with greater certainty than does a mere lowering of tissue concentration of essential nutrients.

The results must be compared with the standards of reference appropriate for the age and sex. In most cases results obtained from normal well-fed healthy groups are used to prepare the normal range and compared with the results from patients clinically ill due to the particular form of malnutrition. Refer Tables 17.1 and 17.2. The results must always be mathematically expressed, including the number examined, the means (averages), SD, and in numbers and percentages in convenient groups.

Nutrients generally examined biochemically are:

- (a) Proteins
- (b) Vitamin A
- (c) Vitamin D
- (d) Ascorbic acid
- (e) Thiamine (Refer Table 17.3)
- (f) Riboflavin (Refer Table 17.4)
- (g) Niacin
- (h) Iron (Refer Table 17.5)
- (i) Folic acid (Refer Table 17.5)
- (j) Vitamin B₁₂ (Refer Table 17.5)
- (k) Iodine.

Also refer Tables 17.6 and 17.7

Table 17.1 Suggested guide to interpretation of urinary vitamin excretion data, young adult males*

	Low	Deficient
N ¹ -Methylnicotinamide:		
mg/6 hours	0.2–0.59	<0.2
mg/g creatinine	0.5–1.59	<0.5
Riboflavin:		
mcg/6 hours	10–29	<10
mcg/g creatinine	27–79	<27
Thiamine:		
mcg/6 hours	10–24	<10
mcg/gm creatinine	27–65	<27

* The urinary values indicated are based on an average creatinine coefficient of 23 and on expected excretion of 1.5 g/day of creatinine by a 65 kg man.

Reproduced by permission from ICNND (1963).

Table 17.2 Suggested guide to interpretation of blood data, young adult males*

	<i>Low</i>	<i>Deficient</i>
Serum albumin: g/100 ml	2.80–3.51	<2.80
Serum ascorbic acid: mg/100 ml	0.10–0.19	<0.1
Serum vitamin A: mcg/100 ml	10–19	<10
Serum carotene: mcg/100 ml	20–39	<20

* Reproduced by permission from ICNND (1963)

Table 17.3 Tentative guide for the interpretation of thiamine excretion in children*

<i>Age (years)</i>	<i>"Low" thiamine excretion (mcg/g creatinine)</i>	<i>"Deficient" thiamine excretion (mcg/g creatinine)</i>
1–3	120–175	<120
4–6	85–120	<85
7–9	70–180	<70
10–12	60–180	<60
13–15	50–150	<50

* Adapted by permission from Pearson (1962).

Table 17.4 Tentative guide for the interpretation of riboflavin excretion in children*

<i>Age group (years)</i>	<i>"Low" riboflavin excretion (mcg/g creatinine)</i>	<i>"Deficient" riboflavin excretion (mcg/g creatinine)</i>
1–3	150–499	<150
4–6	100–299	<100
7–9	85–269	<85
10–15	70–199	<70

* Adapted by permission from Pearson (1962).

Table 17.5 Haemoglobin levels below which anaemia can be said to exist, and associated packed cell volumes (pcv%) found in iron deficiency*

<i>Age (years)</i>	<i>Sex</i>	<i>Hb (g/100ml)</i>	<i>PCV%</i>
0.5–4		10.8	32
5–9		11.5	33
10–14		12.5	37
Adults	Male	14	42
	Female	12	36
	Pregnant female	10	30

* Reproduced from WHO Study Group on Iron Deficiency Anaemia (1959).

Table 17.6 Serum vitamin B_{12} concentrations in humans

Serum B_{12} level ^a (mmg/ml)	Interpretation
200–960	Range in normal healthy subjects
140–200	Diagnostically indeterminate
80–140	Equivocal: in non-anaemic patients such levels probably indicate early B_{12} deficiency
< 80	Levels in anaemic patients with B_{12} deficiency and in patients with neurological complications of B_{12} deficiency

^a Assayed with *Euglena gracilis*.

Table 17.7 Interpretation of serum *L. casei* folate levels

Level (mmg/ml)	Interpretation
< 3	Folate deficiency
3–6	Probable folate deficiency
6–20	Normal
>25	Elevated

17.7 CLINICAL METHODS

This is one of the most practical and important method used in assessing the nutritional status of a community.

External examination of the body for changes in superficial epithelial tissues especially skin, eyes, hair and buccal mucosa may be carried out. Similarly, organs close to the surface of the body may be examined, e.g. the parotid and thyroid glands.

It may be necessary to supplement these methods by certain physical tests. The main advantage of this method is that since, it is based on observation of physical signs, it is relatively inexpensive and does not require any elaborate field equipment or even a laboratory.

Clinical assessment can give very valuable but approximate information to the public health worker. It is an effective tool where severe malnutrition prevails.

Since interpretation is based on observations of signs of deficiency diseases, one must not be confused by identical appearances. For example, angular stomatitis resulting from ariboflavinosis could be confused with the changes at the corner of lips caused by excessive chewing of the paan (this contains large amount of irritant lime). Or Bitot's spots which are pathognomonic of vitamin A deficiency may be mistaken since, they also occur in certain eye infections.

Most signs of malnutrition are not specific to lack of one nutrient and can often be produced by various non-nutritional factors.

If these signs are associated with biochemical and other tests, it may help to identify the lacking nutrient/nutrients responsible. Table 17.8 shows some biochemical tests which are useful when conducting nutrition surveys.

The physical signs recorded must always be defined as precisely as possible. This will enable a fair comparison between the findings of different observers all over the world.

Table 17.8 Biochemical tests applicable to nutrition surveys

<i>Nutritional deficiency</i>	<i>First category^a</i>	<i>Second category</i>
1. Protein	Amino acid imbalance test Hydroxyproline excretion test (F) Serum albumin Urinary urea (F) ^b Urinary creatinine per unit of time (T)	Serum protein fractions by electrophoresis
2. Vitamin A	Serum vitamin A Serum carotene	
3. Vitamin D	Serum alkaline phosphatase (in young children)	Serum inorganic phosphorus
4. Ascorbic acid	Serum ascorbic acid	White blood cell ascorbic acid Urinary ascorbic acid Load test
5. Thiamine	Urinary thiamine (F) ^b	Load test Blood pyruvate Blood lactate Red blood cell haemolysate transketolase
6. Riboflavin	Urinary riboflavin (F) ^b	Red blood cell riboflavin Load test
7. Niacin	Urinary N-methylnicotinamide (F) ^b	Load test Urinary pyridone (n-methyl-2-pyridone-5-carbonamide)
8. Iron	Haemoglobin Haematocrit Thin blood film	Serum iron Percentage saturation of trans ferrin
9. Folic acid Vitamin B ₁₂	Haemoglobin Thin blood film	Serum folate (<i>L. casei</i>) Serum B ₁₂ (<i>E. gracilis</i>)
10. Iodine		Urinary iodine (F) Tests for thyroid function

^{*} Adapted from WHO Expert Committee on Medical Assessment of Nutritional Status (1963).^a Urinary creatinine used as reference for expressing other urine measurements in first category.^b Expressed per gram of creatinine.

(F) In a single urine specimen, preferably fasting.

(T) In timed urine specimens.

It is important to remember that the appearances of some nutritional signs are difficult to describe with scientific precision and objectivity.

After completion of clinical assessment, it may be useful to conduct therapeutic trials so that it is possible to establish the identity of a deficiency syndrome or to differentiate between two conditions with similar clinical manifestations. For example, nutritional anaemia can be confirmed from the effectiveness with which it responds to treatment as seen from the rise in the red blood cell count and haemoglobin level. Such a trial can also be carried out at the end of a survey or as part of a follow-up.

17.8 DIET SURVEYS

Diet surveys are a practical way to assess the energy intakes of groups of a population. It is very difficult to obtain accurate information about what people actually eat. In most food surveys, the subjects tend to under-report their consumption levels. Dietary assessment is a blanket term for any method used in diet surveys. In India, the following techniques have been used to conduct diet surveys in various states. The details of the dietary patterns of various states can be obtained from the relevant literature and Diet Atlas of India.

Nutrient profiles of foods are important for the following purposes:

1. For dietitians and physicians to plan menus for both regular and therapeutic diets.
2. To evaluate national and regional household food consumption.
3. To study an individual's food intake for relatively brief period of time as an index of his diet.

The techniques may be of two types:

- A. Qualitative
- B. Quantitative

1. Interview Technique This technique is widely used by dietitians to obtain a general picture of a person's food intake. It requires a skilled interviewer who is able to elicit an accurate picture of the diet history. It involves asking more or less detailed type of questions. A typical question would be "What do you usually eat for breakfast, lunch, or dinner?" or "What did you have for breakfast today?" Diet history rarely goes beyond a day or two since, people do not accurately remember what they ate yesterday or the day before yesterday. A checklist of foods may be used to remind the subject about foods that they eat but forget to mention. Some types of interview techniques used are as follows:

(a) Diet Recall In this method, the actual food and drink consumed in the immediate past 24 hours is recorded. Sometimes, a longer period may be used.

(b) Diet History This is a detailed method of recording the intake. The subject is interviewed for about one to two hours and the typical or usual food intake is noted. It is possible to construct a seven-day eating pattern of the subject. Most of the questions are open-ended. This technique may be supplemented with a checklist of foods usually consumed.

(c) FFQ [Food Frequency (and amount) Questionnaire] This type of survey is either interviewer administered or self-completed. A detailed questionnaire includes the list of foods and the subject answers as to how often and in what quantity each food is eaten per day, per week and per month.

(d) Study Specific Dietary Questionnaire This consists of a set of predetermined questions. It may be interviewer administered or self-completed.

2. Record Technique This is the ideal and realistic method used in dietary intake studies. This technique involves a record of actual food and drink consumed on specified days after the first contact by the investigator. Generally, a seven-day record is maintained. Food eaten by the subject during a period of usually one week is weighed and recorded together with any plate waste. The nutritive value of the food is then calculated using nutritive value tables. A major drawback of this technique is that it requires a considerable degree of motivation and cooperation on the part of the subject. It is an intrusive method and time consuming; hence, it may deter a busy person.

(a) Menu Record No quantities of foods are specified but the frequency of consumption of each food is recorded. The investigator assigns average weights to portions consumed. This method does not attempt to identify the true weights of individual portions.

(b) Estimated Record In this method, portions of foods consumed are described in household measures such as cups, spoons, *katoris*, etc. This gives the actual quantity eaten by the subject.

(c) Weighted Record (Weighed Inventory Technique) By this method, a record of foods in terms of weights of portions as served and the plate waste is recorded.

(d) Precise Weighed Record This method maintains a detailed record of all ingredients used in the preparation of meals, also inedible waste, total cooked weight of meal items, cooked weight of individual portions and plate waste.

(e) Cardiff Photo Record In this method, the food on the plate is photographed and the portions are quantified by comparison with reference photographs of portions of known weights.

(f) Semi-Weighed Method for Measuring Family Food Intake The total quantity of food served to a family is weighed and quantities served to individuals are given in household measures.

3. Techniques of Direct Analysis

(a) Duplicate Diets In this method, the subject keeps a weight record and duplicate portion of each food as consumed is put aside for later analysis by the investigator.

(b) Aliquot Sampling Technique It is similar to duplicate diets except that aliquot samples of food as consumed by the subject are kept aside for later analysis.

(c) Equivalent Composite Technique In this method also, a weighed record is maintained. Subsequently, a combined sample of raw food equivalent to average amounts of foods eaten is made up by the investigator for the analysis.

(A) Front of card

Paediatric Card for children Ages 0–4 years.

READ INSTRUCTIONS BEFORE USING

DATE		NAME					<input type="checkbox"/> Boy		AGE		CARD NO.	
							<input type="checkbox"/> Girl		—yrs —mo			
LOCATION		AREA OF ORIGIN				<input type="checkbox"/> Rural		<input type="checkbox"/> Other siblings examined		<input type="checkbox"/> Informant not mother		
LENGTH in om		STD	%	WEIGHT 1b kg	STD	%	1	2	3	4	5	6
MOTHER AGE Yrs	If now pregnant mos	Number of Past Pregnancies — liveborn — stillborn — abortions				of the liveborn: — now living — now dead		of those dying — died at < 1 yr — died at 1–5 yrs — died at 5+ yrs		Mother's age at: term. 1st preg. yrs term. last preg. yrs		
THIS CHILD: U R M	Age U R M	Birth order	Premature? Yes No	Walked mos	DIARRHOEA <input type="checkbox"/> Current <input type="checkbox"/> Recent <input type="checkbox"/> Recurrent	RESPIRATORY <input type="checkbox"/> Current <input type="checkbox"/> Recent <input type="checkbox"/> Recurrent	<input type="checkbox"/> Pica <input type="checkbox"/> Parasites <input type="checkbox"/> Malaria <input type="checkbox"/> Other					
GENERAL IMPRESSIONS			GUMS <input type="checkbox"/> Swollen red papillae (diffuse) <input type="checkbox"/> Bleeding			LOWER EXTREMITIES <input type="checkbox"/> Bilateral oedema <input type="checkbox"/> Calf tenderness						
			TONGUE <input type="checkbox"/> Filiform papillary atrophy <input type="checkbox"/> Mild <input type="checkbox"/> Mod. <input type="checkbox"/> Severe <input type="checkbox"/> Glossitis			SKELETAL <input type="checkbox"/> Cranial bossing <input type="checkbox"/> Frontal <input type="checkbox"/> Craniotabes <input type="checkbox"/> Parietal <input type="checkbox"/> Costochondrial beading <input type="checkbox"/> Enlarged joints <input type="checkbox"/> Bone tenderness <input type="checkbox"/> Muscle wasting						
			GLANDS <input type="checkbox"/> Thyroid enlarged (visible)									
			SKIN, GENERALLY <input type="checkbox"/> Inelastic <input type="checkbox"/> Petechiae <input type="checkbox"/> Dermatitis, with desquamation or crazy pavement type									
			ABDOMEN <input type="checkbox"/> Hepatomegaly <input type="checkbox"/> Splenomegaly <input type="checkbox"/> Pot-belly									
LIPS												
<input type="checkbox"/> Angular lesions <input type="checkbox"/> Cheilosis												
REMARKS: G F P			PHOTOGRAPH # _____ of			OTHER <input type="checkbox"/> 1. _____ <input type="checkbox"/> 2. _____			CLINICAL IMPRESSION <input type="checkbox"/> Marasmus <input type="checkbox"/> Pre-kwashiorkor <input type="checkbox"/> Kwashiorkor Examiner's Initials _____			
<input type="checkbox"/> URINE sample _____			<input type="checkbox"/> BLOOD sample _____			<input type="checkbox"/> FAECES sample _____						
URINE DATA Urine volume _____ ml, during _____ hours Creatinine _____ mg/ml or _____ mg/hr						BLOOD DATA Total plasma protein _____ Albumin _____						
Thiamine _____ Riboflavin _____ N'methylnicotinamide _____						Haemoglobin _____ Hematocrit _____ M.C.H.C. = 100 Hgb/PCV _____						
Other, # 1 _____ Other, # 2 _____ Other, # 3 _____						Serum vitamin C (mg/100/ml) _____ Serum vitamin A (mg/100/ml) _____ Serum Caretene (mg/100/ml) _____						
PARASITOLOGIC FINDINGS 1_____, 2_____, 3_____, 4_____, 5_____, 6_____						Alkaline phosphatase _____ Other, #1 _____ Other, #2 _____						

(Contd.)

Fig. 17.1 Detailed child health and nutrition survey form used by ICNND

Fig. 17.1 (Contd.)

(B) Reverse of Card

DIETARY					Information obtained by:	
CHILD -- BREAST FEEDING	CHILD NON FED (one or more)	IF CHILD NOW NURSES	IF NURSING TERMINATED		FACTORS OF TIME WEANING	
	<input type="checkbox"/> Breast milk <input type="checkbox"/> Other milk <input type="checkbox"/> Other foods	feedings/day <input type="checkbox"/> Self-demand <input type="checkbox"/> Schedule _____ hrs	<input type="checkbox"/> Abruptly at _____ months <input type="checkbox"/> Gradually _____ to _____ mos <input type="checkbox"/> NEVER breast fed		Maternal Illness Work Pregnancy	Infant Illness
CHILD -- INITIAL NON-MILK FOODS	1	2	3			
	4	5	6			
CHILD -- PHARMACEUTICAL SUPPLEMENTS	Iron from _____ months to _____ months or <input type="checkbox"/> PRESENT <input type="checkbox"/> Regularly <input type="checkbox"/> Occasionally	Vit A & D from _____ months to _____ months or <input type="checkbox"/> PRESENT <input type="checkbox"/> Regularly <input type="checkbox"/> Occasionally	Vitamin C from _____ months to _____ months or <input type="checkbox"/> PRESENT <input type="checkbox"/> Regularly <input type="checkbox"/> Occasionally			
	<input type="checkbox"/> _____ from _____ months to _____ months or <input type="checkbox"/> PRESENT <input type="checkbox"/> Regularly <input type="checkbox"/> Occasionally					
CHILD -- MILK FEEDING (not breast)	Fresh milk: <input type="checkbox"/> Cow <input type="checkbox"/> Water buffalo <input type="checkbox"/> Goat <input type="checkbox"/> _____ <input type="checkbox"/> Sheep <input type="checkbox"/> _____ <input type="checkbox"/> Camel	Processed milk: <input type="checkbox"/> Dry skim <input type="checkbox"/> Dry whole <input type="checkbox"/> Evaporated <input type="checkbox"/> _____	PRESENT intake (vol)/ day <input type="checkbox"/> _____ (wt.)/ day <input type="checkbox"/> _____ (times)/ day <input type="checkbox"/> _____	Is formula water boiled? YES NO Is drinking water boiled? YES NO		
CHILD'S PRESENT DIET						
Do you give this child any special foods or juices other than the family diet ? YES NO						
If YES, what kinds?						
Usual present diet:						
Food type	Food	Quantity/Day	Times/day	OR times/wk	Age this food first started	
MILK						
GRUELS, CEREALS						
VEGETABLES						
FRUITS						
MEAT, FISH, FOWL						
EGGS						
OTHER						
MOTHER'S DIET during LATEST PREGNANCY						
Foods avoided	Special foods	Supplements	Foods avoided	Special foods	Supplements	
Why?	Why?	Why?	Why?	Why?	Why?	
1 Salt	1 Milk	1 Iron	1 Salt	1 Milk	1 Iron	
2	2	2 Calcium	2	2	2 Calcium	
3	3	3 Vitamins	3	3	3 Vitamins	
4	4	4	4	4	4	
5	5	5	5	5	5	
6	6	6	6	6	6	
At what age do your children begin to drink....		Coffee? _____ yrs	Wine? _____ yrs	Soft drinks? _____ yrs	(kind _____)	
		Tea? _____ yrs	Beer? _____ yrs	Other? _____ yrs	(kind _____)	

In some situations while conducting the diet survey, the investigator must note the detailed description of the foods because the method of preparation, cooking methods, and variety of the food may be relevant to the study.

17.9 INDIRECT NUTRITIONAL ASSESSMENT OF HUMAN GROUPS

There are several ways of judging the nutritional status of an individual indirectly. They include:

1. Vital Statistics Morbidity rates for various diseases (such as tuberculosis), maternal and prenatal mortality rates, life expectancy and other health statistics are influenced by malnutrition. They can thus, be considered as indirect indicators of the nutritional status of the community. However, the availability and reliability of the local statistics, the percentage of deaths certified by doctors occurring in hospitals or autopsies must be taken into consideration before interpreting the data.

2. Age-Specific Mortality Rates The mortality rates at specific age-periods have been used to record the incidence of certain types of malnutrition. A high mortality rate due to infantile beriberi is observed between two to five months of age. Between one to four years of age, infant mortality rate is recorded to be 30 to 50 times greater in underdeveloped countries than Europe and North America. This age group is a vulnerable period characterized by rapid growth and high nutrient needs. Refer Table 17.9.

Table 17.9 *Infant and child mortality in countries where protein-energy malnutrition is unknown or extremely rare, and where it has been frequently encountered**

Country	Infant mortality per 1000 lives births	Proportion of mortality, all ages (%)
Protein-energy malnutrition unknown or rare		
Canada	28.4	10.8
Czechoslovakia	25.7	5.0
England and Wales	22.2	3.7
Japan	33.7	9.2
USA	26.4	7.8
Protein-energy malnutrition frequent		
Chile (1958)	127.7	41.6
Mexico	74.4	46.3
Sri Lanka	57.5	39.1
India (1956)	101.8	38.4
Philippines (1958)	109.2	49.9

* The figures given in the table are for 1959 and 1960, unless otherwise stated, and are taken from Annual Epidemiological and Vital Statistics 1959 and 1960, published by the World Health Organization.

3. Morbidity and Cause Specific morbidity.

Information regarding PEM should be looked for. This can be done by conducting a community-wide nutritional survey. Clinically identifiable syndromes such as kwashiorkor, nutritional marasmus, pellagra, keratomalacia must be observed.

Information concerning geographical distribution and seasonal incidence can be obtained from data at health centres. Hospital statistics are important but they do not reflect the actual community conditions.

Cause-of-death records are especially useful to obtain specific death rates due to malnutrition. However, in many countries, official notification of deaths gives very distorted figures of the real problem. A great proportion of deaths in children below five years is attributed to diarrhoeal diseases, parasitism, respiratory conditions, or some infectious diseases particularly measles and whooping cough. Careful interpretation of this valuable data is necessary.

4. Nutritionally Relevant Diseases

Morbidity and mortality in disease such as tropical ulcer, diarrhoeas of infectious origin, tuberculosis and measles are caused by malnutrition. It is important that death certificates should include mention of severe malnutrition whenever it occurs along with the principal cause of death or primary disease.

The two main causes of death among young children in the developed countries are alimentary bacterial infection and PEM. Diarrhoea is the principal cause of death in both these diseases.

In some countries measles is a well-recognized precipitating factor in the etiology of kwashiorkor. Attempts can therefore, be made to collect date regarding mortality from measles in the community as a whole and in hospitalized children. This data will provide approximate indices of the nutritional status of children in the population.

□ Malnutrition in Geriatric Patients

To judge the nutritional status of old persons (generally above 60 years of age) the MNA form is used:

Table 17.10 Mini nutritional assessment form

Last name:	First name:	Sex:	Date:
Age:	Weight, kg:	Height, cm:	I.D. Number:

Complete the screening portion of the form by filling in the boxes with the appropriate numbers.

Add the numbers for the screening. If the score is 11 or less, continue with the assessment part of the form to get a Malnutrition Indicator Score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?

0 = severe loss of appetite

(Contd.)

(Contd.)

(Contd.)

(Contd.)

<ul style="list-style-type: none"> ● Meat, fish or poultry everyday yes <input type="checkbox"/> no <input type="checkbox"/> <p>L Consumes two or more servings of fruits or vegetables per day? 0 = no 1 = yes</p> <p>M How much fluid (water, juice, coffee, tea, milk, soups, etc.) 0.0 = less than 3 cups 0.5 = 3 to 5 cups 1.0 = more than 5 cups</p> <p>N Mode of feeding 0 = unable to eat without assistance 1 = self-fed with some difficulty 2 = self-fed without any problem</p> <p>O Self view of nutritional status 0 = views self as being malnourished 1 = is uncertain of nutritional state 2 = views self as having no nutritional problem</p> <p>P In comparison with other people of the same age, how does the patient consider his or her health status? 0.0 = not as good 1.0 = as good 2.0 = better 0.5 = does not know</p> <p>Q Mid Arm Circumference (MAC) in cm 0.0 = MAC less than 21 0.5 = MAC 21 to 22 1.0 = MAC 22 or greater</p> <p>R Calf circumference (CC) in cm 0 = CC less than 31 1 = CC 31 or greater</p>

Assessment (max 16 points)

Screening score: _____ points

Total Assessment (max 30 points)

Malnutrition Indicator Score

17 to 23.5 points: At risk of malnutrition

Less than 17 points: Malnourished

References:

1. Vellas B, Villars H, Abellan G et al. Overview of the MNA—its History and Challenges. *J Nutr Health Aging* 2006;10: 456–465
 2. Rubenstein L Z, Harker J-O, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF). *J. Geront* 2001; 56A: M366–377.
 3. Guigoz Y. The Mini-Nutritional Assessment (MNA) review of the Literature – what does it tell us? *J Nutr Health Aging* 2006; 10:466–487.
- SGA is truly a subjective means of assessing the nutritional intake. SGA classifies the patient as
 - A. Well nourished; B. Malnourished; C. Severely malnourished

- Patients are placed into one of these categories based on their subjective rating in two broad areas: A. Medical history; B. Physical examination. The clinician rates each, medical history and physical examination parameters, as A, B or C on the SGA scoring sheet. Using the ratings of the parameters as a guide, an overall SGA score is given, which corresponds to his subjective opinion of the patient's nutritional status.
- SGA is not a numerical scoring system. Therefore, it is inappropriate to score or add the numbers of A, B and C ratings to arrive at the overall SGA classification. The items on the form are used by the nutritionist to obtain a general feel of the patient's status. If there are more B or C ratings, the patient is more likely to be malnourished. If there are more A ratings, the patient is likely to be well nourished.

Table 17.11 Modified subjective global assessment form (SGA)

A. Medical History

- A.1– Weight change over 6 months**
 - A. Weight gain or No change or Mild weight loss
 - B. Moderate weight loss
 - C. Severe weight loss
- A.2– Weight change in past 2 weeks**
 - A. Weight is increasing
 - B. No change in weight
 - C. weight is decreasing
- A.3– Change in dietary intake**
 - A. No change or slight change for short duration
 - B. Intake borderline and decreasing. Intake poor and increasing.
Intake poor, no change based on prior intake.
 - C. Intake poor and decreasing
- A.4– Duration and degree of change**
 - A. Less than 2 weeks, little or no change
 - B. More than 2 weeks, mild to moderate suboptimal diet
 - C. Unable to eat or starvation
- A.5– Presence of GI symptoms**
 - A. Few or no symptoms intermittently
 - B. Some symptoms for more than 2 weeks, severe symptoms that are improving
 - C. Symptoms daily or frequently more than 2 weeks
- A.6– Functional status**
 - A. No impairment in strength, stamina and full functional capacity, mild-moderate loss and improving
 - B. Mild to moderate loss of strength, stamina / some loss of daily activity or severe loss but now improving
 - C. Severe loss of function, stamina and strength

(Contd.)

(Contd.)

A.7– Disease state and co-morbidity

- A. No stress
- B. Low or moderate stress
- C. High stress

B. Physical Examination

B.1– Subcutaneous loss of fat

- A. Little or no loss
- B. Mild to moderate in all areas, severe loss in some areas
- C. Severe loss in most areas

B.2– Muscle wasting

- A. Little or no loss
- B. Mild to moderate in all areas, severe loss in some areas
- C. Severe loss in most areas

B.3– Oedema

- A. Little or no oedema
- B. Mild to moderate oedema
- C. Severe oedema

B.4– Ascites

- A. No ascites or only on imaging
- B. Mild to moderate ascites
- C. Severe ascites or progressive ascites

Overall SGA score – A or B or C

Finalization of SGA score

17.10 NUTRITION SURVEYS

There are two types of field investigations:

1. Longitudinal incidence studies
2. Cross-sectional prevalence.

□ Longitudinal Incidence Studies

These are general health surveys with special emphasis on nutrition.

These studies are generally undertaken on children. They are carried out for a period of at least one-year using select members of families in a community.

They not only permit the true annual incidence of malnutrition and disease to be judged but also indicate seasonal variations due to climate, availability of food, community activities and other factors.

They are also helpful in recording short-term illnesses such as infantile beriberi and measles. Children born during the study, their age and causes of death can also be accurately recorded. Growth of children can be compared with standards for age and vital statistics such as mortality rates in the four year age group as well as prenatal period.

Most important, these studies permit an understanding of the dynamic interplay of factors at work, thereby isolating the local causes of malnutrition.

These studies pose certain difficulties for the surveyor. They are not easy to organize, are costly and time-consuming. Also, by the time the results are assessed they may become obsolete as the community itself may have changed.

Table 17.12 *Information useful for assessment of nutritional status **

<i>Sources of information</i>	<i>Nature of information obtained</i>	<i>Nutritional implications</i>
(1) Agricultural data Food balance sheets	Gross estimates of agricultural production Agricultural methods Soil fertility Predominance of cash crops Overproduction of staples Food imports and exports	Approximate availability of food supplies to a population
(2) Socio-economic data Information on marketing, distribution and storage	Purchasing power Distribution and storage of foodstuffs	Unequal distribution of available foods between the socio-economic groups in the community and within the family
(3) Food consumption patterns Cultural-anthropological data	Lack of knowledge, erroneous beliefs and prejudices, indifference	
(4) Dietary surveys	Food consumption Distribution within the family	Low, excessive or unbalanced nutrient intake
(5) Special studies on foods	Biological value of diets Presence of interfering factors (e.g., goitrogens) Effects of food processing	Special problems related to nutrient utilization
(6) Vital and health statistics	Morbidity and mortality data	Extent of risk to community Identification of high-risk groups
(7) Anthropometric studies	Physical development	Effect of nutrition on physical development
(8) Clinical nutritional surveys	Physical signs	Deviation from health due to malnutrition
(9) Biochemical studies	Levels of nutrients, metabolites and other components of body tissues and fluids	Nutrient supplies in the body Impairment of biochemical function
(10) Additional medical information	Prevalent disease patterns including infections and infestations	Interrelationships to state of nutrition and disease

* Adapted from WHO Expert Committee on Medical Assessment of Nutritional Status (1963).

Standard methods of interview and examination must be used. These studies involve a lot of ethical responsibility, which must be defined before beginning the survey. Patience, dedication and team spirit are essential aspects of conducting longitudinal studies.

Cross-sectional Prevalence Studies

These are also known as *point-prevalence surveys*. They are single examinations of population which are undertaken in a specified short period of time, usually ranging from a few days to a few weeks.

These studies are relatively inexpensive, requiring few staff and short time periods.

Since the time period is short, the information gathered must be supplemented with that obtained from other health services.

They provide valid information for relatively chronic conditions such as fluorosis or PEM. They do not provide authentic information for acute conditions of short duration such as infantile beriberi.

They pose far greater disadvantages when assessing the nutritional status of the community.

They may be more useful if periodic cross-sectional prevalence surveys are carried out at selected periods of the year such as the annual climate and agricultural cycle.

Figure 17.3 shows a typical detailed form used by ICNND while conducting the survey. Table 17.10 gives data of some information that is useful while assessing the nutritional status.



SUMMARY

Nutritional status of a community can be assessed by four methods, namely, Clinical, Anthropometric, Biochemical and Dietary. The findings of such epidemiological surveys have a bearing on judging the magnitude of malnutrition. They also guide the government in making policies for preventive and corrective measures for the nutritional problems in the community. The public health worker can use one or more methods depending on the study underway.



REVIEW QUESTIONS

1. What are the three main aims of nutritional assessment of a community?
2. By which methods can we assess the nutritional status?
3. What measurements are used in anthropometry?
4. Which aspects are judged by biochemical tests?
5. What are the indirect methods of assessing groups for their nutritional status?
6. Differentiate between longitudinal incidence studies and cross-sectional prevalence studies.

Chapter

18



Malnutrition and Nutrition Programmes

18.1 FOOD SHORTAGE AND ITS PROBLEMS

In the international context, scientists have attempted to explain the overwhelming inequalities in the nutritional status. The association of better nutritional status with higher Gross National Product (GNP) and greater evidence of malnutrition with lower GNP is clear. By improving the GNP of countries (developing as well as developed) the power relations and flow of resources from poor to rich countries continues to be maintained. This approach is referred to as “A World Systems Perspective”. Current inequalities have posed a food shortage in developing countries precipitating malnutrition and resulting in food excess in developed countries causing over-nutrition.

Ranking countries at the periphery, i.e. those with low GNPs like Tanzania, Bangladesh, El Salvador, Egypt, Mexico, Brazil and Korea to core countries, i.e. those with high GNPs like USA and Japan, results in a gradient, which reflects prevalence of poor nutritional status. Statistical data on malnutrition is given in Appendix IX.

India a developing country, accounts for less than 20% of the world's child population, but it has 40% of the malnourished children. *Protein Energy Malnutrition (PEM)* is the most widely prevalent form of malnutrition among children: over one half (53%) of those under four years old, suffer from moderate and severe forms of PEM. India and South Asia as a whole have higher rates of malnutrition than any other region of the world, including Sub-Saharan Africa. Among the large countries India ranks second only to Bangladesh in the proportion of young children affected by malnutrition. In addition, iron deficiency anaemia is rampant among children and women, especially pregnant women. A nationwide survey found that 87% of the pregnant women were anaemic. Vitamin A and iodine deficiency diseases are the other serious problems, concentrated in specific areas. These micronutrient deficiencies seriously affect physical and mental performance in individuals and increase the country's burden of disease.

Malnutrition varies widely across regions, states, age, gender and social groups, with children under 5 years being the worst hit. It is found in the populous northern states, in rural areas, and among women, tribal populations and scheduled castes. For example, in Kerala, 29% of children under four years age are moderately or severely underweight, while the corresponding figures for Bihar and Uttar Pradesh are 63% and 59%, respectively.

Evidence from different sources demonstrates that malnutrition, while still unacceptably high, has declined substantially in the past two decades. For example, National Nutrition Monitoring Bureau data from eight states shows that severe

protein energy malnutrition declined from 5 percent in 1975 to less than 7 percent in 1996 among one to five years old children. Also, severe and moderate malnutrition combined among these children declined from about 63% to 49% in the same period. The National Family Health Survey of 1992–93 provides a comparable figure of 53% severe and moderate malnutrition among zero to four years old in the country as a whole. Similar progress is evident in micronutrient malnutrition.

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

18.2 CAUSES AND CONSEQUENCES OF MALNUTRITION IN INDIA

Causes of severe under-nutrition are:

1. An inadequate intake of food, due either to a poor appetite or limited availability of food, leads to a wasting syndrome with a relative loss of weight and associated with a range of complex adaptive changes in all tissues and organs.
2. The presence of an underlying specific pathology, such as an infection, or a poor quality diet, separately and together might predispose to a reduced food intake and in addition challenge metabolic integrity that predisposes to the formation of oedema.

Malnutrition results from a combination of three key factors: inadequate food intake, illness and deleterious caring practices. Underlying these is household food insecurity, inadequate preventive and curative health services and insufficient knowledge of proper care. In India, household food insecurity stems from inadequate employment and incomes; seasonal migration, especially among the tribal populations; relatively high food prices; geographic and seasonal mal-distribution of food; poor social organization; and large family size. The country still has a high incidence of disease, especially preventable communicable diseases, and maintains inadequate health services. In addition, caring practices at home—including feeding, hygiene, home-based health care, use of available health services, and psychosocial stimulation of children—are inadequate, substantially due to the lack of education, knowledge, skills, and time among families, especially mothers. These problems are rooted in the socio-cultural and economic processes that determine access to and control over resources, including information, education, assets, income, time and even how resource allocation decisions are made in society.

A major determinant of protein energy malnutrition is household caloric inadequacy. According to the 1993–94 round of the National Sample Survey, about 80 percent of the rural population and 70 percent of the urban population had caloric intakes below the 2400 calories per day recommended for rural areas and 2100 calories recommended for urban areas. In 1993–94, the poorest 30 percent of India's population consumed on an average, fewer than 1700 calories per day. The poorest 10% consumed less than 1300 calories per day. At lower levels of caloric intake, people simply do not survive for long.

While poverty largely explains the high level of malnutrition in India, additional factors are responsible for the concentration of the problem among women and children. Foremost among these is the low status of women in Indian society, which results in women and girls getting less than their fair share of household food and health care. Adult women comprise one third of India's labour force and are usually engaged in heavy manual tasks that place additional energy demands on them. Women's heavy burden of childbearing adds to the problem—India's total fertility rate is still 3.5 children per woman.

Lack of information and education among women also underlies child malnourishment. Malnutrition is directly or indirectly responsible for more than half of the deaths of children under five years of age worldwide. While India has successfully brought down infant mortality rate from 146 per 1000 live births in 1951 to 72 in 1996, most of the children who survive are malnourished (Fig 18.1, Plate 1). Indeed, widespread malnutrition among children and others is a major barrier to further reduction in mortality rates, including those among pregnant women. India's maternal mortality ratio of 420 per 100,000 live births is unacceptably high. The country accounts for approximately one quarter of all maternal deaths worldwide.

High levels of anaemia, low pregnancy weight gain, repeated acute infections, major chronic diseases, such as tuberculosis, and inappropriate management of deliveries are important determinants of maternal and infant deaths. A large proportion of adult Indian women is at high risk of maternal mortality because their low pre-pregnancy height or weight may cause obstetrical difficulties. Moreover, a vicious intergenerational cycle commences when a malnourished or ill mother gives birth to a low birth-weight female child; she remains small in stature and pelvic size due to further malnourishment, and produces malnourished children in the next generation.

Malnourishment can also significantly lower cognitive development and learning achievement during the preschool and school years, and subsequently results in low physical and mental performance and is exacerbated by common worm infestations. Malnutrition not only blights the lives of individuals and families, but also reduces the returns on the investment in education and acts as a major barrier to social and economic progress. Malnutrition reduced India's GDP by nearly three to nine percent in 1996, or by approximately US\$ 10 billion to \$28 billion. The higher figure is greater than the sum of India's current public expenditures on nutrition, health and education combined.

While mortality has declined by one-half and fertility by two-fifths, malnutrition has only come down by about one-fifth in the last 40 years. The inescapable conclusion is that further progress in human development in India will be difficult to achieve unless malnutrition is tackled with greater vigour and more rapid improvement in the future than in the past.

18.3 SOME FACTS ABOUT MALNUTRITION AND MICRONUTRIENT DEFICIENCIES

According to the Department of Women and Child Development, Ministry of Human Resource Development, 1999:

1. Nearly one-third of the world's children suffering from malnutrition are in India.

2. Incidence of micronutrient deficiencies, nutritional anaemia, vitamin A and iodine deficiencies are still very high.
3. Rate of malnutrition is falling much too slowly—at only one per cent per year.
4. More than half of preschool children are stunted (56.5%) and nearly a similar proportion (49.2%) are underweight. (DNP Survey, 1995–96).
5. One in every six children is excessively thin (wasted).
6. Nearly 16 percent infants less than 6 months and about 43 percent infants between six to eleven months are malnourished.
7. About 30 percent babies are low-birth-weight babies.
8. Nutritional anaemia affects about 50 percent of young children, adolescent girls and women in the reproductive age group.
9. More than 10 percent of population, in 235 districts of India is affected with goitre—an iodine deficiency disorder.

□ Infant Feeding Practices

1. Only 51 percent mothers exclusively breastfeed their babies for the first four months.
2. Only about one-third of children are given solid/mushy food in addition to breast milk at the recommended age of six to nine months.
3. A substantial majority of women squeeze the first milk containing colostrum from the breast before breastfeeding their babies.

18.4 PROTEIN-ENERGY MALNUTRITION (PEM)

Protein-Energy Malnutrition (PEM) is one of the largest public health problems of our country. As the name suggests, this condition is a deficiency of protein and calories in the diet. Strictly speaking, it is not one disease, but a spectrum of conditions arising from an inadequate diet. Although, it affects people of all ages, the results are most drastic in childhood due to the highest requirements in that period. In adults, mild degrees of it results into some wasting, while severe degrees are encountered in famines and wars of long duration. Fortunately, both the latter have spared us during the last several decades and therefore do not qualify as a “problem”. But in infants and children PEM is a major problem. Till recently it was assumed that there was always a primary deficiency of proteins associated with varying degrees of energy deficiency, based upon observations in Africa. But in the light of extensive studies conducted mainly at the National Institute of Nutrition (NIN), a different concept has emerged whereby it is a condition, at least in India, primarily due to a deficiency of total dietary energy; the protein deficiency being only secondary. This condition in children embraces at one end of the spectrum the puffed up cases of kwashiorkor, the shrivelled cases of marasmus; and on the other, cases of nutritional dwarfing. In between these extremes are various degrees of intermingling of the two conditions. It would not be out of place to first look at the clinical picture of the different manifestation.



Fig. 18.1 Severe emaciation of a child due to malnutrition. Note the swollen abdomen



Fig. 18.2 A child suffering from marasmus



Fig. 18.3 *Marasmic kwashiorkor*



Fig. 18.4 *Rickets: note the bossing of forehead*

18.5 MARASmus

The term derived from the Greek word meaning ‘to waste’, has been in usage in medical literature since old times. It was as common in Europe and North America in 19th century as it is in India today. This is the childhood equivalent of starvation in adults. Clinically, the presentation is of an irritable or apathetic child who fails to thrive, is markedly emaciated and has incessant diarrhoea. The appetite may be extreme or reduced. There is extreme shrivelling of the body with occasional dehydration, loss of subcutaneous fat, marked wasting of muscles, and low body weight and length. The abdomen may be shrunken or distended with gas. There may also be associated vitamin deficiencies like hypovitaminosis A (see Fig. 18.2, Plate 1).

18.6 KWASHIORKOR

This term used by the *Ga* tribe in and around Accra in Ghana meant ‘the sickness the older child gets when the next baby is born’. It was adopted for the medical literature by Cicely Williams in 1933. The child is apathetic, anaemic, anorexic, diarrhoeic and oedematous; usually brought to the doctor on account of some infective condition. There is severe growth retardation but on account of oedema the weight might not be severely subnormal. The oedema may be varying in degree and distribution and associated with ascites and pleural effusions.

The skin changes may involve any part of the body, the more common sites being lower limbs, buttocks and perineum. The skin changes show characteristic areas of desquamation and pigmentation or depigmentation. Cracks appear at folds and ulcers may develop at anal region and over pressure points. The muscular wasting is extreme and may result in incapability to crawl or walk. The hair is sparse, softer and thinner than normal. Its colour also might change and become reddish, brown or gray (dyschromatichia). There are associated symptoms such as angular stomatitis, cheilosis and atrophy of the tongue, anaemia, hepatomegaly; and at times, tremors like those in parkinsonism.

18.7 MARASMIC KWASHIORKOR

As the name implies, this is a combination in varying degrees of the features of the two conditions marasmus and kwashiorkor, and is found in places where PEM is prevalent. It is the superimposition of kwashiorkor on any degree of marasmus and is the most common presentation of PEM in India. Clinically, some features of both marasmus and kwashiorkor are present and the picture may be complicated further by gastrointestinal or respiratory infections, due to which the child is usually brought to medical attention (see Fig. 18.3, Plate 2).

18.8 VITAMIN DEFICIENCY

1. Night Blindness This is an impairment of the vitamin A function, namely the formation of rhodopsin in the eye. A child suffering from a deficiency of vitamin

- The terms marasmus, kwashiorkor, marasmic—kwashiorkor, protein deficiency, energy deficiency and protein—energy deficiency have all been used at different times to describe severe under nutrition with or without oedema.
- An estimated 854 million people are hungry, 20 million children under 5 suffer from severe malnutrition and around 1 million children die due to malnutrition each year. Over two billion people—more than 30% of the world's population—are anaemic.
- Underlying causes of malnutrition are poverty and agricultural underdevelopment leading to food insecurity. Meeting overall energy needs and dietary diversity is the major challenge.
- Infants and children suffering from severe malnutrition frequently have moderately reduced haemoglobin—80 to 100 gm/lit., or reduced hematocrit—30–35%.
- The normal life of a red blood cell is on an average 120 days but may be shorter in severely malnourished children.
- Despite low haemoglobin there is an increase in both stored and free cellular iron, and supplementation with iron increases mortality.

A first displays this symptom at night by bumping into objects. Slowly the eye develops Bitot's spots, which lead to dryness in the cornea and further lead to xerophthalmia. This is a stage of irreversible blindness. Total blindness cannot be cured even if large doses of vitamin A are given at this stage.

2. Beriberi This is caused due to the deficiency of thiamine, a water-soluble B vitamin. There are two types of beriberi, dry and wet. Dry beriberi is characterized by emaciation, generally associated with infection such as TB or dysentery. Polyneuropathy occurs followed by weakness, inability to walk, wrist drop and foot drop.

Wet beriberi involves swelling on the body, which is its characteristic. There is pain and tenderness in the legs and even slight movement causes palpitation, breathlessness, which can later cause acute cardiac failure.

3. Pellagra This is caused due to the deficiency of niacin, another of the watersoluble group of B vitamins. It has been found to commonly occur in corn eaters since, corn is devoid of niacin as well as tryptophan. It is also found in people who consume only *jowar* as their staple, since, leucine, an amino acid, is found to interfere with niacin metabolism. This disease is characterised by feeling of unwellness, anorexia, mild gastro-intestinal upsets and nervousness; rashes appear on the skin exposed to the sun; cheilosis, angular stomatitis, headache, burning sensation in the hands and feet, hallucinations, delusions and delirium. If untreated, it can lead to death. Pellagra is, therefore, also known as the 4 D's disease, that is, diarrhoea, dermatitis, dementia, and death.

4. Scurvy This disease caused due to vitamin C deficiency, was first noticed in sailors who would travel for months in the sea with only salted foods as their diet. This diet was devoid of any fresh fruits and vegetables, which are rich in vitamin C. The typical symptoms of scurvy are weakness, fatigue, and pain in the muscles, bones and joints. The skin becomes dry, pinpoint haemorrhages appear, followed by black and blue spots on the skin. Wounds take a long time to heal, fractures appear spontaneously: anaemia develops, followed by convulsions, stupor; coma and death can occur if untreated.

18.9 DEFICIENCY OF MINERALS

1. Anaemia The main causes of anaemia are:

- (a) Dietary iron deficiency;
- (b) Infectious diseases such as malaria, hookworm infections, schistosomiasis, HIV/AIDS, tuberculosis and other chronic diseases including almost any inflammatory illness that lasts several months or longer, and some malignancies;
- (c) Deficiencies of other key micronutrients including folate, vitamin B₁₂, vitamin A, protein, copper and other minerals;
- (d) Inherited conditions that affect red blood cells, such as thalassemia;
- (e) Severe acute haemorrhage (such as occurs in childbirth);
- (f) Chronic blood losses (e.g. in peptic ulcer);
- (g) Trauma.

However, the most common type is iron deficiency, which occurs more commonly among women than among men. Girls suffer from anaemia particularly around puberty, due to menstrual disturbances. The blood shows low haemoglobin levels and the cells are pale and small. The person suffers from weakness, frequent headaches, pallor, breathlessness and dislike for work and exertion. There is giddiness, sleeplessness, heartburn, palpitation, blurred vision and swelling of the feet.

There are four key processes which contribute to anaemia:

(a) Reductive Adaptation It is the body's adaptation to reduced food intake and decreased metabolic activity. It is different from anaemia due to chronic disorders.

(b) Specific Nutrient Deficiencies The formation of mature erythrocytes requires all the nutrients and deficiency in any of the nutrients will limit their formation and their functional capability. Besides this, nutrients like folic acid and B₁₂ are directly involved in the formation of haemoglobin.

(c) Infection A complex interaction between infection and poor nutrition exists which may elicit an inflammatory or immune response. The availability of nutrients for red cell formation will increase the likelihood of anaemia.

(d) Haemolysis, Pro-oxidant Damage Enhanced susceptibility to pro-oxidant damage will predispose RBCs to a shortened life span. Iron in the stored form can act as the focus for pro-oxidant stress and result in cellular pathology.

- Iron deficiency accounts for approximately half of the anaemia in developing countries, with the other being proposed as due to a lack of copper, zinc, foliate or vitamins A, B₂, B₁₂, or C.
- The overriding principle of any intervention must be ‘first do not harm’.
- The usual nutritional supplement doses are:
 - 30–60 mg iron for a 70 kg adult
 - Maximum of 120 mg iron during pregnancy
 - 2 mg iron/kg for children
- Side effects of iron are not usually seen after oral intakes of 30–60 mg.
- An oral dose of 180–300 mg iron/kg body weight can be lethal to humans but oral doses below 10–20 mg iron/kg of body weight represent a No Observed Adverse-Effect-Level (NOAEL).
- Asia has the highest number of cases of anaemia, while Africa has the highest prevalence rates of anaemia in pre-school children.
- The Recommended Daily Intake (RDI) of iron for men ranges between 9 mg in diets with high bioavailability to 27 mg where bioavailability is only 5%. In premenopausal women (aged 19–50) the RDI for iron is 59 mg.
- Food based strategies, by increasing availability and consumption of a nutritionally adequate micronutrient-rich diet, are the sustainable way to improve nutrition.
- Haeme-iron from flesh foods (meats, poultry, fish) is well absorbed with an average absorption of 25%, ranging from 40% during iron deficiency to 10 % when iron stores are replete.
- Non-haeme-iron, present in plant foods such as cereals, pulses, legumes, grains, nuts and vegetables, has an absorption rate of 2% to 10% depending upon the balance of iron absorption inhibitors and enhancers in the meal.
- Addition of vegetables and fruits containing ascorbic acid can double or triple iron absorption. Each meal should preferably contain at least 25 mg of ascorbic acid.

2. Rickets Generally, rickets occurs during childhood and is a combination of deficiencies of calcium, phosphorus, vitamin D and vitamin C. The child suffers from growth retardation; bones become fragile and bent, with the short bones being affected more (see Fig. 18.4, Plate 2). Knock-knees and bowed legs are the characteristic symptoms of rickets. The young infant develops teeth late and there is delayed closure of the fontanelles. Bleeding time is longer and the bones are porous.

Adult rickets are also known as *osteomalacia*. Generally, women who remain indoors or in purdah and old persons and bedridden persons are found to suffer from osteomalacia.

3. Goitre This deficiency of the trace element iodine is found to affect people in the sub-Himalayan regions, parts of Madhya Pradesh, Saurashtra and Maharashtra. The affected parts of Maharashtra are Aurangabad, Jalna, Amravati, Buldhana, Satara, Wardha and Thane districts.

Goitre is characterized by abnormal growth of the thyroid gland. The hypothyroidism causes dullness, gain in weight, decreased work efficiency, and protrusion of the eyeballs and low levels of thyroxine. Pregnant women, who suffer from thyroidism, can give birth to children who may suffer from cretinism.

Details of the functions of the above nutrients, their deficiency symptoms and food sources are given in Chapter 3.

18.10 CURRENT NUTRITION PROGRAMMES IN INDIA

Major nutritional problems in India are Protein Energy Malnutrition (PEM), Iodine Deficiency Disorders (IDD), Vitamin A Deficiency (VAD) and anaemia. Besides, fluorosis is also prevalent, and lathyrism is localized to certain regions. The Nutrition Cell in the Directorate General of Health Services provides technical advice on all matters related to nutrition. State nutrition divisions, set up in 17 States and Union Territories, assess the diet and nutritional status in various groups of population, conduct nutrition education campaigns, and supervise supplementary feeding programme and other ameliorative measures. Surveys conducted by State nutrition divisions and National Nutrition Monitoring Bureau (NNMB) under ICMR reveal that malnutrition and other deficiency disorders are found more in young children, and pregnant and lactating mothers.

While the progress made in various child survival indicators like IMR (infant mortality rate), education, immunization, etc. over the last 50 years is impressive, about two million infants still die each year, almost the same number as in 1960, and most of these deaths are preventable. Despite the fact that we have a large buffer stock of food grains, about 53 percent of children below the age of five years are undernourished. Although, the literacy rate has more than doubled from 24 percent in 1961 to 62 percent in 1997, there are more illiterate people in the country than there were in 1961. Only 60 percent of all children reach grade V, and many of those completing primary school cannot even read and write.

Children in difficult circumstances continue to face greater deprivation and neglect. It is estimated that there are 17.38 million working children, five million street children and 4,00,000 child prostitutes in the country. Also, one in every ten children suffers from one form of disability or the other (75 percent of such childhood disabilities are preventable), and incidences of crime against children are on the increase.

□ Schemes and Programmes

The Government of India is implementing more than 120 schemes and programmes for the welfare and development of women and children through more than 13 Government Ministries and Departments. Tables 18.1 and 18.2 outline the policies of the government to improve the nutritional, social, and overall health status of women and children in the country. In spite of the various programmes being implemented, there are gaps in the achievement and performance of the desired goals, which is shown in Table 18.3. Table 18.4 gives the chronological highlights of the achievements of the government of India in the attempt to alleviate the situation in the procurement, distribution and quality control of food grains.

Table 18.1 National policies and action plans

Year	Policy
1974	National Policy for Children
1983	National Health Policy
1986	National Policy on Education
1987	National Policy on Child Labour
1993	National Nutrition Policy
1996	Communication Strategy for Child Development
1991–2000	National Plan of Action for SAARC Decade of the Girl Child
1992	National Plan of Action for Children
1995	National Plan of Action on Nutrition

Ref.: DWCD, Ministry of HRD, New Delhi, 1999.

Table 18.2 Important days

Day	Date
International Day of Families	15 May
World Environment Day	5 June
World Breast-feeding Week	1–7 August
National Nutrition Week	1–7 September
International Literacy Day	8 September
World Food Day	16 October
Universal Children's Day	14 November
Child Right Day	20 November
International Day of Disabled Persons	3 December
International Children's Day of Broadcasting	13 December

Ref.: DWCD, Ministry of HRD, New Delhi, 1999.

□ Integrated Child Development Services (ICDS) Programme

The Integrated Child Development Services Programme (ICDS) of the Department of Women and Child Development was started in 1975 and has emerged as the world's most unique and largest early childhood development programme. ICDS, which started as a social experiment with 33 projects, has emerged as a social experience to reach the unreached. It is a viable vehicle for achieving major national nutrition, health and education goals embodied in the National Plan of Action for Children, 1992.

The programme delivers an integrated package of basic services for improved child care, early stimulation, learning, and health and nutrition care, targetting and reaching out to 2.77 crore beneficiaries, including 2.29 crore children below the age of six, and 48 lakh pregnant and lactating women, through more than seven lakh frontline workers in 4200 ICDS projects.

It provides a package of services to control nutritional and health problems. The Department of Women and Child Welfare had developed a Management Information System (MIS) for monitoring and implementing the ICDS projects. The department

Table 18.3 Achievements and performance gaps in nutrition indicators

Nutritional indicator	1990s	Existing levels	Expected levels (Year) 2000
Nutritional Status of Children	(1–5 Years)	(0-4 Years) Rural)	
Normal	10.0%	—	Reduction in severe and moderate malnutrition by half of moderate 1990 levels.
Mild	37.0%	Stunting 37%	
Moderate	43.8%	Moderate 21%	
Severe	8.7% (1988–90)	Wastage 5% (1999)	
Prevalence of Goitre	21% (1989)	> 10% (1998)	Control of iodine deficiency disorders.
Prevalence of Vitamin A deficiency (Bitot's spots)	1.1% (1993–94)	0.21% (1998)	Control of Vitamin A deficiency.
Maternal deaths due to anaemia during child birth and pregnancy	19.9% (1991)	17% (1995)	Reduction in iron deficiency
Incidence of low birth—Weight babies	30% (1990)	30% (1998)	10%

Ref.: DWCD, Ministry of HRD, New Delhi. 1999.

Table 18.4 Chronological highlights

Year	Highlights
1939	Rationing introduced in Bombay for the first time in the country.
1965	The National Cooperative Consumer's Federation of India Limited registered.
1965–66	Save Grain campaign launched.
1966	The Super Bazaar, the Cooperative Store Limited started functioning.
1982	North-Eastern Regional Agricultural Marketing Corporation Limited, Guwahati set-up
1984	The Paddy Processing Research Centre established at Thanjavur.
1987	All the Provisions of the Consumer Protection Act came into force.
1987	The Standards Weights and Measures (Approval Model) Rules came into force.
1987	The Bureau of Indian Standards became functional as a statutory body.
1988	The Ministry of Food Processing Industry set-up.
1991	The Rajiv Gandhi National Quality Award instituted.
1992	Consumer Welfare Fund created.
1993	Food Corporation of India (FCI) authorized to sell wheat in open market.
1994	FCI authorized to sell rice in open market.
1997	The Sugar Export Promotion Act, 1958 repealed.
1998	Edible Oils Packaging (Regulation) order promulgated.
1998	Vegetable Oils Products (Regulation) order promulgated

(Ref.: INDIA 2000—A Reference Annual, Ministry of Information and Broadcasting)

generated QPRS (quarterly progress reports), which were regularly analyzed for delivery of services to beneficiaries under the scheme. The states were also regularly being advised to take necessary corrective actions based on the analysis. By 1995, 3908 ICDS projects had been sanctioned in the country, of which 3242 are operational. Selection of community is done on the basis of proportional distribution of rural population living below poverty line with first preference being given to the community development block having the highest concentration of Scheduled Caste population.

In order to improve the quality of services in the ICDS, an extremely comprehensive training programme called UDISHA (Sanskrit for “the new dawn”) has been devised. It is seen as an important element in empowering child-care workers, parents and communities for a continuous process of assessment, analysis and informed action to promote the fulfilment of children’s rights in the communities in which children live, grow and develop.

□ Objectives of ICDS Programme

The main objectives of the ICDS Programmes are to

1. Lay the foundation for the proper psychological, physical and social development of the child.
2. Improve the nutritional and health status of children below the age of six years.
3. Reduce the incidence of mortality, morbidity, malnutrition and school dropouts.
4. Achieve effective coordination of policy and implementation among various departments to promote child development.
5. Enhance the capability of the mother to look after the normal health and nutritional needs of the child through proper health and nutrition education.

The ICDS programme provides six services to 0–6 year old children and mothers: supplementary feeding; immunization against preventable childhood diseases; health checkups and referral; health and nutrition education to adult women; and preschool education to 3–6 year olds¹. Although, the 0–6 year old population of areas covered by the ICDS programme is already 63 million and the population of pregnant and lactating women is 13.6 million, only 30 million children and 5.2 million mothers are actually covered by supplementary feeding and 15 million 3–6 year old by preschool education.

The ICDS, fewer than 10 percent of 4200 programme blocks, also includes schemes for adolescent girls² nutrition, health awareness, and skill development; in some areas it has been linked with women’s income generating programmes. All of the ICDS’s services are delivered through a village centre, the *anganwadi*, by a trained village woman who is assisted periodically in the health tasks by an Auxiliary Nurse Midwife (ANM) from the health sub-centre.

The programme is targeted at poor areas and increasingly at poor households. Programme guidelines call for the food supplements, which are limited to 40 percent of the expected beneficiary population of an *anganwadi*, to be given preferentially to children and pregnant women from households at high risk of malnutrition—those of landless labourers, marginal farmers, Scheduled Castes or Tribes. The adolescent

girls and women's programme are intended to improve health and nutrition over the longer term through improvements in women's skills and access to resources.

However, evaluations of the ICDS have found its impact on nutritional status to be limited. The reasons for this include:

1. Inadequate coverage of children below three years of age, those at greatest risk of malnutrition, and women and children living in hamlets.
2. Irregular food supply, irregular feeding and inadequate rations.
3. Mothers and families are not educated regarding nutrition, which might encourage improved feeding practices at home and other relevant behavioural changes.
4. Inadequate training to workers, particularly in nutrition, growth monitoring and communication.
5. *Anganwadi* worker (AWW) is overloaded and in a weak position; non-supportive supervision to AWWs results in the neglect of crucial nutrition related tasks.
6. Poor linkages between the ICDS programme and the health system.

To prevent blindness among children due to vitamin A deficiency, a concentrated dose of vitamin A is given orally to children along with their immunization. Similarly, to prevent nutritional anaemia among women and children, tablets of iron and folic acid are distributed through health centres. A pilot programme against micronutrient malnutrition has been initiated in five districts in Tripura, Bihar, Orissa, West Bengal and Assam to assess and improve micronutrient status in school children, adolescent boys and girls, women of child-bearing age and elderly population. The National Institute of Nutrition and All India Institute of Hygiene and Public Health, Kolkata are the principal organizations for nutrition research and training.

Food Subsidy Programmes

1. Public Distribution System (PDS) While the PDS has been an important buffer against local food shortages, in many respects it has fallen short of providing food security to the poor. It has been inadequately targeted, with a large number of beneficiaries actually coming from non-poor households. Many of the poorer states do not obtain the requisite quantities to cover their needy populations. They take less than their share of supplies from the PDS mainly because of a weak administrative capacity and the inability to move the food stocks. There are serious leakages in the programme, with supplies often finding their way to the open market.

The PDS is a high-cost operation relative to the caloric support it provides. It costs about three times as much for the PDS to provide a given number of calories to a household, compared with the ICDS. Most important, as late as 1997 the poor man's access to the PDS proved extremely limited, particularly in the most poverty-stricken states.

2. Targeted Public Distribution System (TPDS) In early 1997, the Central Government introduced the Targeted PDS (TPDS) to ensure better coverage of households below the poverty line. Under the TPDS, BPL (below poverty line) households are given a special identity card to obtain up to 10 kg of rice or wheat

per month at half the issue price. The Central Government will allot adequate stocks to each state to cover the requirement for BPL households and in most states it will allocate additional amounts for those above the poverty line as a transitory measure. The TPDS guidelines imply that the second non-targeted channel will be phased out gradually.

While the TPDS is designed to improve food supplies in the poorest households, it has not gone far enough in a number of ways. The quantity of subsidized grain provided amounts to a marginal supplement of 100 calories per person per day, much less than the estimated gap of poor people in rural areas. Secondly, in most states the PDS will still provide large quantities of subsidized food to non-poor households, although this food could be targeted to needy children and mothers, for example, through the ICDS programme. While politicians may waver at such reallocation, it is likely that more rural poor households will be helped immediately through the ICDS than the TPDS because of its wider reach and targeted nature. Finally, it is unclear how the TPDS will plug leakages, particularly in the absence of a rigorous monitoring system.

India's foodgrain production has continued to increase fairly steadily, although population growth has eroded these gains somewhat. Per capita availability of foodgrains was 384 kg in 1960 and 464 kg in 1996. Unfortunately, the production of pulses, an important constituent of the vegetarian Indian diet, has fallen from 65.5 kg per capita to 34 kg in the same period, although availability has been boosted somewhat by imports. To ensure proper nutrition, adequate quantities of pulses or other protein-rich foods such as milk, eggs, or meat, which are also in short supply, must become more widely accessible, requiring increased production and improved distribution and consumption. Unless the prices of these commodities are reduced substantially, through vastly increased availability, they will remain out of reach of the poor.

There is little independent corroboration of the extent to which the employment programmes have supplemented the incomes and food available to the poor, although they are intended for this purpose. The programmes are unfortunately fraught with leakages so that official data on the number of person days of work cannot be assumed to accrue fully to the poor. The efforts of the employment programmes to provide household food support by part payment in grain have been poorly implemented, and the programmes have also fallen short of meeting other nutritionally relevant objectives, such as ensuring that 30% of beneficiaries are women, or raising participant families above the poverty line.

□ National Midday Meal Programme (NMMP)

The Mid-day Meals Scheme was launched by the Ministry of Human Resources Development (HRD) during 1995–96 for the benefit of students in primary schools. Food grains (rice and wheat) were supplied by FCI free of cost to the States and Union Territories. However, FCI charges the economic cost of the foodgrains supplied under the scheme from the Ministry of HRD. A quantity of 1.91 lakh metric tons of wheat and 3.74 lakh tons of rice was lifted under the scheme during 1995–96. The scheme was extended to all other low female literacy (LFL) blocks during 1996–97 and to all primary schools and Nagar Palikas during 1997–98. During 1998–99,

9.61 lakh metric tons of wheat and 17.46 lakh metric tons of rice has been allotted to the States/Union Territories of which 3.85 lakh metric tons of wheat and 9.33 lakh metric tons of rice has been lifted.

Initiated in 1995, the NMMP aims to increase primary school attendance and retention as well as improve the nutritional status and learning achievements of school children, generally, in the 6–11 years old age group. Some states, Andhra Pradesh, for example, emphasize the education of young girls through this programme. The NMMP purportedly covers 91 million children, but the actual number fed is far fewer. School meals are provided in many areas in five states, while take-home rations are the norm in the majority of states. About 23 percent of the GOI education budget in 1997–98 and 16 percent in 1998–99 was earmarked for this programme. The programme is currently short of funds, and continuation of its existing coverage is uncertain.

To enhance nutrition and health status, food intake, including vitamin A and iron, needs to be assured and also accompanied by deworming, and control of infections is a must. These improvements in the NMMP would require state commitment to providing cooked meals at school health programme, and a larger quantity of resources than is currently available from either GOI or the state governments. Most countries have found universal school feeding programmes unsustainable.

□ Micronutrient Programmes

1. National Nutritional Anaemia Control Programme This programme aims to reduce anaemia among women of reproductive age and preschool children by providing iron-folate supplements, identifying and treating cases of severe anaemia, and promoting the consumption of iron-rich foods. In 1992, about 50% of Indian women received iron-folate supplements during prenatal care, although significant differences in coverage were found between urban and rural areas, age groups, educational status, and number of children per woman. The majority of poor women do not obtain adequate supplementation. Major shortages of iron-folate tablets have plagued the programme continuously. Other problems include lack of worker motivation to distribute tablets and inadequate education of women and communities about their value—many women who receive the tablets do not consume them. As a result, India's very high rates of anaemia persist, especially among pregnant women, and the impact of severe anaemia on birth weight and maternal mortality is profound.

2. Vitamin A Prophylaxis Programme The Ministry of Health reported 68% coverage of 6–11 month olds, and 25% coverage of 1–5 year olds in 1996, but field reports suggest that actual coverage is considerably lower. Persistent shortages of vitamin A restrict the programme, along with poor logistics and low community awareness.

This programme targets children between one and five years of age for a six month dose of 200,000 I.U. of vitamin A and 6 to 11 month old infants for a 100,000 I.U. dose. Therapeutic doses are given to those with detected deficiencies, and the programme promotes improved dietary intake of foods rich in vitamin A.

WHO has laid down criteria for recognizing traditional signs of severe deficiency of vitamin A such as Bitot's spots, corneal xerosis, as well as low serum retinal

and low breast-milk retinol. About 3 to 10 million children mostly in developing countries become xerophthalmic and between 250,000 to 500,000 go blind every year.

Vitamin A supplements at dosage levels of 50,000 to 200,000 IU (15000 to 60000 µg RE, depending on the age) are considered prophylactic if administered for four to six months.

3. National Iodine Deficiency Disorders Control Programme Iodine is an essential micronutrient and is required at a level of 100–150 µg (micro grams) daily for normal human growth and development. Deficiency of iodine in the daily diet may cause goitre and other Iodine Deficiency Disorders (IDD). Endemic goitre has been recognized as a major health problem in India. Results of sample surveys conducted in 275 districts of 25 states and four union territories have revealed 235 districts endemic for IDD where the prevalence of IDD is above 10 percent. It is estimated that in India more than 71 million people are suffering from various Iodine Deficiency Disorders.

Having concentrated largely on ensuring the iodization of salt, this programme is the most successful of the micronutrient programmes. Yet, production of iodized salt still falls woefully short of requirements, and quality control and transportation are bottlenecks. Although the government had banned the sale of non-iodized salt, it is now available widely, even in goitre-endemic areas. The poor probably benefit least from this measure as they are more likely to consume unprocessed salt.

The government launched fully centrally assisted National Goitre Control Programme (NGCP) in 1962 with focus on provision of iodized salt to identified endemic areas. In 1985, the Government decided to iodize the entire edible salt in the country by 1992 in a phased manner. To date the production of iodized salt is 42 lakh metric ton per annum. Only about 532 of the 790 private manufacturers licensed by the salt commissioner have commenced production of iodized salt. The NGCP has been redesignated as National Iodine Deficiency Disorders Control Programme (NIDDCP) to emphasize the importance of all the IDDs. As per the directions of the Centre, 29 State/Union Territories completely banned the use of salt other than iodized salt for edible purpose under PFA Act, while another two states had imposed a partial ban and had also set up IDD monitoring laboratories in their respective health directorates. However the court overruled the decision and has upheld the right of the consumer to access non-iodized salt also. Hence, non-iodized salt is now made freely available.

This programme has some problems which need to be tackled in order to achieve success. Iodized salt is fortified with potassium iodate which is heat sensitive and can benefit the consumer if used at the table and preferably not during cooking. Also excessive iodine intake may cause toxicity in a population which does not need iodine supplementation. Hence, it would be advisable to provide iodized salt only to the goitre-prone population.

18.11 FOOD FORTIFICATION

“Fortification” is defined by the Codex Alimentarius as the addition of one or more essential nutrient to a food, whether or not it is normally contained in the food.

Fortification of foods with micronutrients is an effective strategy to increase the micronutrient intake of a population. It can be passively targeted to some or all population groups and thus, does not necessitate any cooperation from the individuals who benefit from it.

For this an industrial infrastructure is required and the fortified food needs to be well accepted by the targeted population group and must be affordable.

The WHO guidelines identifies three approaches:

- 1 *Mass*—Addition of micronutrients to foods generally consumed by the general public. Provides greater population coverage but may satisfy only partially the micronutrient needs of the at-risk subgroups.
- 2 *Targeted*—Fortification that focuses on coverage of specific, at-risk subgroups. Delivery can be sufficient to satisfy nutritional requirements.
- 3 *Market-driven*—Where a food manufacturer takes the initiative to fortify products in order to increase sales and profits. Has a very small coverage in developing countries.

There is, in addition, a relatively new concept, namely *household fortification*. This is the consumption of dietary supplements (usually in powder forms) mixed with foods at meals. In the case of mass fortification, the main advantage over the other interventions is that it uses already existing distribution and trade system, and therefore the cost is basically restricted to the added vitamins and minerals and the fortification process.

The WHO guidelines on food fortification with micronutrients (**iron, folic acid, vitamin B₁₂, vitamin A, riboflavin, copper, zinc**) provides detailed information on fortification levels based on safety, and technological and cost constraints. The salient features are:

- Not more than 3 mg of fortificant iron can be added to a 50 g serving portion of a solid food or 250 ml of beverage—contributing a maximum of 22% of daily iron needs from a diet with high biological availability. Fortifying flour with iron has the potential to increase National IQ by 5% National GDP by 2% and eliminate 60,000 deaths of pregnant women every year.
- Iron and folic acid supplementation in malaria-endemic areas is not recommended, since it shows an increased incidence of adverse effects and death.
- Traditional treatment for vitamin B₁₂ deficiency megaloblastic anaemia is a single, intramuscular dose of parenteral cyanocobalamin of 200 µg. Alternately oral doses of 1000 µg–2000 µg of cyanocobalamin have been found to be as effective.
- The upper limit for foliate is set at 1000 µg/day for adults.
- For macrocytic anaemia due to foliate deficiency, a daily supplementation course in doses of 500 µg to 5000 µg can be given preferably with vitamin B₁₂.

(Contd.)

- Folic acid as prophylactic intervention is targeted to pregnant women who are at risk of neural tube defects and the dose is 400 µg either given alone, or in combination with iron, or iron and micronutrients. This can significantly reduce the 200,000 cases of NTDs in newborn babies every year.
- 1.3 mg folic acid/kg of edible food stuff is the maximum amount that can be added for fortification of staples and a maximum of 27 µg of folic acid per 40 kcal serving of product for other fortified commercial foods
- The upper limit for vitamin A has been set at 10,000 IU (3,030 µg as retinol) daily.
- Total vitamin A exposure should be limited to a cumulative dose that maintains a hepatic vitamin A concentration of <300 µg/gm, which is considered the threshold of toxicity.
- Regular daily consumption of 30 mg of vitamin A in the retinoid form is associated with chronic toxicity.
- The WHO does not specify a safety limit for fortification of staple foods with vitamin A, but it is suggested that such fortification should provide at least 15% of the daily vitamin A needs of the target group but should not exceed 30%.
- For commercial products the WHO recommends a maximum vitamin A addition of 60 µg per 40 kcal serving.
- It is no longer recommended that high dose supplements of vitamin A be given postpartum to lactating women to support vitamin A in milk.
- Oral doses of approximately 2 mg daily are used to treat individuals with hyporiboflavinosis.
- Riboflavin is generally added to multinutrient supplements and in the fortification of staple cereals where it is typically added at a concentration of up to 200 mg/kg of cereal flours.
- Copper deficiency anaemia has been successfully treated with daily doses of copper as cupric sulphate of 1 mg–2 mg per day in adults and young children and doses of up to 9 mg/day in divided doses are safe and tolerable in adults.
- Where high-dose zinc is given, copper should be included in the formulation to prevent distortion of copper nutriture by the zinc.



SUMMARY

Malnutrition is like the iceberg in an ocean, only its tip being visible. The worst affected are our children who must become able citizens of tomorrow in order to make our country one of the foremost in the world. Various nutrition programmes have been launched over the years but the success rates of these programmes are, unfortunately, very limited.



REVIEW QUESTIONS

1. Write a brief note on the prevalence of malnutrition in India.
2. What are the causes of malnutrition in India?
3. What are the consequences of malnutrition in India?
4. Write short notes on PEM, kwashiorkor, night-blindness, goitre, and ICDS programme.
5. What is PDS and how is it different from TPDS?
6. Visit your nearest PDS and note the commodities distributed through it.
7. Define food fortification, what are the three approaches? Give example of each.



Section 4 FOOD COMMODITIES AND SAFETY

- **Chapter 19** Basic Food Commodities and Effect of Processing on Nutrients
- **Chapter 20** Microorganisms and Their Application in Foods
- **Chapter 21** Safety of Foods

Chapter

19



Basic Food Commodities and Effect of Processing on Nutrients

The nutritionist, in order to plan normal and therapeutic diets, must be aware of the wide variety of food commodities she can choose from and their nutritive value. The various diverse food commodities have great importance in Indian dietaries since they comprise the basic foods on which generations of Indians have thrived. Probably no other country can boast of a range of foods from which a multitude of recipes having such varied taste, aroma, colour and gastronomic appeal can be made.

The NIN, ICMR, Hyderabad, has published the nutritional composition of various foods, which is listed out in the food composition tables in Appendix VIII.

Food commodities are of two categories:

1. Major Food Commodities These are used in ample amount at household and industrial level. Most of them comprise the staple foods, which are grown and harvested over much larger areas than the minor commodities. Also, we derive most of the macro-nutrients from these foods, e.g. cereals and cereal products.

2. Minor Food Commodities In comparison to the major ones, these food commodities are required in smaller quantities either as accompaniments or as adjuncts in our diet. However, it must be borne in mind that they too contribute to a number of nutrients especially the micro-nutrients, to our dietaries. For example preserves, pickles, *papads*, *chutneys*, sauces, etc.

19.1 CEREALS, MILLETS AND THEIR PRODUCTS

Rice

India grows about one-fifth of the world's rice. Rice is the staple food of the South Indians and certain people in the North of India and is widely cultivated, accounting for about 25% of the total cropped area. There are strong regional preference for size, shape, flavour and cooking texture. In broad terms, rice is classified as fine, medium and coarse. Fragrant, long grained varieties like Basmati are prized in the north for everyday eating. In the south, people prefer to use these varieties only for making *pulao*, *biryani* or *ghee* rice. A coarser quality is preferred for everyday use. Parboiled rice or *Ukda*, as it is commonly known, is slightly yellow in colour and preferred in the south. Everywhere in India, rice that is at least a year old is preferred since, it cooks to a firm consistency and has separate grains. In some countries like the Far East, a semi-glutinous mass is desired after cooking the rice.

Harvested rice undergoes threshing after which it is dried. Husk is removed due to the milling process but it also affects the nutritional quality. Milling reduces all components markedly except proteins, which are only slightly reduced, and starch content increases.

Rice contains 90% starch. Protein content of rice is low. Lysine content amongst cereals is highest in rice. Predominant sugar is sucrose and predominant mineral is phosphorus. Sugar, amino acids, ash, crude fibre and pentosans are confined largely to the bran and germ. The B-vitamins present mostly in the germ and bran are drastically reduced on milling. Phosphorus in the form of phytin, calcium and iron are also reduced. However, the milling process much improves the cookability and digestibility. Polished white rice amongst all rice is the worst in respect of the nutritional quality, since it contains only about a third of the vitamins and half the calcium after polishing it. Brown rice (rice with bran) contains the various vitamins like thiamine, riboflavin, niacin and folic acid. Hand-pounded rice, which retains a good part of the bran, is close in comparison to brown rice.

Parboiling is a pre-milling process, which has nutritional advantages. By this process, the vitamins, mostly seated in the bran, diffuse slightly inwards during soaking and are then firmly held in the kernel by the process of gelatinization. Since, a layer of gelatinized starch forms on the surface of parboiled rice, it prevents the nutrients from leaching out during boiling. Hence, they are largely retained in parboiled rice even after milling. Modern methods of parboiling yield products of excellent taste and appearance, which do not stick together after cooking. It is interesting to note that stored parboiled rice also resists insect and mould attack better than the other forms.

Some varieties of rice which are easily available are *Basmati*, *Dilpasand*, *Dudhkalma* and *Sanharsana*. Some poetic varieties of rice are *Jaya*, *Padma*, *Sona*, *Madhu* and technically named varieties like CO-25, MTV-15 and T-138.

Processed rice products like beaten rice (flattened rice or *poha*), parched rice (*murmura*) and puffed rice (*kurmura*) are available in the market.

Since both puffed and beaten rice have undergone fairly drastic treatments, half the thiamine disappears from both products and riboflavin is all but destroyed, especially in puffed rice. Riboflavin is fairly well retained in beaten rice, as is the calcium. Instant rice, which is a common product in supermarkets abroad, cooks in 2 to 10 minutes. However, in India growing use of pressure cookers that cook even ordinary rice quite rapidly is a factor that could limit the success of quick cooking rice in India.

Rice noodles are popular in many countries of the Far East and South East Asia. Vermicelli can also be made from rice. Extruded and puffed sweet and savoury snacks such as rice *papris* (small rice *papads*) are available in India.

□ Wheat

Wheat is another staple food of Indians. It is widely used in Indian dietaries besides its various products like *rawa* (semolina), *maida* (refined flour). In South and East parts of India its use was very limited, but enforced rationing during the Second World War gently pressurized people into using wheat.

Today, wheat is a part of the diet all over India. A number of varieties of wheat are widely used such as *Sharbati*, *Saphed pissi*, *Bansi*, *Khandwa*, etc. The inner endosperm of wheat is mainly starch and its protein content is low. The bran has high proportion of protein, fibre and ash while the germ is particularly rich in protein and fat. However, as compared to rice, wheat has greater protein content.

The bran carries particularly high levels of niacin, pantothenic acid, calcium and phosphorus and wheat germ is rich in tocopherol, thiamine, pyridoxine; and potassium. The nutrients in wheat are not evenly distributed in the grain; hence, using whole wheat *atta* ensures full value of this cereal grain in the diet. The percent proportions of endosperm, bran and germ in wheat are 83, 14.5 and 2.5 respectively.

The wheat is milled either by grinding on a *chakki* or *jate* at home, i.e. by traditional method or in a flourmill on an electrically driven *chakki*. *Atta* or wholemeal flour, semolina (*suji*) and *maida* are the three main products obtained by milling wheat. *Atta* is used for making *chapati*, *puri*, *phulka*, *paratha*, etc. *Chapati* or *roti* is a traditional product made by kneading the dough, sometimes using a little salt, and shortening, rolling out small balls of the well kneaded dough, which are then roasted on a *tawa* of flat grill. '*Sharbati*' variety is suited for making *chapati* flour.

Rawa, *suji* or semolina is granular wheat particles, which are used for making *upma*, *sheera*, *rawa dosai* and macaroni type products. *Dalia* or broken wheat is a product similar to *rawa* but has much larger particle size than *rawa*. *Dara* wheat is used for making *dalia*, *rawa*, etc. *Maida* is obtained mainly from *Pissi* or soft white wheat. A variety of nutritious foods such as *Bal-ahar* have been developed using wheat flour, groundnut flour and pulse flour.

□ Millets

Besides the fine cereals, rice and wheat, there are coarse cereals or millets such as *jowar*, *bajra* and maize. The flours are used for making *bhakri*, puffed products (*lalya*) and used in making snacks such as *murukku*, *chakli*, *thalipith*, *kharda* (salted) *sev*, etc. One of the most nutritious millet, *ragi* or *nachni* is widely used in Karnataka and Maharashtra. It is milled like wheat, germinated and malted for *sattu*, made into *papad*, etc. For generations, it is being used as a weaning food for children and a nutritious drink for pregnant and lactating women.

1. Sago Also known as *Sabudana*, which is available as small, white pellets (globules), is widely used as a fasting food and valued as food infants and invalids. Traditional sago was made from the pith of the stem of the sago palm grown in Malaysia and Indonesia. Today in India, sago is prepared using starch from various roots and tubers such as tapioca. *Papris* made from sago are a favourite Indian snack. Sago is starch-based. It gives about 350 kcal per 100 g and contains 87 percent starch and 12 percent water; it contains very little of other nutrients such as a small quantity of protein and no vitamins.

2. Ragi Five species of *ragi*, which occur in India of which *Eleusine coracana* is the widely cultivated millet, particularly in the coastal regions. It is also known as the finger millet or African millet. About 75 percent of *ragi* area lies under South India, especially, Mysore, Madras and Maharashtra. It is a highly adaptable crop. It can be grown with cereals, pulses, castor, niger, groundnut and *til*.

It is converted to flour to be made into cakes, puddings, porridge, etc. A fermented drink or beer is also prepared from *ragi*. Grain is malted and flour made from the malted grain is used as a nourishing food for infants and invalids. It is especially a nourishing food for diabetics.

The nutritive value is higher than rice and equal to wheat. Husk forms only 5% – 6% of the weight and is lowest in foodgrains.

Protein content varies between 6 to 11 percent and a strain of white *ragi* has 14 percent protein. At a five percent level of intake, the BV and digestibility coefficient of *ragi* is 89 and 80 respectively. *Ragi* starch is low viscosity starch.

3. Sorghum It is also known as Great Millet Sorghum. 80% of cultivated Sorghum in India is durras. *S. cernuum* is grown throughout Asia Minor, Arabia, some parts of Persia, Afghanistan and in India. Sorghum is grown in various states of India.

Sorghum protein is superior to wheat protein in BV (BV is 83 and digestibility coefficient is 91%). PER of sorghum protein at 8% level of intake is 0.95. This value is enhanced to 2.44 when supplemented with L-lysine and 2.92 when supplemented with L-lysine and DL-threonine.

Sorghum is ground and used to make unleavened bread. By mixing up to 25% with wheat flour, it can be used to make leavened bread. Popped grain, especially of *S. roxburghii*, can be eaten as such or ground into flour.

4. Bajra It is also known as Pearl Millet, Bulrush Millet, and Spiked Millet. About 16 species occur in India, of which *Pennisetum typhoides* is widely cultivated.

The *biological value* and *digestibility coefficient* at five percent level of protein intake are 83% and 89%. At 10% level of protein intake, PER is 1.43 as compared to 1.2 of rice. Partial or complete replacement of rice by *bajra* appreciably increases the nutritive value of the diet. A partial replacement of wheat by *bajra* in poor vegetarian diets improves the biological value of the protein in the cereal mixture.

It is the staple foodgrain especially in the rural areas. Consumption of *bajra* causes heat in the body, so during summer it is taken as gruel and, hence, used more in winter. It is nourishing and comparable to rice and wheat. It is generally made into unleavened bread and thin porridge. It is eaten after it is parched, the product being similar to popcorn. It is also found suitable for malting.

Ergot-infested *bajra* makes the grain toxic to human beings, the symptoms being nausea, giddiness, vomiting and diarrhoea. Spoilt, infested crop must be burnt in order to prevent animals from consuming the toxic material, which can even be fatal.

Bread and Biscuits

Bakery products that fall under the category of flour confectionery are wafers, waffles, pancakes, sponge rolls, bread, tea cakes, butter buns, scones, cakes, butter sponge and sponge cakes, plain biscuits, short pastry, puff pastry, sweet biscuits, etc. All the bakery products are gaining extreme popularity as processed foods, which offer ready-to-eat convenience as well as have comparatively long shelf life. Of these, biscuits are the most convenient and compact in form and are ideally suited for storage and distribution to a larger number of people. They are also capable of being enriched with additional proteins, vitamins and minerals to enhance their nutritive value. They are suited for promotion of protein-rich foods for middle and low-income groups.

Bread and biscuits contain calcium and iron. A slice of toast or plain cake or two slices of bread or a cup of corn flakes would weigh about 25 g and contribute 100 calories, 2 g protein, 5 mg calcium, 0.3 mg iron, 50 micrograms thiamine and riboflavin and 500 micrograms of niacin to the diet.

19.2 PULSES, LEGUMES AND THEIR PRODUCTS

□ Dals and Grams

Pulses form about 15% of the grains consumed in the Indian dietaries. In India, grams denotes mainly lentils and split gram is *dal*. The legume is milled to remove the husk and split the pulse. Pulses (*dals*) are an important food item and used in a vast variety of forms. They may be cooked into thick or thin gruels or combined with cereals—*khichadi*, *dahi wada*, *idli*, *dosa*, *thalipith*, *murukku*, *dhokla*, *puranpoli*, etc. Grams may be germinated, roasted, puffed or fried. Flours like *besan* (Bengal gram flour) are used as a base for sweets like Mysore *pak*.

India boasts of a number of grams—Bengal gram (*chana*, chickpea), *tuvar dal* (red gram, pigeonpea), *mung dal* (green gram), *masur dal* (lentil), *urad* or *mash dal* (black gram), *kulith* (horse gram) and *kala tur* (Indian soybean). Other less common ones are *rajmah* (kidney, haricot or French bean), *avave* or *valpapdi* (field bean), *bakla* (broad beans), *chastang* (broad bean), *matar* (green pea), *babril* (pink bean), *lobia* (cowpea), *kheri* (moth beans), *safari* (rice bean), *sim* (scarlet inner bean), *guar* (cluster beans), *bora sim* (sword bean). Some part of the harvested grain is processed in the home and the rest in *chakkis*.

□ Gram-based Products

Besan is the flour of Bengal gram of chickpea. The flour is widely used in preparing batters, doughs, which can be suitably salted and spiced and used in extruded preparations like crisp *sev*, *murakku* or *chakli*, *thengole*. It is also used in preparation of *pakoras* and *bhajias*, potato *vadas*. Bengal gram and black gram are used in preparation of these snacks, they have exceptional glutinous nature, which lends to excellent moulding, extruding and binding qualities.

□ Puffed Grains

Bengal gram is puffed and used by itself as a snack. It is also used as an ingredient for blending into other snacks. It is rolled into *laddus* with *jaggery* syrup. Both the digestibility and nutritive value of puffed Bengal gram are high.

□ Prepared Mixes

Dals are used for making *rasam*, a thin soup, *dal dhanshakh* and *sambhar*, a thicker *dal*. *Dals* are widely used in making commercial instant mixes. *Dals* are the backbone of protein nutrition in India. They are more economical than meat (about half the price of meat/fish). All *dal* products are exceptionally rich in lysine. Since, cereals are lysine limiting, a combination of cereal with pulse complements this deficiency.

Pulses are good in thiamin, riboflavin and niacin as well as iron and calcium. Processing grams to remove husk does not affect these nutrients since they occur in the body of the grams. Many pulses contain anti-nutritional factors such as haemagglutinins, goitrogens and trypsin inhibitors. They are also present in small amounts but are destroyed when *dal* is cooked. They also contain verbascose, stachyose and raffinose-sugars, which are not metabolized easily. They find their

way to the large intestines where they ferment. Hence, pulses are gas producing. Sprouting and fermentation reduces these sugars to a very great extent.

Papads, which are the crisp, textural contribution to an Indian diet, may be roasted or deep-fried. Since *dals* such as black gram *dal* (*urad*), green gram *dal* (*mung*), red gram *dal* (*tur*) and Bengal gram *dal* (*chana*) are used, the protein content of *papad* is approximately 22%. The nutritive value of a single 10 g *papad* can be as much as 50 calories, if deep-fried.

19.3 MILK AND MILK PRODUCTS

In spite of the theories for and against consumption of milk, it remains the most common commodity of any Indian household, rich or poor. Cow and buffalo milk are preferred although other types of milk such as standardized milk, toned milk and homogenised milk are also available.

Powdered milks or milk powders, either skimmed, partly skimmed or whole milk powders, are also available and are suited for use in case the milk supply is short. They are also useful to impart taste and in various preparations like fruit salad, *kheer* (porridge) and suitable to be used in place of fresh milk.

Baby food, which is a homogenized concentrate made from buffalo milk, contains added sugar and other permitted additives. It is suitable for a baby's digestive system. *Weaning food*, which may be introduced in the child's diet at the age of six months or more, usually contains both, cereal and milk. The base preparation may either contain rice or wheat. Such precooked weaning foods can be eaten as gruel with water or milk. Malted milk foods contain whole or skimmed milk or their powders along with malt extract and cereal grain flour. The product may also contain cocoa powder. The final product is such that it contains protein and fat in a partially digested form, which is helpful for use by children, convalescent and old people. The malted flavour also appeals to everyone.

Condensed milk is milk in which the water content is between 25–30%, that correspondingly increases the percentage of fat and protein to 9 and lactose to 11. Sweetened condensed milk is also available, made either with whole or skimmed milk. It is characterized by a light brown colour and slight caramelization of both natural as well as added sugars.

At home, butter is made by churning soured cream. Commercially, it is made from ripened cream. Annatto and salt are added. The characteristic aroma of butter is due to diacetyl and propionic acids.

Ghee is the clarified product obtained by heating unsalted white butter till it obtains the characteristic aroma.

Dahi, yoghurt and *shrikhand* are products which are made routinely in the Indian household. *Dahi* is used as the base for preparing sweet or salted *lassi*, which is offered to guests especially in North India. Yoghurt has not yet gained the commercial importance it has in advanced countries. It is prepared by adding to milk a mixed culture, i.e. an equal amount of two cultures, *Streptococcus thermophilicus* and *Lactobacillus bulgaricus*. In addition, it also contains fruit pulp, sugar, colour and flavour. Cultured buttermilk is a product not yet available in India. It is prepared

by incubating skim or partly skimmed milk with a pure strain of *Lactobacillus acidophilus*.

Shrikhand is being produced from cow's milk or buffalo's milk by various milk cooperatives and has proved to be successful particularly in households with working homemakers.

Cheese is not a common traditional product used in the Indian dietaries. It is made in the hilly regions of Northern and North-eastern regions namely Bandar, Surati, Dacca and Kalimpong. Today, processed cheese and spread manufactured by various milk cooperatives like Amul, is available in the Indian market. Processed cheese has a long shelf life but it tends to dry out in storage.

Khoa or *mava* based sweets such as *pedha*, *burfi*, *gulab jamuns*, *kalakand*, *dudhi burfi*, *kajukatri*, etc. are available in the Indian market. Although *khoa* is made both from cow's milk and buffalo milk, the one made with the latter is preferred since it gives a softer and smoother *khoa*. *Chainna* or *paneer* is also an indigenous cottage cheese made in India. It is used to prepare *rasgulla*, *chumchum*, *rasmalai*, *sandesh* and other sweetmeats.

Milk contains two important minerals, calcium and phosphorus, although it lacks iron and vitamin C. It contains protein, lactose and fat although the latter depends upon the type of milk. Skimmed milk does not contain any fat hence, it is also a poor source of vitamin A. Milk powders are a concentrated source of all nutrients whether whole or skimmed. Condensed milk is usually deficient in certain nutrients except those present in milk. Due to condensation it contains about two and a half times the nutrients present in milk. *Shrikhand* contains only 60% water as compared to 90% in milk. *Dahi* is similar to milk in composition except for the lactose content, which is lowered due to its conversion to lactic acid.

Cream and butter are fat rich products obtained from milk. Cream contains fat and some vitamin A. It also contains protein, lactose and about one-third of the other nutrients in milk. *Chainna* and *paneer* contain all the milk protein, fat and casein, half the minerals and vitamin A. When the whey is lost, all the lactose and lactoglobulin, protein and half the minerals and vitamin A are lost too. Processed cheese is a calorie-rich food with fair levels of vitamin A and the three vitamins namely, thiamine, riboflavin and niacin.

19.4 VEGETABLES, FRUITS AND THEIR PRODUCTS

A vast variety of fruits and vegetables are grown and harvested all year round. Since, there have been advances in water management and irrigation as well as hybridization techniques, a number of vegetables and fruits flood into the markets every season. Among these are the relatively less expensive dark green leafy vegetables like spinach, amaranth, *bathua*, cabbage, colocasia, coriander, drumstick, fenugreek, etc. Their contribution to the diet in terms of vitamins, especially A, C, folic acid and B₂, minerals such as calcium and iron, water and above all the fibre content, cannot be under-estimated by the nutritionist.

The yellow and orange fruits and vegetables comprise red pumpkin, carrots, mango, papaya, guava, orange, lemon, sweet lime, *amla* (Indian gooseberry), etc. They contribute significant amounts of vitamins, especially A and C, minerals,

potassium and a large amount of water. If the fruit is not peeled before eating, it will contribute to the fibre content of the diet.

Roots and tubers like potato, onion, yam, sweet potato, tapioca, and other vegetables and fruits, namely, beans and peas, brinjal, lady's fingers, all varieties of gourd, sapota, apple, pear, peach, plum, *seetaphal* (custard apple), are used in a wide variety of dishes in the Indian dietaries. Most of them are a fair source of several nutrients. Since, they are consumed in substantial quantities and are a part of the daily diet, their contribution is significant. The roots and tubers are rich in carbohydrates and, hence, they mainly yield energy.

During the glut season numerous vegetables and fruits are preserved in the form of pickles, jam, *murabba*, squash, etc.

□ Pickles, Chutneys and Sauces

Indians love the tickle and tang these products offer. They are an indispensable part of the Indian dietaries. The Indian market is flooded with a vast variety of pickles, *chutneys*, sauces and *papads*. Various fruits such as mango, lemon, chilli, carrot, onion, ginger, fresh turmeric, pepper, meat and fish and a vast list of other foods are pickled. Salt and oil content of pickle is quite high and calorie conscious people would do better without large helpings of pickles in their diets. Nutritionally, pickles contribute to calories and salt.

Chutneys are relishes made with various ingredients such as garlic, ginger, dates, raisins, mint, cucumber, coconut, green mango and sprouted and soaked *dals*. These are consumed fresh. Some *chutneys* prepared by using mango, *jaggery*, honey, dates with spices and some oil can be preserved and used for a longer time.

Sauces such as tomato, chilli, Worcester and soybean are becoming increasingly popular. Tomato sauce and ketchup contribute about 90 calories per 100 gms. Soya sauce made by fermenting soya beans with salt contains up to 18% salt and up to 10% sugars. It is commonly used in Chinese cookery. Due to its high salt content, it must be used sparingly by persons having high blood pressure and cardiovascular problems.

□ Preserves, Squashes, Jams, Jellies and Murabbas

Since these products are prepared using fruits such as citrus fruits like lemons and oranges and other fruits such as mango, guava, banana, *chikku*, grapes, etc. along with high amounts of sugar, these products contribute to calories along with vitamin A and vitamin C.

A *murabba* (sugar preserve) prepared with Indian gooseberry (*amla*) is a rich source of vitamin C since it retains about two-third of the vitamin C. Dried fruit and pulps carry little or no vitamin C and only about half the vitamin A content of the fresh fruit. Fruits used in syrups, jelly and jam may contain three-fourths of the original vitamins A and C. Canned or bottled fruit juices may also contain almost the same quantity of vitamin C when purchased, since, there is as yet no law by which vitamin C must be added or fortified in packed fruit juices.

19.5 EGGS, MEAT, FISH AND POULTRY

□ Eggs

Eggs are available in the market either as fertilized or unfertilized eggs. Eggs are composed of 12% shell, 30% yolk and 58% white. Nutritionally, eggs are one of the most complete foods having the highest PER of 3.9 as against 3.1 for milk proteins and 2.3 for meat proteins. The NPU for egg is 100 while it is 80 for meat and 75 for milk protein.

Eggs contain lipids mainly as linoleic acid and arachidonic acid as well as phospholipids. Eggs contain 14 vitamins, besides containing 12 minerals, mainly calcium and phosphorus. Iron is not present in large amounts yet the body wholly absorbs it. The only nutrient absent in eggs is vitamin C. The egg yolk is rich in cholesterol. Eggs contain biotin (a B complex vitamin), which is bound by avidin and made unavailable to the body. Avidin is destroyed on boiling or frying.

Nutritionally, there is not much difference between boiled, fried or beaten and cooked egg (i.e. an omelette).

□ Fish

Till recently, fish was mainly consumed as fresh fish and the rest was dried. As the mode of transportation became efficient and ice was made available, as well as more cold storages were set up, fish began to be transported to distant places. Very little fish is canned, except prawn, shrimp, mackerel and sardine. Prawns and lobsters are exported in large amounts.

Fish furnishes first-class proteins, which are superior to meat and almost equal to milk. On an average, fish contain 18–20% proteins. Most fish have less than two percent fat in their flesh. Fish is rich in lysine (10%) and methionine (3%). Minerals are present in fair amounts. Fish is also rich in iodine and fluorine. Fish livers are rich in vitamins A, D and E. Fish is the only animal protein rich in PUFA, especially the Omega 3 fatty acids and hence, advisable for consumption by arteriosclerotic persons.

□ Meat

In our country, meat symbolizes goat meat, sheep mutton and beef. This contains between 40–45% proteins.

Different types of meat products that are available include frozen dressed chicken, ready to eat products such as chicken *samosa*, *kabab*, sausages, etc. Some ready-to-eat products are also now becoming popular. A number of processed products such as nuggets, *kababs*, fingers, patties, cutlets, *samosas*, etc. are available in the market today.

□ Poultry

The development of poultry has taken long strides. It is available in the frozen and in the dressed form. A number of ready to eat preparations are today at the consumers disposal such as chicken *kababs*, nuggets, *samosas*, peppered fingers, etc.

19.6 FATS AND OILS

Fats of various kinds have been used for cooking since time immemorial. In India, fats and oils have come mostly from vegetable oil seeds. *Til* or gingelly and mustard have been used in cooking. South Indian people use coconut oil for cooking. In the northern region of India, *til* oil and mustard oil have been used in cooking. Groundnut oil was introduced much later, i.e. after it was brought by the Portuguese traders in the 16th century. Today, groundnut oil is a major oil, followed by mustard and then niger (*Ram til*).

Ghee, made by clarifying butter, is a popular medium of cooking, particularly used in preparing sweetmeats like *chiroti* and *Mysore pak*. It is used for daily consumption. Coconut oil is more popular in Kerala while sesame oil is used commonly in the other southern states. Mustard oil is widely used in Bengal, UP, Punjab and Haryana. *Vanaspati*, i.e. hydrogenated vegetable oil contain at least five percent sesame oil or safflower oil, both of which are rich in linoleic acid. The acid is necessary to prevent atherosclerosis. Palm oil has also now entered the Indian kitchen. It contains 10% linoleic acid and palmolein contains about 12% linoleic acid.

Other fats such as margarine or bakery fats are used sparingly in the daily diet. They are generally used in making cakes, bread and biscuits. Although margarine has replaced table butter in foreign countries it is not yet an important constituent of our Indian diet.

19.7 BEVERAGES

□ Soft Drinks

“Soft drinks” is a terminology used for aerated waters or waters impregnated with carbon dioxide. They are purely synthetic drinks made by mixing water with three to four volumes of carbon dioxide. Artificial sweetener, such as saccharin, along with natural sugar is used. A bottle containing 180 ml of carbonated beverage contains about 16 to 18 g sugar and 18 mg saccharin. Nutritionally, it is an empty food since it provides only calories and no other nutrients. A bottle of an aerated beverage (180 ml) gives about 70 calories.

Soft drinks are highly acidic due to added acids such as citric, tartaric or phosphoric, hence, are not advisable for consumption by patients suffering from gastric acidity and ulcers. Saccharin, which is still permitted in India, has been banned in several other countries since it is a suspected co-carcinogen. Cola drinks contain 40 mg caffeine in every bottle. Children should not be encouraged to consume soft drinks since they have no food value and depress the appetite.

□ Mineral Waters

Mineral waters are natural spring waters. Those waters having a specially pronounced flavour have been popularised, since they are thought to have health-giving properties and sometimes even miraculous healing powers. Many of these natural waters are rich in mineral salts and others contain sulphurous compounds.

The high mineral content of many of these waters would have a purgative effect on the consumer.

The multitude of bottled waters available in the market is generally pure drinking water. Till recently, many of them claimed to be mineral waters but were only microbiologically safe drinking water. Now ISI standards have made mandatory for the same. The Bureau of Indian Standards gives a detailed list of the composition of drinking water as well as packaged drinking water (other than packaged natural mineral water). (Refer IS: 10500–1991; IS: 14543–1998 respectively).

□ Alcoholic Beverages

Alcoholic beverages such as the distilled ones like whisky, gin and brandy contribute 250 calories for every 100 ml. Beer and toddy contain 40 calories per 100 ml but in addition also contribute small amount of riboflavin and niacin. No other alcoholic beverage contributes the B vitamin or any vitamin C. Wine, which is an undistilled alcoholic beverage containing between 6–20% alcohol, gives about 100 calories per 100 ml. Like the soft drinks, alcoholic beverages must be sparingly used in the dietaries since they do not contribute significantly to the nutrient intake except calories.

The energy-value calculation of an alcoholic beverage is as follows:

$$\text{kcal in beverage} = \text{Volume of beverage (in ounces)} \times \text{Proof} \times 0.8 \text{ kcal/Proof/one oz.}$$

Proof = the proportion of the alcohol to water or other liquids in an alcoholic beverage. (100 Proof is equal to 50% of ethyl alcohol by volume)

So, to determine the percentage of ethyl alcohol in a beverage, divide the proof value by 2)

Factor to determine the caloric density of alcohol (7 kcal/gm) is 0.8 kcal/Proof/one oz, since, all the alcohol in liquor does not give energy.

Example: A 2 ounce of 88 proof whisky would give $2 \times 88 \times 0.8 \text{ kcal} = 141 \text{ kcal}$

□ Tea and Coffee

These two beverages are popular all over India in all seasons. They are drunk with milk. They may not be considered as food but as refreshing and stimulating beverages. The nutritional contribution of one cup is extremely low but since, it is not unusual for individuals to consume six to eight cups of tea or coffee everyday, even the minuscule nutrients contributed by them would have significance. The macro-nutrients in tea and coffee brews are very low but an addition of sugar and milk to the final "cup" will contribute to calories and protein. Minerals such as manganese, iron, copper and fluorine are found in significant amount in tea.

The stimulating action of tea and coffee is attributed to caffeine, theobromine and theophylline, all of which are alkaloids. The quantity of these in a 150 ml cup of tea are 50 mg, 2–3 mg, and below 0.3 mg respectively. A cup of coffee contains 50–80 mg caffeine but not the other two alkaloids.

19.8 FOOD ADJUNCTS AND SWEETENERS

□ Spices and Condiments

India has been the home of spices. At least 50 spices cultivated in India are widely known. Spices in India are widely used in foods cooked everyday to add flavour, taste and colour.

Each state has its own unique combination of spices. They are sun-dried and sold either as the whole spice or in its powdered form or as *masala*, i.e. compounded spices roasted and ground together. Spices, condiments and herbs contain water, which generally varies between 10 and 15%. Besides water, they also contain cellulose, starch, sugars, etc. Fibre content could be as high as 30%. Protein content is low (less than 10%) except for seed derived spices like *methi*, mustard, *jeera*, *ajowan*, coriander seeds, etc. Minerals in spices are usually between two and seven percent. Spices are fragrant, aromatic or pungent and are valued for their essential oils. For example, ginger contains camphene, zingiberen and phellandrene; pepper contains piperine; chillies contain capsaiacin and capsanthin; spices also contain colour, like curcumin in turmeric or crocin in saffron.

Condiments that are used as souring agents contain acid. Tamarind has tartaric acid, *kokam* has hydroxycitric acid, *amchur* has malic acid and pomegranate, seeds have oxalic acid. Oleoresins are obtained from spices by extraction with alcohol or acetone, which are also used in place of the whole spices. Chillies contain 15%, ginger 6%, pepper 11% and turmeric 7% oleoresins.

The nutritional contribution of spices is of no significance, since spices, condiments and herbs are consumed in small quantities. Some spices, which contain a large quantity of minerals, may contribute if consumed in significant amounts. Spices have been found to aid digestion, e.g. nutmeg and saffron, enhance the activity of two enzymes pepsin and rennin. They relieve distension.

The anti-microbial or antiseptic properties of spices are also well known. Allicin present in garlic has a killing action against a wide range of bacteria and is also active against fungi. Curcumin in turmeric (*haldi*) also has a powerful antibacterial action and asafoetida destroys coliforms and anaerobes in the caecum.

Several spice oils as those of *ajowan*, aniseed, asafoetida, clove, cinnamon, onion and pepper have suppressive powers against organisms.

Due to the antiseptic properties of spices, they are used in preserved foods. Mustard seeds are used in pickles, cloves and cinnamon in *murabbas* and fruit preserves. For several centuries now, meat is being stored using pepper. Curcumin in turmeric is an antioxidant. Kokum has shown to preserve fresh fish as does garlic for pork.

All the spices are valued for the zest and flavour that they impart to food. Pepper contains two to three percent of an aromatic volatile oil and three to six percent of a pungent alkaloid, piperine. Ginger contains an aromatic essential oil two to four percent and gingerol, a chemical responsible for its hot taste. Both are valued as food flavourings.

Chillies contain fat-soluble red carotenoid pigments and capsaicin, an alkaloid responsible for its intensively hot taste (0.2–1%). Both the colour and capsaicin are useful in giving foods an attractive colour and hot taste.

Cardamom contains three to five percent of an aromatic volatile oil, very much valued in food flavouring.

Turmeric is chiefly valued for the yellow pigment, curcumin, present in it between two to six percent. It also contains two four percent of aromatic essential oil.

Coriander contains an essential oil (0.5–1%), which is chiefly made up of an alcohol alpha-linalcol and some esters and terpenes. The spice and its oil are used extensively in flavouring baked foods, meat products and sauces. The spice is also an ingredient of curries.

Cumin contains about three percent of an aromatic volatile oil responsible for its strong smell. The oil contains chiefly cuminaldehyde. The spice and its oil are used for flavouring soups, meats, cheese, etc.

Fennel seeds contain two to four percent of an aromatic volatile oil responsible for its attractive flavour. The oil contains chiefly anethole. Fennel is used for flavouring baked confectionery, soups and pickles.

Celery seed has a pleasant characteristic odour, slightly pungent taste and contains about 2.5% volatile oil. It is used to flavour soups, sauces, meats and tomato products. Celery salt is used to flavour eggs, fish and salads.

Cinnamon and cassia contain one to two percent essential oils. Cinnamaldehyde is the main constituent.

Nutmeg and mace contain 10–11% volatile oil responsible for the exotic odour. Garlic contains about 0.1% volatile oil.

□ Sugar and Jaggery

India is one of the largest producers of sugar. *Jaggery* was prepared in 6th century BC, which is the earliest record of its preparation in India. Sugar is available as table sugar and other forms are cube sugar, icing sugar or castor sugar. Brown granulated sugar is made from the final molasses. In our country, liquid sugar is not yet as common. Invert sugar, which is made by hydrolyzing sucrose, is used in making confectionery or soft drink and in baking and canning operations. Solid dextro glucose is used as an invalid's food in energy tablets and in various medicines. All sugars contribute four calories per gram. Jaggery does contribute some minerals, especially iron, since jaggery is made in iron cooking vessels.

□ Salt

Salt is made by evaporating water from seawater. Crude salt contains sodium chloride along with calcium carbonate, calcium sulphonate, magnesium chloride, magnesium sulphate and sodium sulphate. Salt is also made from lake water, e.g. Sambhar Lake in Rajasthan or Chilka Lake in Orissa. Rock salt is mined at Mandi in Himachal Pradesh. Salt may contain anti-caking agents to prevent it from absorbing moisture and sticking together.

Since salt is consumed by all it has been found to be ideal vehicle for supplementation with iron. Now it is also being used for fortification with iodine in the form of potassium iodate.

Iodised salt has been proved to be a boon to the people in hilly regions who have been suffering from endemic goitre.

Since salt contains large amount of sodium chloride, people suffering from hypertension and cardiovascular disease should consume it very minimally.

19.9 NUTS AND OILSEEDS

No Indian cooking is complete without the use of nuts and oilseeds, in their form as the nut or the oilseed or its oil. Groundnut and coconut are used abundantly along with mustard, *til* (gingelly seeds), poppy seeds, etc. Other nuts like almond, cashew nut, pistachio nut, walnut, are consumed as such or in the form of products, which may be salted or made into a hard-boiled sugar or *jaggery* confectionery. *Chikki* is extremely popular with children and adults alike.

Since they contain fat, nuts and oilseeds contribute to the energy value of the diet. De-fatted meals of the nuts and oilseeds are very rich sources of protein. Today efforts are being made to prepare acceptable products from the de-oiled meal. Besides protein, nuts and oilseeds are also a rich source of B-complex vitamins.

Care must be taken to store the nuts and oilseeds in a cool, dry place since they are prone to fungal infestation.

19.10 FAST FOODS

Modern foods can be grouped into two categories:

1. Convenience foods
2. Fast foods

Convenience foods are the result of modern technological advances in the field of food processing, preservation techniques and the invention of various newer food additives. The list comprises:

1. Instant dry mixes such as those of *gulab jamim*, *pulao*, *khichadi*, *biryani*, *idli*, *dosa*, noodles, soups, and so on.
2. Canned products, which need only to be warmed for a few seconds in the microwave oven before being served piping hot. For example, *Alu mutter*, *paneer mutter*, *palak paneer*, *dal palak*, *dal masala*, *undhiya*, *alu vadi (patra)*, *baingan bharta*, *sarson ka saag*, etc. A variety of canned curries are today being exported from our country.
3. Frozen foods are available in the market in a wide variety such as all types of vegetables, chicken, meat, fish and their products.
4. Pre-prepared or fabricated foods such as *laddos*, *chaklis*, *vadis*, *chiwda* are our age-old preparations. Soybean is today used to make texturized products, which are similar to meat products and are popularly known as meat analogs, e.g. nutrinuggets, nutrela, soya chunks.

The second category is the rapidly growing sector of fast foods. This concept of fast foods is not new to our country. Our indigenous fast foods have existed along with the multitude of cuisines in our country. There must be no Indian who has not heard of *dosa*, *idli*, *chaat*, *chhole bhature*, *parathas*, *kababs*, *tandoori* preparations,

samosas, kachoris, sweets, pakoras, pavbhaji, dabeli, vada pav, samosa pav, etc.! The American and Italian fast foods owe their popularity particularly to the impressionable teenage crowd due to the eight Fs.

1. *Family* The products offered by the fast food restaurants cater to the tastes of young and old alike. Hence, a visit to the nearest restaurant is a family outing enjoyed by all.
2. *Fast* The service is quick from the time food is ordered, especially when compared to the three course or five course meals eaten in restaurants. Many a times it is self-service.
3. *Fried* Several items are fried, which most people like, for example, French fries, potato chips.
4. *Filling* Several fast foods are calorie dense and have a high satiety value. Vegetable burgers with French fries accompanied with an aerated drink, followed by a milk shake or ice-cream is sufficient to satisfy one's hunger.
5. *Fresh* Due to a large turnover, the foods served are fresh. There are a few salad vegetables which need to be freshly cut prior to being used.
6. *Fantasy* The customer likes to try out new concepts, which adds to the excitement and the fantasy of the dish. Entree salads, savoury pancakes, salsa and dips are some of the latest additions to fast foods.
7. *Fordism* Most fast food vendors have the capacity to machine produce a fast food that is well standardized and with almost no variation in it from batch to batch.
8. *Franchising* The availability of the fast food in convenient places such as drive-in restaurants, kiosks, carts, malls, department stores, airports has made it popular. The vending of the food at easily available locations adds to its popularity.

Nutritionally, fast foods contribute to a number of nutrients, mainly calories, fats (especially saturated fats), refined carbohydrates, proteins and sodium.

Most of the fast foods are a concentrated source of calories since, they contain large amounts of carbohydrates and fats. Many of them are fried and contain visible fat. Others may contain invisible fat in the form of cheese, cream, eggs, various dressings, and toppings made from oils and eggs.

The fats in many fast foods are of the saturated variety, since animal fats may dominate. These fats are essential for stored energy in our body but PUFA must also be used in equal amounts. Animal fats are a rich source of cholesterol (with the exception of fish). Cholesterol, as we all know, is one of the principal causative factors of atherosclerosis.

Fast foods contain salt in high concentrations, particularly the spiced, fried, and animal-based products. Chinese food is rich in sodium as well as monosodium glutamate. This latter substance, which is said to be a flavour enhancer, is also responsible for the "Chinese restaurant syndrome" characterized by headache, dizziness, nausea, and other allergic symptoms. Sodium is directly held responsible for hypertension. Generally, fast foods are a rich source of sodium. They are also low in fibre, unless a large proportion of raw or cooked vegetables, whole legumes, unrefined flour and fruits are included.

Table 19.1 Nutritive value of some fast foods

Item	Calories	Protein (g)	Fat (g)	Carbohydrate (g)
Chicken burger	520	18	31	43
Veg burger	418	10	22	48
Veg burger with cheese	473	12	26	48
Salad sandwich	207	6	9	39
Fries	210	3	10	27
Vanilla milkshake	214	6	5	37
Chocolate milkshake	223	6	5	39
Soft drink	126	0	0	33
Potato <i>kachori</i>	166	2	10.7	15.2
<i>Upma</i>	233	4.9	10.2	30.0
<i>Dosa</i>	360	6.3	20.6	37.2
<i>Kachori</i>	500	7.4	35.5	37.7
<i>Samosa</i>	256	3.8	12.8	31.2
Radish <i>paratha</i>	246	5.4	10.7	32.6
<i>Adai</i>	571	13.4	28.2	65.8
<i>Uttappa</i>	330	6.4	17.1	37.8

Besides, they may contain a number of additives like artificial colours, flavours, artificial sweeteners, flavour enhancers, flavour modifiers, release agents, gelling agents, and scores of other artificial substances. Not only do these additives affect our systems in the long run but they are also responsible for unexplained reactions in several people. These should be consumed in very minute quantities only.

19.11 GENETICALLY MODIFIED (GM) FOODS AND THEIR SAFETY

Biotechnology has been applied to food technology and food processing more than 8000 years ago. Hence, the food industry is one of the oldest users of biotechnological products and processes.

Since the 19th century, the science of biotechnology has developed more rapidly than ever before, especially over the past decade. There are many applications of biotechnology in areas such as drugs, but it must also be realized that the new technologies are also potentially capable of revolutionizing the world's food supply, in both quantity as well as quality. Contemporary techniques have made it possible to speed up the classical processes of plant and animal breeding and also to effect interspecies gene transfers, which were not possible by classical plant and animal breeding methods.

Thus, genetic engineering could have an enormous impact on our ability to provide food for the world's rapidly increasing population, provided that the food

is safe for human consumption, since biotechnology raises a number of important non-scientific issues related to ethics, consumer perception and food labelling.

Biotechnology has a direct impact on food production and processing, as also in the production of veterinary drugs, pesticides and other products used in agriculture. It may also play a role in the development of improved methods for use in food analysis.

□ Applications of Biotechnology in Food Production and Processing

1. Bacteria and Fungi

(a) Fermented Foods Alcoholic drinks, tea, coffee, bread, sauerkraut, miso and tempeh and a wide variety of fermented fish, milk, and meat products are also available in the market. The microbes used in the production of these foods contribute to increased palatability, acceptability, nutritional value and shelf life of foods. Developments underway include genetic modification techniques to the microorganisms that produce certain fermented foods like bread and beer. Also, lactic acid producing bacteria may be genetically modified to produce strains with improved phage resistance or bacteriocin or flavour production. Production of human food from the organism *Fusarium graminearum* grown on hydrolyzed starch has been successful commercially,

(b) Food Additives and Processing Aids A wide range of food additives, including amino acids, citric acid, vitamins, enzymes and polysaccharides such as xanthan gum have been produced for many years using microorganisms. Microorganisms have replaced chemical methods, e.g. microbes have largely replaced lemons as a source of food grade citric acid.

(c) Applications Using Enzymes The starch industry is based on enzymes derived from plants, animals or microbes. Rennet used to produce cheese and other dairy products is one of the examples of the largest use of enzymes by the dairy industry. Extracellular fungal proteinases can serve as rennet substitutes. Low lactose milk is produced by using fungi, which produce lactase. The plastein reaction provides a way of using certain protein sources like leaf protein. The important technique of enzyme or microorganism immobilization allows continuous processing of large amounts of material.

(d) Products Used in Agriculture

(i) Biological Pesticides These are advantageous to mankind since they have relatively narrow host ranges, do not affect natural predators and beneficial species; also, pests are slow to develop resistance to them. Since they are easily biodegradable, their effect on the environment is relatively small. The most commonly used biological pest-control agents include bacteria, viruses, fungi, nematodes, insects and their toxins. Cloning of *Bacillus thuringiensis* gene for toxin production and its transfer to another strain to produce a more effective insecticide is one example of the use of biotechnology.

(ii) *Veterinary Drugs* Biotechnological processes have been used to produce veterinary vaccines and other products. Cloning of genes responsible for the production of porcine and bovine growth hormone have been cloned. Genetically modified bacteria have been developed to produce products like vaccines and monoclonal antibodies used in the prevention of animal diseases.

(iii) *Rhizobia* Genes coding for nitrogen fixation can be transferred from nitrogen fixing bacteria (*Rhizobia*) into *Escherichia coli*. Similarly, *Agrobacterium* spp. was found to be more beneficial for the transfer.

2. Plants Biotechnology has aimed at improving agronomic characteristics and quality of food plants. Conventional breeding and selection techniques have been used to facilitate inter-specific hybridisation. Improvements to the degree of resistance to pests and diseases have also been made. Recently, biotechnology has been aimed at improving quality and processing attributes. For example, high protein wheats, oilseeds such as rapeseed have negligible levels of glucosinolate and erucic acid. Triticale, a hybrid of wheat and rye, is the most successful outcome of newer techniques in biotechnology. Gene transfer is the latest in biotechnology. New traits can be incorporated into plants using gene transfer.

3. Animals Conventional breeding techniques and husbandry have been used to modify the characteristics and quality of animals used in food production. This is marked in poultry industry. Also, cattle with improved milk yields and altered fat content of milk and flesh have been made. Of the new methods of gene insertion, micro-injection is the simplest and the most widely used technique. Several important applications of gene transfer have been used in large animals, including growth enhancement and introduction of drug resistant genes.

4. Food Analysis The application of biotechnology has resulted in the development of rapid and sensitive analytical methods, which have many applications in food analysis. These methods, which include the use of DNA probes and immunoassay methods, can prove to be useful in improving the detection of food contaminants. Recent advances in non-isotopic methods have led to the development of highly sensitive and rapid detection systems.

□ Problems of Biotechnologically Produced Products

Safety assessment for human health should cover potential pathogenicity, toxicity and nutritional considerations. Many of the potential hazards relating to the safety of GM crop plants for consumption, produced by means of the new biotechnological methods, may not pose any new risks as compared with those that might be expected from existing food sources and the genetic modification of crops via traditional plant breeding.

In the safety assessment of food derived from transgenic animals, an appropriate system of evaluating the molecular and chemical data of the product must be developed. Food intolerance and food allergies may be a potential hazard particularly with interspecies transgenesis or the production of new hybrid proteins.

A careful, rigorous analysis of the microbiological, molecular, chemical and toxicological parameters will provide a sound basis of safety when the food substance is produced in accordance with current *Good Manufacturing Practices*.

19.12 EFFECTS OF FOOD PROCESSING AND PRESERVATION ON NUTRITIVE VALUE OF FOODS*

Some loss of certain nutrients during food processing is inevitable. The major consideration in evaluating food processing from a nutritional point of view is the balance between increased food availability and the effects that each of the various processing methods has on nutrients and food quality. The degree of nutrient loss and the relative importance of the loss of a specific nutrient from a particular commodity should also be taken into consideration. For example, loss of Vitamin C from milk during pasteurization and refrigerated storage is relatively unimportant, since milk is an insignificant source of this nutrient in the daily diet as compared to other foods like citrus fruits and juices.

The net effect of food processing on product quality is positive. The nutritive value of foods may be improved by an increase in nutrient content and/or digestibility of food components. Besides, the aesthetic qualities of food are also improved, resulting in enhanced appeal of the food of the appetite and better nutrient retention through consumption.

□ Processing Loss vs. Natural Differences

Variations in the nutrient content of raw food materials may affect the content of vitamins and minerals in the final product as much as, and sometimes more than, processing itself. Raw foods may vary widely in their vitamin content as a result of genetic differences, climatic or soil conditions, maturity at harvest, handling conditions following harvest, and the nutrient intake of the animal in the case of meats, fish and poultry. There may be great variations in the vitamin and mineral content of some fresh fruits and vegetables. Samples of fresh tomatoes and carrots may vary twofold in their concentrations of Vitamin C and beta-carotene. Similarly, investigators have found a wide range of thiamine concentration in pork depending on the thiamine intake of the animal.

□ Positive and Negative Effects of Processing

The basic food preservation methods which have been used by early man are still utilized today. An analysis of the processing techniques reveals both favourable and unfavourable effects on nutritional quality.

On the positive side, heat processing destroys antidigestive factors such as trypsin and amylase inhibitor in cereal grains, peas and beans, thus improving the digestibility and bio-availability of protein and carbohydrates in these products. Heat processing also destroys thiaminase, which destroys thiamine in fish, shell-fish, and cabbage, and it destroys the avidin and other factors in raw egg-white that would otherwise bind biotin and some of the iron present in egg-yolk and make these nutrients biologically unavailable. Heat processing increases the digestibility of starch and protein (by gelatinization and denaturation, respectively), and it increases the bioavailability of

* Adapted from an update of the Scientific Status Summary of the Institute of Food Technologists' Expert Panel on Food Safety and Nutrition, published by the Institute of Food Technologists, 221 No. LaSalle Street Chicago IL 60601.

niacin, which is present in many cereals in bound form. Heat processing also increases the palatability of food, resulting in an increased appeal and nutrient consumption.

On the other hand, certain vitamins are sensitive to processing and storage. Generally, the water-soluble vitamins, especially thiamine, riboflavin and Vitamin C, are more susceptible to loss due to leaching while washing and blanching, while the fat-soluble vitamins, particularly A, D and E, are more sensitive to oxidation during processing and storage. Minerals which are water-soluble are also susceptible to leaching.

Certain water-soluble and fat-soluble vitamins are also sensitive to high temperatures during processing. Water-soluble vitamins are generally more heat-sensitive than fat-soluble vitamins. Vitamin C and thiamine are the most heat-sensitive. Minerals are not sensitive to heat, but their bio-availability may be altered as a result of interaction within the food. Additionally, some small losses in protein bio-availability as a result of nonenzymatic browning (Maillard reaction) between certain amino acids and sugars may occur. However, the resultant flavour and colour which is characteristic of this browning reaction is very desirable in some foods.

19.13 EFFECT OF PROCESSING AND STORAGE ON NUTRIENTS

□ Heat Processing

Ever since the discovery of fire, man has used heat to cook his food. The various purposes and methods of cooking and heat processing are deliberated in Chapter 4. In spite of numerous beneficial effects, heat processing also has a detrimental effect on nutrients since thermal degradation of nutrients does occur.

Commonly used heat processes are cooking, blanching, pasteurization and commercial sterilization. The amount of time varies with individual methods to a certain extent.

1. Carbohydrates The effects of heat processing on these are not of great consequence. Reducing sugars undergo the caramelization reaction. The digestibility of starch increases because of gelatinization.

2. Proteins In the presence of reducing sugars, proteins are degraded via the Maillard reaction, the basic amino acids being most reactive. The most heat labile amino acids are lysine and threonine.

3. Fats Some fats degrade at very high temperatures.

4. Vitamins The most heat-labile vitamins are ascorbic acid, thiamin, vitamin D and pantothenic acid. During the canning process, the most significant losses occur in the washing and blanching steps. Vitamin B₆ and pantothenic acid are significantly reduced (67% and 62% respectively). However, B₁, B₂, B₃ are well retained in canning of tomato juice.

The fat-soluble vitamins are generally less heat-labile than the water soluble ones, but they are susceptible to degradation at high temperatures especially in the presence of oxygen.

5. Minerals Loss of trace minerals occurs in the blanching operation. Zinc, copper and manganese retention is of importance in terms of availability and quantity in foods.

□ Freezing

In this method, nutrients are affected at the pre-freezing treatment stage, during freezing, frozen storage and thawing. Although the retention of sensory attributes and nutritive properties are better than canning or dehydration, one should not conclude that freezing process is perfect. Carbohydrates, fats, and proteins are not significantly affected but it is well known that significant amounts of some vitamins are lost during the freezing process.

1. Vitamins During the pre-freezing operations, slight loss of vitamins does take place. Blanching of vegetables when performed by dipping in hot water results in substantial losses of some water-soluble vitamins. Loss of vitamin C can range from about one percent to 25%. B₁ may be lost between 9 percent to 11 percent and about 30% niacin is lost from beans; B₂ is lost between 14% to 19%.

Freezing does not have any significant effect on the vitamin content of vegetables, fruits and animal tissues.

During frozen storage substantial loss of vitamins can occur depending upon the product, pre-freezing treatments, the type of packaging, the type of pack and the storage conditions. Losses of vitamins C, B₁ and B₂ during storage are considerably less in blanched vegetables than in unblanched ones.

Thawing has a small and probably insignificant effect on the vitamin content of vegetables, fruits and animal tissues. Thaw exudate will contain water-soluble vitamins and minerals and hence the nutrient losses will be proportional to the amount of thaw exudate, especially if it is discarded.

2. Minerals Most minerals are lost, although in small amounts, from vegetable during steam blanching than during water blanching, especially if the surface area is large and followed by a method of cooling that does not involve liquid water. Iron is the only mineral, which shows significant losses during storage.

□ Freeze Drying

1. Amino Acids and Proteins On an average in various freeze dried foods such as beef, chicken, egg, fish, green beans, sweet corn, etc., the percentage retention of amino acids ranges from 95% to 100%.

2. Vitamins About 50% to 70% of ascorbic acid in raw, unblanched food are retained. The retention increases to 90% to 100% in the case of blanched food. About 95% or more of vitamin A and carotenoids are retained. Thiamine is retained at a level of 75% or more while 90% or more of riboflavin remains intact after the freeze-drying process. The other vitamins such as folic acid, pantothenic acid and B₁₂ are not much affected, except pyridoxine, which is lost to a great extent in the freeze-drying process.

3. Fats About 57% to 100% of PUFA are retained in various freeze-dried foods such as beef, chicken, pork and shrimp.

Thus, it can be said that freeze-drying of foods can give dehydrated products with little loss of nutritional value except that which occurs in the pre-drying steps.

□ Fermentation

The effects of fermentation processes on nutrients are outlined in detail in Chapter 20 (Microorganisms and their Applications in Foods).

□ Irradiation

Radiation sterilization is comparable to canning or the thermal processing of foods.

1. Carbohydrates Changes take place in foods resulting in decomposition and synthesis. Hexoses are degraded by dehydrogenation and complex polysaccharides exhibit a break in the glycosidic linkage. Effects produced by irradiation continue during storage.

Polysaccharides such as cellulose and starch are depolymerised by irradiation, as is sucrose.

2. Lipids The effects of radiation on fats is similar to that of auto-oxidation, with hydroperoxides being the first products formed during irradiation. In this regard, animal fats are more susceptible to radiation-induced chemical changes than are vegetable fats. The effects on lipids could involve transformation of some essential fatty acids, thereby inducing nutrient deficiency.

3. Fat-soluble Vitamins The percentage destruction of vitamin A is most in fresh milk and less in evaporated milk, butter, cheese and cream. This is probably due to more water in fresh milk than the other products. It must be noted here that other components in a food such as ascorbic acid and alpha-tocopherol may provide a protective mechanism.

Vitamin K is retained from about 20 to 78% in irradiated foods. 26% to 85% of vitamin E is destroyed in various irradiated foods. It must be remembered that vitamm E is the most sensitive vitamin among fat-soluble vitamins to irradiation.

4. Water-Soluble Vitamins Destruction of thiamin appears to be the greatest in foods that have a relatively high level of that vitamin, which may range from 65% to 95%. Riboflavin, niacin and ascorbic acid are not as radiation labile as thiamin. Vitamin B₂ decreases from about 1.8% to 50% in various foods such as milk, fruits and beef. Pyridoxine is retained from 24% to 82% in beef, chicken, cabbage and such foods. Vitamin C is retained between 72% to 100% depending upon the food and the radiation dose.

In general, vitamins are most affected by ionizing radiation. Vitamins E and K and ascorbic acid and thiamin are the most radiosensitive. The micronutrients receive some protective effect from other chemical constituents and the interacting vitamins themselves. Hence, it is quite unlikely that nutrient loss would be significant in the human diet.

□ Microwave Cooking

This appliance has relatively new meaning for the urban homemaker. In microwave heating, non-ionizing electromagnetic wave vibrating at microwave frequencies create temperature rises when absorbed by certain materials.

1. Vitamins About 83% to 91% vitamin B₆ is retained in meats. About 52% to 91% vitamin B₁, 73% to 98% vitamin B₂ and 64% to 100% vitamin B₃ is retained in various meat products. 48% to 98% of Ascorbic acid is retained in vegetables. On the whole microwave-cooking results in higher vitamin retention in foods than those conventionally cooked.

2. Proteins The protein content and the amino acid content of microwave cooked food is not significantly affected.

3. Minerals Conventionally cooked food has a significantly higher mineral content, especially phosphorus and iron.

19.14 HOME PREPARATION PRACTICES

It is important to consider the nutrient losses, which occur due to the various food-handling practices in the home. It is observed that major losses occur during the final preparation in the home or institution, prior to eating. Utilization of proper preparation techniques will lead to maximum nutrient retention in foods as consumed.

Losses during home preparation take place due to:

1. Storage condition
2. Cooking methods
3. Holding and reheating

□ Animal Foods

Animal foods can be stored either refrigerated or frozen for various lengths of time and at various temperatures. Frozen meat, beef, eggs, and such foods lose small but significant amounts of B-vitamins especially B₁, B₂, B₃, B₆, pantothenic acid, folic acid, and B₁₂, ranging from six percent to 19% after storing animal foods from three to 12 months. Niacin appears to be stable during storage.

During ice storage, fish undergoes extensive autolysis, bacterial breakdown, dehydration and oxidation. This results in a loss of the nutritive value. Trimming animal foods causes about one-third loss of nutrients such as P and Mg.

Thawing causes a loss of B-vitamins to the thaw juices but may not be appreciable. Thaw juices contain drip losses, which may range from six per cent to 12% of the B-vitamins. Reuse of drip can conserve small amount of proteins, some minerals and considerable amount of B-vitamins. If the drip losses are to be compensated, a combination of the meat and the drip will retain a majority of the vitamins.

Cooking involves broiling, braising, roasting, frying and microwave cooking, stewing or other cooking methods. Thiamine is unstable in all heating processes. Use of water during cooking increases loss of vitamin B₁. Vitamin B₂, is better retained than vitamin B₁. The most heat-stable vitamin is Niacin. Folic acid retention is poor.

Reheating and holding foods causes a loss of the vitamins. Vitamin B₂ from milk is lost to a very great extent from stored, refrigerated milk packed in glass or translucent plastic containers. Retention of vitamin A in margarine and butter exceeds by 75% after refrigerated storage (41°F) for one year.

Freezer storage generally retains all the vitamins in the foods. Canned foods also retain most of the vitamins over a long period of time except thiamin.

□ Plant Foods

The most damaging practices include improper storage, washing and soaking, trimming and chopping.

Since large percentage of plant foods are lost due to improper storage conditions, unprocessed cereal grains, vegetables, fruits and other plant stuffs are a cause of concern. In order to prevent deterioration of fresh vegetable products, storage temperature, humidity, time of storage and light directly affect the shelf life and therefore the nutritional value of fresh foods. Vegetables such as spinach, salad leaves (lettuce) must be refrigerated in a vegetable crisper or in moisture-proof bags near freezing to maintain their nutritional value.

Carrots, potatoes and other tubers retain their food value best at cool and moist temperatures. Grains, dry legumes, flours, etc. must be kept cool and dry, to prevent microbial attack. When stored properly, grains and legumes can stay for long periods without any nutritional changes.

Freezing can best retain nutrients in processed vegetables. If they are properly blanched, quick-frozen and stored, nutrient retention is as high or perhaps higher than in foods preserved by any other technique. Except ascorbic acid, all other nutrients are very well preserved after freezing.

Canning of vegetables and fruits result in significant losses of nutrients. The losses will continue if the canned foods are not stored at cool temperatures (0 °F to 65 °F) at home and used within a reasonable period of time. Nutrients mainly affected are the B-complex vitamins, ascorbic acid and beta carotene.

Soaking grains and legumes tenderizes them. Some nutrients do leach out into the soak water. Washing losses may be considerable. Almost 60% of niacin and thiamin are lost in raw, milled rice. Vegetables soaked in water with their peel on will lose very little vitamins.

Trimming vegetables, especially outer leaves, causes a substantial loss of the vitamins since nutrient concentration is higher in the outer leaves than inside. Besides loss of nutrients, the amount of trimming wastes is also high when expressed as a percentage of the purchase weight.

Leafy vegetables (trimmed)	21%–61%
Root vegetables (scrapped)	14%–26%
Fresh peas and broad beans	63%–71%

Chopping, mashing, mincing fruits and vegetables cause damage and rupture the cells, exposing the contents to nutrient destruction. Vitamin C, the most easily oxidizable vitamin, can be lost as much as 35% to 52%.

Major losses in nutritive value of plant foods can occur during cooking processes. Most of the nutrients in plant foods are heat-labile and water-soluble and about half of them are lost due to excessive heating and overuse of cooking water. The best method to cook vegetables is to cook them in very little water until tender. Pans with tight fitting lids may also be used.

Nutrient losses may vary according to type of food, amount of cooking water, time of cooking, type of equipment and the nutrient under consideration. The homemaker's choice of the cooking process can directly affect nutrient intake of a family.

Since most plant foods are cooked for a very short time period, more losses occur due to leaching than heat destruction. In many cases short time, waterless heating such as steaming of vegetables can lead to almost 100% retention of the nutrients.

The most labile nutrient of concern is ascorbic acid. Since ascorbic acid is lost in greater amount than other vitamins in most cooking procedures, it can be used as an indicator of quality of total nutrient retention in plant foods.

Thiamine and folic acid are the next most easily affected vitamins. Thiamin is unstable at alkaline pH and prolonged heating. Use of bicarbonate and sulphite easily destroys this nutrient.

Riboflavin and niacin are relatively stable to cooking methods but more than half of these vitamins along with ascorbic acid, thiamine and folic acid and many minerals leach into soaking and/or cooking waters.

Heating and freezing do not affect the natural carotenoids in fruits and vegetables since, they are relatively stable.

Holding the plant foods and reheating them causes very high and significant losses of nutrients especially vitamin C. Prolonged refrigeration storage is also very damaging particularly for ascorbic acid.

The following paragraphs outline the effect of various processing techniques on nutrients, with special emphasis on vitamins. This group of nutrients is sensitive and destroyed by mishandling of foods. It is necessary to observe those handling and processing practices by which optimal quantities of vitamins will be preserved.

19.15 EFFECT OF PROCESSING ON VITAMINS

Factors which may contribute to nutrient loss during processing include: air exposure (oxidation), light, pH, water content, natural biological enzyme systems of the food and the combined effects of these factors and heat. The relative stability of nutrients under these conditions is shown in Table 19.2.

Vitamin C is the most sensitive nutrient, rapidly destroyed when exposed to heat, especially in the presence of light or air and neutral pH (6-7). It is relatively stable in more acidic foods—an important advantage, since, acidic products like tomato and citrus juices are important sources of this vitamin. Similarly, thiamine is more heat-sensitive in neutral and alkaline foods such as cake mixes (which contain baking powder) than more acidic foods such as bread which has been leavened with yeast. On the other hand, niacin and pyridoxine are very stable under a variety of processing conditions.

These factors, along with natural variations in raw food, differences in procedures in handling the food from the farm to the consumer, and individual methods of cooking at home result in variations in the final nutrient content. This makes it difficult to have precise estimates of nutrient concentration as consumed.

Table 19.2 Stability of nutrients*

Nutrient	Effect of Food pH			Effect of Food Environment		
	Neutral (pH7)	Acid (<pH7)	Alkaline (>pH7)	Air or Oxygen	Light	Heat
Vitamin A	S	U	S	U	U	U
Vitamin C	U	S	U	U	U	U
Biotin	S	S	S	S	S	U
Beta-carotene	S	U	S	U	U	U
Choline	S	S	S	U	S	S
Cobalamin (B-12)	S	S	S	U	U	S
Vitamin D	S	S	U	U	U	U
Folic acid	U	U	S	S	U	S
Inositol	S	S	S	S	S	U
Vitamin K	S	U	U	S	U	S
Niacin	S	S	S	S	S	S
Pantothenic acid	S	U	U	S	S	U
Pyridoxine (B-6)	S	S	S	S	S	S
Riboflavin	S	S	U	S	U	U
Thiamine	U	S	U	U	S	U
Vitamin E	S	S	S	U	U	U
Mineral salts	S	S	S	S	S	S

S = stable (no major destruction); U = unstable (significant destruction)

* Modified from Harris (1975)

□ Processing Methods and their Effects on Nutrient Concentrations

1. Heat Processing Each type of heat process has a specific purpose and the severity of each process depends of its objectives. Most vegetables and fruits are blanched prior to canning, freezing or dehydrating them. Foods may be blanched by exposure to either boiling water, steam, or hot air for approximately one to three minutes. Blanching inactivates enzyme systems which degrade flavour and colour and which cause vitamin loss during subsequent processing and storage. Blanching also removes air from the tissue—an important advantage, since oxygen can affect product quality and shelf-life detrimentally. Blanching also destroys some of the contaminating microorganisms present.

Nutrient loss due to blanching usually results directly from leaching of water-soluble vitamins into the water used in processing. Blanching with steam, hot air, or microwave ovens does not require immersion in water and, hence, substantially reduces leaching of vitamins. Steam blanching of vegetables results in loss of vitamin C approximately 16–26%, in contrast to water blanching which may result in loss of 16–58%.

Heat treatment during the canning process (commercial sterilization) is specifically designed for each type of food product and container to destroy all micro-organisms causing concern for public health. Nutrient losses due to canning can vary considerably depending on a variety of factors, such as type of food, container and the severity of heat used. Retention of certain vitamins may be as low as 10% or as 100%. As a result of these variations, it is difficult to make general statements about the effect of heat processing on nutrients. Nutrient loss can be minimized with the use of proper processing and cooking techniques.

Commercial sterilization is the application of sufficient heat to prevent any growth of microorganisms which may cause spoilage under normal storage conditions. Low-acid foods (pH 4.7 and above) must be heated sufficiently to destroy *Clostridium botulinum* spores and render them incapable of germinating, multiplying and producing a toxin. The canning process for these foods depends on the product, type of retort and container size and ranges from 230–275°F for 12–325 minutes. The process used for high-acid foods (pH below 4.7) is less severe because the acidity of the food itself inhibits growth of the botulinum microorganisms and thus requires less heat (approximately 212–220°F for 5–280 minutes). Traditionally, food was canned either in glass jars or cans. Now it may also be done by a new, high temperature/short time (HTST) technique, coupled with aseptic packaging in flexible or brick-style packages. These types of packages, currently used primarily for fruit juices, allow a substantial reduction in the temperature and time necessary to accomplish sterilization and thus provide increased nutrient retention and food quality. The retention of thiamine and pyridoxine, in particular, is significantly improved.

Aseptic packaging, which was developed to overcome the problem of heat transfer through cans, allows fluid products to be pumped continuously through heat exchanges where they can be heated to the appropriate temperature very quickly. The juice is held at that temperature for the required time and then cooled. The sterile product is placed in sterile containers and the opening sealed. Still another procedure for canning fluid products, the Flash-IB process, involves sterilizing the product and placing it into sterile containers inside a chamber which has increased atmospheric pressure (18 psi) so that the boiling point of water is increased beyond 212°F, thus requiring less time to heat products to commercial sterility.

Heat transfer is slow in conventionally canned product, particularly non-liquid products such as meat. Since heat is applied outside the product (or its container), the outer material is subjected to more total heat than necessary in order to ensure sterility at the centre. Canned beans (semi-solid) retain approximately 55% of the heat-sensitive vitamin thiamine, while canned tomatoes (a more liquid product which requires less heating time) retain a larger percentage.

Pasteurization is designed to destroy all pathogenic microorganisms present, but because the heat treatment is not as severe as that for shelf-stable products, the process does not destroy or inactivate all microorganisms. Some spoilage organisms remain which are capable of multiplying, thus spoiling the product. Besides, not all the enzymes are inactivated. Therefore, these products must be dated for shelf-life. Pasteurization also inactivates enzymes such as lipase which promote rancidity and spoilage. Treatments used for pasteurization include low-temperature-Holding (LTH), high temperature short time (HTST) and ultra-high-temperature (UHT). In

the US, commercially pasteurized milk must be processed at a minimum of 145°F for 30 minutes (LTH) but is usually pasteurized with an HTST treatment (161° F for 15 seconds). The UHT process (minimum of 270°F for two seconds) is a sterilization treatment which is applied to products and provides unrefrigerated shelf stability. This process, used primarily for milk, is more common in Europe than the US.

The HTST process provides more advantages over the older LTH method for pasteurization as a result of the effects of temperature on bacterial destruction compared to the effects on chemical reactions. For example, an 18°F rise in processing temperature usually produces a ten-fold increase in bacterial destruction, while only doubling the chemical reactions which lead to the destruction of certain nutrients and flavours. Therefore, the higher the temperature and the shorter the processing time, the greater is the nutrient retention—*a fact which should also be noted while cooking at home*. Milk pasteurized with the HTST process, for example, retains 90% of its vitamin C, 100% of its Vitamin B₁₂ content, while milk pasteurized by the LTH method retains none of its vitamin C and only 90% of vitamin B₁₂ content. HTST pasteurization of milk also results in little or no loss of vitamin A, niacin, or riboflavin. This system is also commonly used for sterilization of liquid eggs, fruit juices, and some high-acid products and less commonly for beer and wine.

2. Drying Foods may be dried by removal of water, either by sun-drying or by various evaporation procedures. As a result of sensitivity of vitamin C to heat in the presence of oxygen, and that of vitamins C, A and beta-carotene to oxygen, most dehydration processes result in loss of these vitamins. Loss of vitamin C during dehydration may vary from 10 to 50%, and losses of vitamin A may vary from 10 to 20%, especially with conventional dehydration methods. The newer methods, puff-drying, spray-drying, and freeze-drying, use less severe heat treatments than conventional methods and result in greater vitamin retention. In fact, freeze-drying, which is carried out in the absence of oxygen, does not detrimentally affect retention of Vitamin C.

Sulphur dioxide is frequently added in the dehydration process to inhibit browning and to preserve the product's colour. Sulphur dioxide also results in increased retention of vitamins C and A and beta-carotene, since, it inhibits oxidation. Sulphur dioxide, however, can cause a considerable loss of thiamine. Since dehydrated, sulphurated food products are not major sources of dietary thiamine, the net dietary effect of sulphur dioxide on thiamine retention is nil.

Another process which may be considered as a form of drying involves binding of water. Water may be bound (made unavailable for chemical and biological reactions) by the addition of salt, sugar, gelling agents and other additives. This procedure has less detrimental effect on nutrients because there is less energy input. However, the solutes (salt, sugar) added may create unfavourable changes.

3. Freezing Freezing preserves the nutritive quality similar to that of fresh, raw foods. In general, nutrient loss during freezing is negligible, using proper packaging (air impermeable) and processing conditions. Exceptions are small losses of Vitamin C and other water-soluble vitamins in vegetables and fruits during blanching and small (10–20%) unexplainable losses of water-soluble vitamins in pork. Proper

freezing conditions are important to retain nutrients. Foods which are not frozen quickly and solidly, and maintained at a constant low temperature (-18°F or lower), or which undergo intermittent thawing, exhibit a greater-than-normal loss when thawed and hence, greater nutrient loss. The shelf-life of frozen foods (nine months to one year) is shorter than that of canned foods because not all the water in food freezes and because some fatty acids as well as vitamins A, C, and E tend to oxidize during storage when exposed to air. This allows some chemical changes to occur, even in the frozen state.

□ Fermentation

Products such as aged cheese, bread, yoghurt, sauerkraut, pickles, summer sausage, soya sauce, tempeh, beer, and wine are made by microbial fermentation. The micro-organisms used may be natural components, selectively grown by manipulation of various factors in the environment, or they may be added as special *starter* cultures.

Nutrient loss as a result of this method of preservation is not major importance. In fact there may be an increase in vitamin content particularly with some of the vitamins (except B_{12}) due to microbial synthesis during fermentation. During the manufacture of cheese, loss of water-soluble vitamins may occur during the separation or fermentation, but they may be partially replaced by microbial synthesis of these vitamins while aging. Some loss of vitamin C may occur during fermentation of sauerkraut.

□ Milling

Milling of grains such as wheat, corn, rice, oat, barley and rye is a process used to produce white flour, rice starch, dextrose, corn syrups and soya products. Milling has detrimental effects on the vitamin content of the resultant flour. The bran, germ and scutellum portion of the endosperm contain significant concentrations of vitamins and fibre which are lost as a result of separation of these components from the grain. The amount of loss depends upon the length of the fractionating process. In the US, milling results in an approximate 60% loss of vitamins and minerals. (Similar may be the case in India too.) Grain products are, therefore, required to be enriched with thiamine, riboflavin, niacin and iron to replace this loss. Addition of calcium and vitamin D is optional and frequently done.

□ Microwaving

Microwaves are non-ionizing electromagnetic waves which accelerate movement of water molecules contained in the food, resulting in a heating effect. Nutrient retention in microwave-cooked foods is equivalent to that of cooking in moderate amount of water. Thiamine retention in microwave processed food is improved because cooking time is shortened, retention varies with cooking time, product type, oven size, final temperature and type of food. Microwave ovens are available with different wattage or power capabilities. Foods cooked or baked at higher wattage levels are heated more quickly and heated for a shorter length of time thereby retaining greater amounts of the heat-labile nutrients than foods heated longer and by more conventional methods.

□ Irradiation

The process of irradiation has been used for many years in some countries. Radiation energy absorbed by food during irradiation is expressed in *rads* or *Grays*-one Gray (Gy) = 100 rads; one kiloGray (kGy) = 100,000 rads.

Irradiation has the same effects as heat treatment, without causing a rise in temperature. Sterilization by irradiation is, therefore, referred to as *cold sterilization*. The effects produced by irradiation start with activation of water molecules. Breakdown products of water activation inactivate the enzyme systems in both the food and its microbial contaminants. Doses used to irradiate food depend on the objectives of the process.

The effects of irradiation on nutritional quality of food varies with the doses. Higher doses, such as those required for sterilization, result in slightly more nutrient destruction than lower doses. Most of the experimental evidence indicates that nutrient retention of irradiated foods is comparable to that of heat-processed food. Pork treated with radiation retains an equivalent or greater amount (20–50% more, depending on the energy source) of thiamine than when canned. Radiation has no significant effect on the digestibility of proteins and carbohydrates. Irradiated fats, however, may be susceptible to oxidation, but the effects can be controlled by irradiation at low temperatures and exclusion of oxygen.

□ Additives and Packaging

A few additives, such as bleaching agents used in flour, can promote oxidation and lead to a small loss of sensitive vitamins. However, other food additives, particularly the anti-oxidants, have a protective effect on vitamins. The common anti-oxidants butylated hydroxyanisole (BHA), and alpha-tocopherol (Vitamin E), protect vitamins A and D and beta-carotene and slow oxidative destruction of fats. Vitamin C can stabilize Vitamins A and E, thiamine and folic acid by inhibiting oxidative reactions promoted by iron and copper.

In addition to the benefits of using anti-oxidants, a number of other techniques are utilized to protect the nutritive quality of our foods. These techniques include use of sequestering agents (compounds which bind to minerals and prevent them from enhancing oxidation), control of moisture content, application of protective gelatin coatings to vitamins prior to addition to foods, use of aerosol supercoatings on products such as breakfast cereals, and use of packaging to protect food from the atmosphere and light.

□ Storage

Nutrient losses can occur during transportation and storage of fresh foods. Foods which are processed with good manufacturing practices from high-quality, freshly harvested, *garden-fresh* commodities will frequently have a higher nutrient content than freshly harvested *market-fresh* commodities which have been improperly handled during transportation and/or which have been stored for a few days or more.

Vitamin loss during storage and distribution of canned or dried foods varies widely, depending on the temperatures to which they are exposed during distribution and storage. Retention of a number of vitamins in canned tomato juice, for example, is markedly decreased by storage at temperatures higher than room temperature.

However, storage of canned goods up to one year at temperatures lower than 70–75° F results in less than 10–20% change in the concentration of vitamins.

Oxidation and browning may occur in some dried foods during storage. Oxidation of fatty acids results in rancidity and an inedible product. Non-enzymatic browning (Maillard reaction) occurs between reducing sugars such as fructose and the epsilon amino group of the essential amino acid lysine, decreasing the bio-availability of this amino acid. This reaction may occur in foods processed by other methods as well, since it is enhanced by heat.

Storage temperatures are also important for retention of the nutritive value and overall quality in frozen foods. Storage at 0°F or lower results in excellent retention of vitamins up to six months. Most commercial home-refrigerator freezer units are maintained at temperatures above 0°F. The major factors affecting loss after prolonged storage at these low temperature the oxygen permeability and light transmission characteristics of the package. At storage temperatures above 15°F, easily oxidizable vitamins will be lost over a period of time. For example, half of the original vitamin C content in frozen asparagus, peas and lima beans will be lost during storage at 15°F for six months. As a result of the oxidative effects on vitamins and other degradative changes which affect flavour and texture, the potential shelf-life of frozen fruits and vegetables is considered to be nine months to one year. Since changes in the nutritive value of foods can occur during storage, the nutrient content of products following typical storage conditions is established in order to accurately estimate the nutritive value of food at the time of consumption. Therefore, the nutrient content listed on the nutrient label represents that which is expected until the expiry date on the product package.

□ Effect of Processing on Proteins

Heat processing has a number of advantageous effects on proteins and carbohydrates. Heat treatment can enhance digestibility of proteins by inactivating antidiigestive factors and by denaturing protein. However, excessive heat treatments can result in decrease in protein bio-availability. The molecular structure of proteins may change due to interactions between their constituent amino acids and other food components (such as reducing sugars, other proteins, and amino acids), so that the body is less able to utilize them.

As mentioned above, the nonenzymatic browning reaction between lysine and reducing sugars may also detrimentally affect the physical properties of food, resulting in undesirable changes in flavour and texture. On the other hand, most baked and fried foods are intentionally browned to improve their appearance and flavour. Maple syrup owes its flavour and colour to the browning reaction, and the distinctive caramel flavours which may be generated in foods that contain dairy produces are the result of the browning reaction in milk or milk components. Thus while it is clear that browning may detrimentally affect the nutritive value of some foods, it may also enhance their desirability.

□ Effect of Processing on Carbohydrates and Fats

Carbohydrates may be made more bio-available and more digestible, as a result of processing. Mild heat treatments can swell and rupture the polysaccharide molecules,

enhancing digestion by amylases. Overheating, however, can cause browning and reduce digestibility. The decrease in availability of carbohydrates is due to their interaction with proteins as noted earlier. In most cases this loss is relatively minor, with no significant effects on protein bioavailability. The nutritive value of the fat content of foods is not significantly altered by normal processing, the majority of reactions which may be promoted by processing are hydrolysis reactions. This results in separation of fatty acids from glycerol portion of the fat molecule, leaving the fatty acids present in the food available for digestion. Reactions which may occur in fats are promoted during prolonged storage, and by heating at excessively high temperatures in the presence of acids, alkalies and lipolytic enzymes.

The reactions include lipolysis (degradation of fat to free fatty acids and glycerol), oxidation of polyunsaturated fatty acids in the presence of air, conversion of PUFA from a cis-molecular configuration to a trans-configuration.

The trans-configuration is metabolized more like a saturated fat. These $r \sim$ reactions are not significant with respect to nutritive value since the daily dietary requirement is low and is easily compensated by a varied diet. The primary effect of heat processing on fats is not a loss in nutritive value but the development of rancidity, objectionable flavour and odour due to lipolysis or oxidation, thus making the food unpalatable.

□ Effect of Processing on Minerals

When food is cooked, processed, or stored, minerals may combine with other food components and become unavailable for digestion. As with vitamins, natural variations in raw food products and cooking methods also result in variations in the final mineral content of food.

Minerals are generally not sensitive to heat during processing, but susceptible to leaching into the processing or cooking water. More than 50% of the manganese, cobalt and zinc may be lost during cooking of spinach, beans and tomatoes if the liquid is not consumed.

Mineral loss during cooking can be minimized by the use of minimum amount of water and by utilizing the cooking water in the preparation of food for consumption such as in gravies, curries and sauces. Loss of manganese, iron, copper, phosphorus, calcium and magnesium during the cooking of pasta may be as high as 86.5–100%. Use of hard water for processing and cooking can result in increase in calcium or magnesium content of food while the use of softened water can result in an increase of the sodium content.

Mineral loss may also occur as a result of physical separation of the product during milling of cereals, refining of sugar and processing of legumes or seeds into pulses, e.g. significant losses of magnesium, zinc, iron, copper, and cobalt have been reported during milling of wheat to flour. Grain milling has positive nutritive benefits as well. Phytate and fibre, which are present in the bran of grains are removed during this process, and they are no longer able to bind the minerals and render them unavailable.

Minerals are also susceptible to changes in bio-availability due to interactions with other food components. For example, oxalates (acidic plant components) may inhibit calcium bio-availability, while vitamin C enhances iron bio-availability.

□ Nutrient Loss During Cooking

Another factor which must be considered in evaluating nutrient loss resulting from food processing is the type and extent of loss that occurs during preparation of food for consumption. Improper method of home cooking leads to loss of nutrients to a great extent, the greatest loss occurring as a result of leaching. In fact, the primary factor responsible for vitamin and mineral loss is often the final preparation step, either at home (during cooking) or in food-service operations (during extended holding on a steam table or repeated refrigeration and reheating) prior to consumption.

As a result of the substantial vitamin loss that occurs during cooking at home, the actual vitamin content of the cooked foods is often about the same, regardless of the type of processing, or lack of processing that the food has undergone. For example, a bowl of peas will contain a similar amount of vitamin C regardless of whether it was prepared from fresh peas (approximately 45% retention), frozen peas (40%), or canned or freeze-dried peas (35%), provided each is cooked and prepared in a similar manner for consumption.

Although home preparation can result in substantial nutrient loss, it can be minimized by adopting proper cooking procedures. These include: refraining from excessive trimming and over-chopping; cooking in covered pans (to shorten cooking time and decrease the amount of water needed); cooking with a minimum amount of water (just enough to prevent scorching); cooking vegetables only until tender; refraining from overcooking; and using cooking water for soups. Steam or pressure-cooking and stir-frying result in less nutrient loss than boiling or typical pan-frying.

□ Nutrient Addition

The addition of vitamins, minerals and other nutrients to foods and beverages is one aspect of food processing which is often overlooked in evaluating the effects of processing on nutritive value. *Restoration* is the replacement, to original levels, of nutrients which were lost during processing; it is used to help prevent nutritional deficiencies. *Fortification* is the addition of nutrients which were originally not present or which were present in insufficient amounts; it is used to correct nutritional deficiencies in certain segments of a population. *Enrichment* is the addition of nutrients to achieve levels specified in food standards and quality; this term is often used interchangeably with restoration and fortification. Each of these processes are beneficial in replacing the nutrients destroyed during processing.

However, when fortification is done a few of the following conditions should be kept in mind:

1. The intake of a nutrient is below the required level in the diet of a significant number of people.
2. The food used to supply the nutrient is likely to be consumed in quantities that will make a significant contribution to the diet of the population in need.
3. The addition of the nutrient is not likely to create an imbalance of essential nutrients.
4. The nutrient added is stable under proper conditions of storage.

5. The nutrient is physiologically available from the food.
6. There is reasonable assurance against excessive intake to a level of toxicity.

In some countries typical foods which have added vitamins and/or minerals include margarine, vanspati, enriched flour, pasteurized milk, non-fat dry milk, table salt, infant formula, meal replacements (liquid or solid) and breakfast bars. These are only a few examples of the vast array of formulated and fabricated food to which nutrients are added so that they may be nutritionally balanced in their dietary contribution.



SUMMARY

Numerous food commodities contribute to the rich heritage of our Indian dietaries. Besides cereals, millets, pulses and legumes, Indians cherish the innumerable papads, chutneys, pickles and spices in their diet. Nutritional contribution of each of the commodities goes a long way in meeting his daily requirements. With the invasion of fast foods, Indians must use it as a dietary change and not as a substitute to their normal, balanced diet.



REVIEW QUESTIONS

1. Define the following terms: parboiling, millets, anti-nutritional factors.
2. Why is it important to combine cereals and pulses at a meal?
3. One should not consume an excess of synthetic carbonated-beverages everyday. Why? What is its nutritional contribution to our diet?
4. Write a short note on fast foods, highlighting their nutritional contribution.
5. What are the main drawbacks of fast foods?

Fill in the gaps:

- 1) One bottle (180 ml) gives _____ calories.
- 2) One cup of tea gives _____ mg caffeine while one cup of coffee gives _____ mg caffeine.
- 3) Beer and toddy give _____ calories per 100 ml.
- 4) The PER of an egg is _____ while that of milk is _____.
- 5) An exception to animal foods is _____, which is rich in PUFA.
- 6) The 8F's of fast foods are _____, _____, _____, _____, _____, _____, and calories.

Chapter

20



Microorganisms and Their Applications in Foods

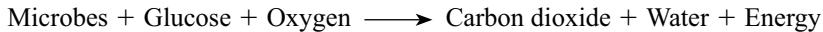
There are many examples where growth of microorganisms in foods is undesirable. But on several occasions the growth of microbes is encouraged. This comprises three broad groups:

1. In the manufacture of foods, e.g. curds, yoghurt, cheese, *idli*, *dosa*, bread, wines, beer, etc.
2. As a source of foods, nutrients, enzymes or food additives.
3. To improve soil fertility or in agricultural practices.

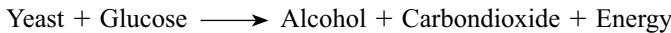
Of all the three groups, the first group occupies the most important position in the dietsaries of people all over the world. The product so obtained is not only acceptable but in some cases it also has a better shelf life.

20.1 RESPIRATION AND FERMENTATION

Microbes help us by their metabolic activities in foods. Since they, like us, require energy, they obtain it by breaking down organic chemicals. The process by which they release energy by breaking down chemicals is called respiration. During aerobic respiration they utilize glucose in the presence of oxygen.



Several food-manufacturing processes depend upon the aerobic respiration of microbes, e.g. vinegar. However, even microbes that respire in the absence of oxygen are also desirable for manufacturing several foods. Both processes result in fermentation, e.g. in making wine, yeasts generally respire anaerobically.



The anaerobic process yields less energy than the aerobic process, but releases a number of chemicals, namely alcohol, lactic acid, propionic acid, etc. which attribute the characteristic taste and flavour of several foods.

20.2 BREAD MAKING

Bread is made by mixing flour, water, salt and yeast. Its texture should be soft and colour of the loaf should be light brown and shiny, indicating even baking.

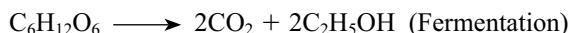
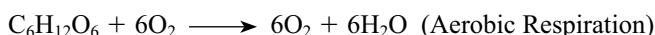
Yeast is used in making bread. Strains of *Saccharomyces cerevisiae* are used, which reproduce by budding and help to raise the dough. This is brought about by the action of enzymes called amylases, which act on starch to form maltose. Yeast use

Table 20.1 Some fermented food products

<i>Organism</i>	<i>Substrate</i>	<i>Product</i>
Lactic acid bacteria	Cabbage	Sauerkraut
	Cucumber	Pickles
	Red meat	Sausages— <i>salami</i> , thuringer, pepperoni
	Milk products:	
	(a) Cream	Sour cream
	(b) Milk	Yoghurt, buttermilk.
	(c) Milk	Cheese (unripened), e.g. cottage cheese, <i>paneer</i>
	(d) Milk	Cheese (ripened), e.g. Cheddar
	(e) Milk	<i>Shrikhand</i>
Acetic acid bacteria	Fermented <i>jaggery</i> , molasses, wines.	Vinegar
Lactic acid bacteria and yeast	Flour (dough)	Sour dough bread
	Beans	Vermicelli
Yeast and moulds	Soybean	Soya sauce
Yeast	Malt	Beer, stout, lager
	Fruit	Wines, vermouth, cider
	Wines	Brandy distilled from wines
	Molasses	Rum
	Grain mash	Whisky
	Flour dough	Bread, <i>naan</i> , cracker
	Rice and <i>dals</i> (lentils)	<i>Idli</i> , <i>dosa</i>

the maltose for their own growth and reproduction and release carbon dioxide, which raises the dough. The gluten in the dough entraps the carbon dioxide. This improves the texture. Besides this function, yeast also contributes to the characteristic flavour and helps to modify the gluten (wheat protein). The gluten becomes more elastic and is capable of retaining the evolved CO₂.

Starch in the wheat flour is broken down by a combination of fermentation and respiration processes:



Aerobic respiration takes place near the outside of the dough and depends upon O₂. It is more likely to occur in the early stage process. A small amount of alcohol is produced in the anaerobic process but is driven off during baking. However, alcohol and other fermentation products contribute to the characteristic aroma of bread.

The traditional method of bread making is the straight dough method. It is shown in Fig. 20.1.

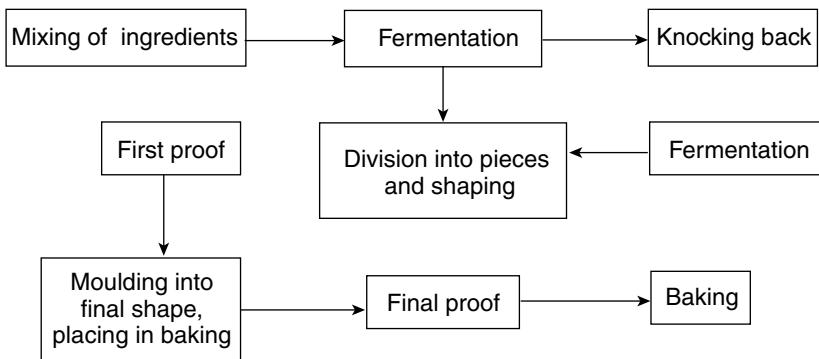


Fig. 20.1 The straight dough method

However, today quicker chemical and mechanical leavening methods are used with the help of improvers and bleachers and are called short dough methods or no-time dough. It also involves the use of larger quantities of yeast and water. The production time decreases by about 60 percent and the resulting loaf has a longer shelf life.

Baking of the loaf at 230°C varies between 22 to 44 minutes.

20.3 ALCOHOLIC BEVERAGES

All alcoholic beverages are prized for their ethanol content, which is produced as a result of yeast fermentation. A variety of raw materials are used namely grapes, apple, cereals, etc.

□ Beer

Beer is made by fermentation of a hop-flavoured extract of barley malt using yeast. The two strains of yeast are *Saccharomyces cerevisiae* (top fermenting) for beer brewing and *Saccharomyces carlsbergensis* (bottom fermenting) for lager making. Lager is a type of beer.

The production of both beer and lager involves conversion of barley to malt by soaking or steeping the barley seeds in water. This initiates the process of germination and leads to activation of amylase enzymes, which break down starch to maltose. Also, proteases break down proteins to soluble peptides. The temperature of the mixture is raised to terminate malting and this 'green malt' is allowed to dry out. For obtaining darker beers and stouts, the malt is 'kilned' or dried out at a higher temperature. After drying, the malt is ground or crushed to obtain 'grist'.

To brew, the grist is mixed with water at approximately 70°C. Enzymes that were formed during fermentation convert starch to maltose. The 'wort', i.e. liquid malt extract is now mixed with hops for flavouring. The mixture is boiled, cooled and stored in vats for fermentation. Yeast is now introduced and aerobic respiration begins which soon changes to anaerobic fermentation to produce ethanol.

Lager fermentation is carried out at a lower temperature than beer fermentation. CO₂ produced during the whole process is collected and used for manufacture of soft

drinks, dry ice, carbonated beer, etc. Yeast is separated after complete fermentation and allowed to 'condition'. After maturing, the beer is filtered, pasteurised and placed into cans, bottles, barrels or kegs.

Generally, these products contain between two percent to five percent alcohol.

□ Wines

This is another category of alcoholic beverage. Grapes are crushed and the grape juice or "must" is treated with SO₂. To produce white wine, the skins of grapes are removed and only the pulp is used at this stage.

Traditionally, using yeast naturally present on the surface of the grape carries out fermentation of the "must". However, modern wine is made using starter culture of yeast *Saccharomyces cerevisiae var. ellipsoideus*. Under anaerobic fermentation, alcohol is produced. As the alcohol content increases beyond 10 percent, the fermentation process slows down. The length of time required (normally a few weeks) for fermentation varies depending on the variety of yeast used, the type of grape, temperature, etc. Sweet wines are fermented for shorter periods and hence contain unfermented sugar. The new wine is drawn off into vats, clarified and pasteurised. It is then filled into bottles and stored. Certain wines are best when consumed fairly young while some expensive wines improve in quality on long storage.

□ Other Alcoholic Beverages

1. *Fortified wines* Such as sherry.
2. *Spirits* These are distilled liquors containing about 40% alcohol. For example, brandy and whisky; these liquors improve with ageing, which can take 20 years or more.
3. *Liquors* These are made with a combination of a spirit with flavouring and adding syrup for sweetening, e.g. creme de menthe (mint and peppermint).

□ Vinegars

Malted/brewed vinegar is made by fermenting grapes, other spoilt wines, etc. The bacteria, belonging to genus Acetobacter, converts the ethanol to ethanoic (acetic) acid.

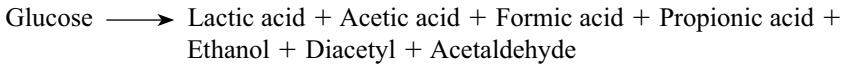
1. Acid Fermentation Bacterial fermentation of carbohydrates generally produces alcohol or some neutral products, often the major end products of fermentation are acidic, e.g. lactic acid.

When other acids are also produced, it is known as heterolactic fermentation.

2. Homolactic Fermentation



3. Heterolactic Fermentation



□ Cheese

In this product, milk is converted into a nutritious product with improved keeping qualities.

Milk is first pasteurized, mixed with a starter culture of bacteria (select strains of homolactic/heterolactic bacteria) at 30°C. The starter culture may be a single strain of *Streptococcus lactis* or *Streptococcus cremoris* or a mixture of the two.

The lactose breaks down to lactic acid. Rennet, an extract from the calf's stomach, was previously added to coagulate casein. Today, microbial rennet has replaced calf rennet. The curd is heated to complete the precipitation of proteins and obtain a stiffer curd. The curd now obtained is cut into small pieces to release whey. It is pressed to remove most of the whey, salted and packed into moulds. The process of aging now begins which matures the cheese and flavour develops. This is brought about by the action of microorganisms and enzymes present in the cheese. Cheese may be ready in two to three weeks or 10 months.

Certain cheeses such as Cheddar and Cheshire are bacterially ripened while some are mould ripened, e.g. Camembert. The mould often gives rise to blue-green colouration such as in Danish Blue or Blue-Stilton. Propionibacter are used in Swiss cheese manufacture, giving it its characteristic holes.

Cream cheese is made from cream. Cottage cheese is a low-fat acid cheese made from skimmed curd.

□ Other Dairy Products

These include yoghurt commonly known as *curd* or *dahi*, which is a fermented milk beverage originating in Eastern Europe and Western Asia several centuries ago. Most yoghurt is made by blending milk with skimmed milk.

Table 20.2 *The production of yoghurt*

Stage	Process taking place.
Milk mix	Blending of milk and skimmed milk
Heat treatment	Similar to pasteurization—For hygiene, to remove air and coagulate some protein
Homogenisation	Breaking-up of fat globules into small globules.
Cooling	37–44°C
Inoculation with starter bacteria	Equal proportions of <i>Streptococcus thermophilus</i> (produces diacetyl) and <i>Lactobacillus bulgaricus</i> (produces acetaldehyde)
Incubation	37–44°C—six hours Fermentation occurs. Pasteurization done
Cooling	4.5°C
Addition of fruit and flavour	End product pH 3.7 to 4.3 and containing approximately equal quantities ($10^8/g$) of each starter culture bacteria.
Packaging	
Dispatch	

A variety of other fermented products similar to yoghurt can be made using cow's milk, goat's milk, e.g. *Kefir* and *Koumiss*.

Butter is produced from separated cream, which may or may not be soured before churning. In some countries, ripened cream is used. Fermentation produces diacetyl which gives the characteristic flavour to butter.

□ Other Lactic Acid Fermented Products

1. *Fermented eastern foods and beverages*: Made by using moulds, yeasts or bacteria, e.g. *Tempeh* from soybeans, *bongrek* from coconut press cake.
2. *Pickled vegetable products*: For example, the unfermented pickles packed in vinegar or those which undergo lactic acid fermentation such as *sauerkraut*, pickled olives/cucumber.
3. *Fermentation of beans*: Complex fermentations take place in the processing of coffee and cocoa. The production of soya sauce also involves fermentation of soybeans.

20.4 MICROBIAL PROTEIN AND VITAMINS

Microorganisms can themselves be used as a source of nutrients, especially protein or vitamins. Single-cell protein is relatively cheap when compared with meat or soybean. The possibility of producing protein from bacteria, moulds, yeast and algae is being explored all over the world using wastes from paper mills, sugar refining, oil industry as well as natural gas (methane) to cultivate the microorganisms.

Pruteen is made from bacteria grown on natural gas. A mycoprotein produced by *Fusarium graminarium* is being incorporated in foods meant for human consumption. Its amino acid composition has been found to be similar to that of plant and animal proteins.

Maritime, a yeast extract is rich in B-vitamins. Certain microorganisms are also used in the production of food additives such as citric acid and glutamic acid, which is used in the production of monosodium glutamate. Also, enzymes such as amylases, proteases, pectinases and rennet are made with the help of microorganisms.

20.5 TEMPE

Tempe fermentations may play an important role in the production of protein-rich meat analogues in the future as the world population rises to as many as 12 to 16 billion by the year 2035. Animal meats, already limited in availability and beyond the means of the world's masses, will gradually become less available on a per-capita basis. As this occurs, humans must consume more vegetable protein. The fermented product tempe is easily digestible, nutritionally adequate and inexpensive.

Tempe is made by a fermentation process in which soyabean are soaked, dehulled, partially cooked and inoculated with moulds belonging to the genus *Rhizopus*, and incubated in a warm place (30 to 37°C). The soyabean are knitted into a compact cake by the fibrous mould *mycelium* in one to three days. The cake, which is over 40%

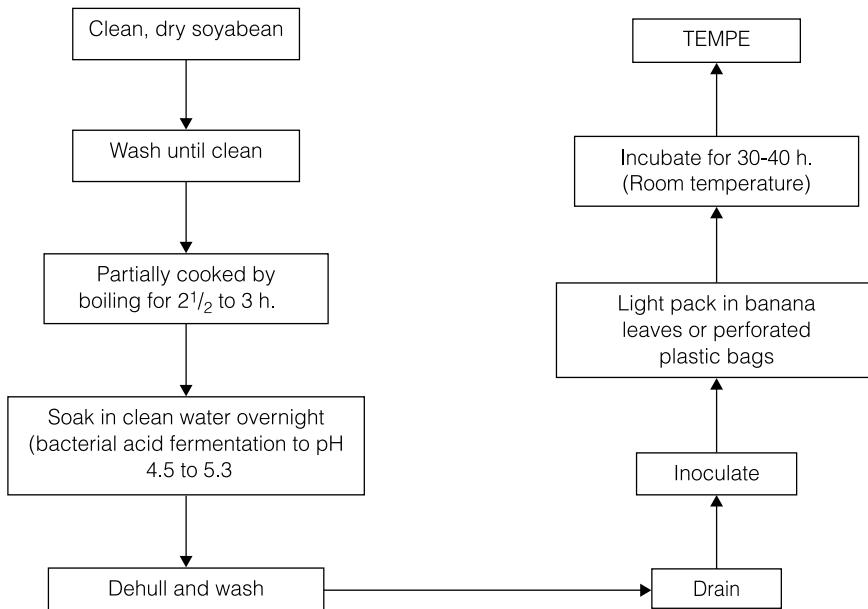


Fig 20.2 Process for making tempe

protein on a dry solids basis, is sliced thin and deep-fried or used as a meat substitute in soups. It has a texture that appeals to the consumer.

□ Nutritive Value and Health Benefits

It is easily digestible, even persons suffering from dysentery can digest tempe. The nutritive value is reported to be equivalent to that of skim milk. The PER is about 2.6. It also has higher BV and NPU.

Due to the process used in its manufacture, the vitamin content increases. Tempe has double the riboflavin content, while niacin is about seven times and vitamin B12 is 33 times the amount in unfermented soyabean. However, thiamine decreases. Biotin and total folate increases to 2.3 and four to five times during fermentation. The increase in B¹² content is important, particularly for vegetarians. Also, an antioxidant 6, 7, 4 trihydroxy isoflavone (factor 2) is produced by the mould.

The phytate content of soyabean falls by 22% owing to the reduced phytase activity.

Tempe can also be made from winged bean (*Psophocarpus tetragonolobus*) known as *Tempe kecipir*.

Other seeds used in making tempe are lupin (*Lupinus angustifolius L.*) soybean (*Glycine max*), yellow peas (*Pisum sativum*), wheat, (*Triticum aestivum*), broad beans (*Vicia faba*), cowpeas (*Vigna sinensis*), and barley (*Hordeum vulgare*).

Coconut grits or press cake are also used to make *tempe bongrek*.

Tempe mata kedele is a low-quality tempe made by collecting and fermenting the soyabean hulls.

Oncorn (Ontjom) is a cake like product prepared by fermenting a soaked, cooked substrate consisting of peanuts (groundnut) press cake as the major ingredient.

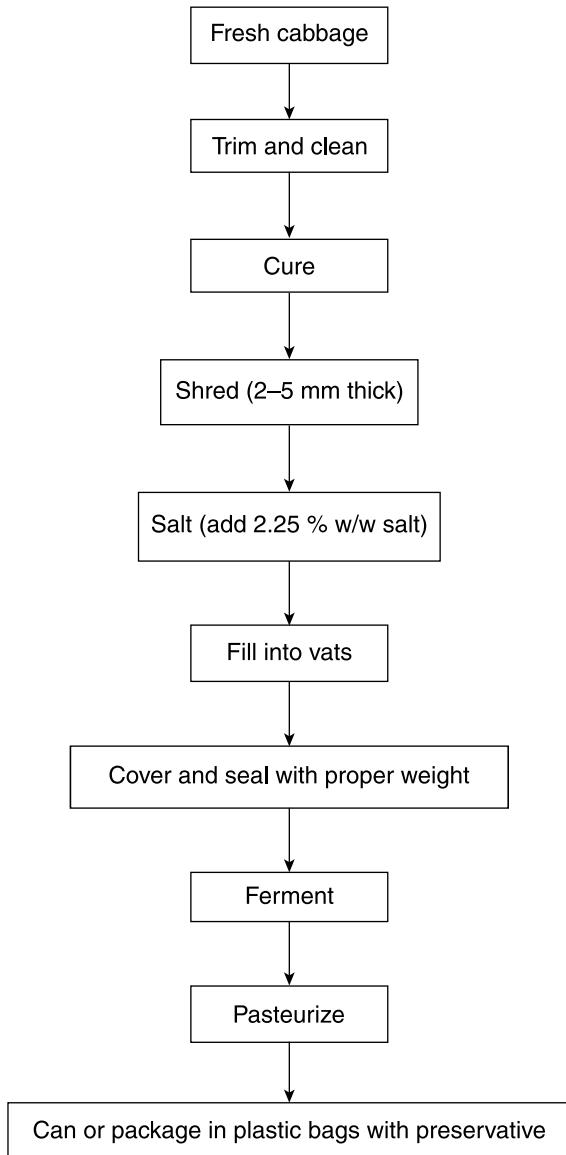


Fig. 20.3 Sauerkraut fermentation

20.6 ACID-FERMENTED VEGETABLES

Advantages of acid food fermentations are:

1. They render foods resistant to microbial spoilage and the development of food toxins.
2. They make the foods less likely to transfer pathogenic organisms.

3. They generally preserve the foods between the time of harvest and consumption.
4. They modify the flavour of the original ingredients and often improve the nutritional value.

Sauerkraut or *sauerkohl* are German terms for “Sour Cabbage” which is generally prepared from shredded white cabbage. *Leuconostoc mesenteroides* are used. Later, *Lactobacillus brevis* and *Lactobacillus plantarum* grow and the *kraut* is completely fermented in a month.

Other acid-fermented vegetables are *Kimchi* developed by the Koreans using Chinese cabbage, radish and other ingredients.

Cucumbers and gherkins are pickled. The Chinese sauerkraut, known as *Hum Choy*, is prepared using a locally grown vegetable *gai-choy*.

20.7 ACID-LEAVENED BREAD AND PANCAKES

Idli It is an acidified and leavened fermented preparation by the heterofermentative lactic bacteria, popular in India. It is closely related to sourdough bread of the western world. Leavening is produced by bacterial rather than by yeast activity. *Idli* is important for three reasons:

1. Its high degree of acceptability as a food in South India.
2. It is protected against food poisoning and transmission of pathogenic organisms because of its acidity.
3. The fact that *idli* fermentation can be used in many parts of the world using various combinations of cereal grains and legumes to produce acid, leavened bread, or pancake like products. No wheat or rye flour is needed.

Indian Idli, Dosa (Dosai) (Puda), Dhokla, Khaman and Related Fermentations

All the above-mentioned are made from rice and black gram dal (*Phaseolus mungo*) or Bengal gram (*Cicer arietinum*).

The flow sheet of traditional Indian *idli* production is given in Fig. 20.4.

Nutritionally, these foods contribute to the protein and calories in the diet of Indians, particularly South Indians. Thiamine, riboflavin and niacin increase during fermentation and phytate phosphorus decreases. *Idlis* are also better tolerated by young children, even by kwashiorkoric or marasmic children, as well as by pregnant women.

Fermentation normally proceeds with the help of microorganisms (*Leuconostoc mesenteroides* and *Streptococcus faecalis*) developed during the initial soaking. But some may use sour buttermilk and/or yeast *inocula* in preparing *idli*.

Other products are fermented rice and *amboli* made with *ragi* (*Eleusine coracana*) and rice to which sour milk is added. *L. mesenteroides*, *L. fermentum* and *S. faecalis* are present in the fermented *ragi*.

Puto It is primarily made in the Philippines. It is a leavened, steamed rice cake made from rice, which is allowed to undergo natural acid and gas fermentation. It

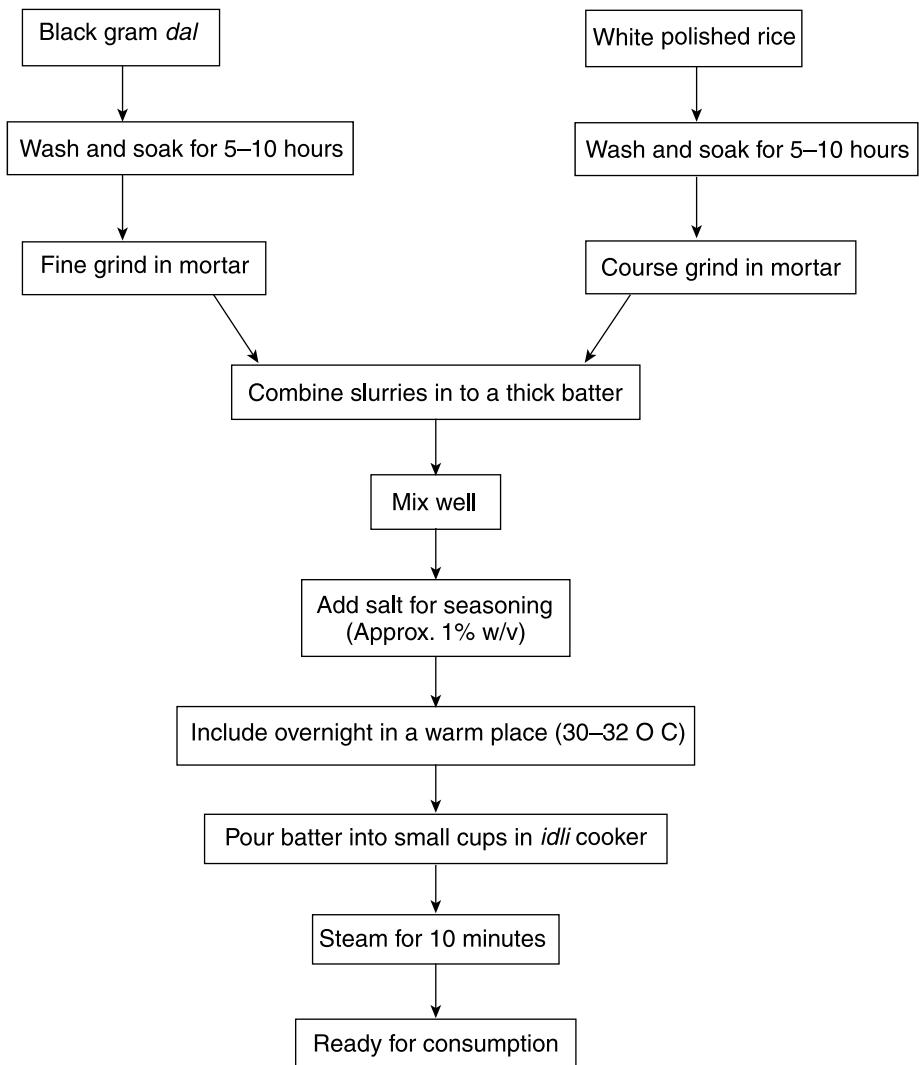


Fig. 20.4 Traditional Indian idli production

is consumed as a breakfast and snack food. It is a common food for the low-income group. Special types made with cheese, eggs, etc. are consumed as a delicacy by people belonging to the high-income group.

It is essentially an energy food containing about 251 (range 206 to 402) calories per 100 g. Protein content is about 3.5% and carbohydrate content about 56%.

Other fermentation pancake-like products are the Ethiopian *enjera*, the Sri Lankan *Hopper (Appa)*, and the Sudanese *Kisra*.

Acid fermentation is also used in the production of *mung* bean starch, which is later used for making noodles, which is the staple diet of Chinese.

Acid fermented cereal gruels include the Nigerian *Ogi*, which is consumed as porridge. Its nutritional contribution is mainly in terms of calories.

Kenyan *uji* is fermented maize, millet, sorghum or cassava flour in water and is consumed like tea.

Other similar drinks include the South Ethiopian *Kocho*, African *Mahewu* (*Magou*), Nigerian *Gari*, Ghanaian *Kenkey*. The latter contains higher levels of thiamine, riboflavin and protein due to microbial activity.

20.8 ACID-FERMENTED SEAFOOD/RICE AND MEAT MIXTURES

These include the Philippine *Balao*, *Burong Dalag*, and the Thai *Nham*.

Balao is a fermented rice-shrimp mixture. The latter is fermented pork. The former is fermented fish and rice coloured with angkok, a deep red to purple coloured rice grain produced by growing *Monascus purpureus* winter on cooked rice.

Nutritionally, they contribute protein to the diets of the consumer.

20.9 ACID-FERMENTED MILK AND MILK/CEREAL FOODS

Milk is not only very nutritious for humans, it is also an excellent substrate for various microorganisms. Soured milk is consumed in products such as buttermilk, yoghurt, *kefir* and *koumiss*. Fermented milks by themselves or combined with cereals offer a means of preserving highly nutritious foods at costs far below canning, freezing and artificial dehydration.

Milk is naturally seeded with *lactobacilli* and *streptococci*.

❑ Buttermilk

It is the liquid remaining after removal of the butterfat. This term is also applied to skim milk that has been fermented with *Streptococcus lactis* subspecies *diacetylactis*, which produces diacetyl imparting a milky, skim milk or buttermilk.

Laban *zeer* is fermented concentrated buttermilk. The primary fermenting organisms are *Streptococcus thermophilus* and *Lactobacillus bulgaricus*.

The Indian *dahi*, yoghurt, *yahourth*; Egyptian *leben* (*leben rayeb*), Ethiopian *ergo*; Iraqi *liban argeel*, *liban khather*; *mast*, *mass taw*, *shemina*, *dabbo*; and Malaysian *tairu* are all types of sour milks or yoghurts.

In most of the above products, some inhibition of pathogens is due to acid production. Also, metabolites such as lactocidin, nisin and acidophiline produced by starter organisms also exhibit antibacterial activity.

The nutritional quality of these products depends upon the type of milk used in making them.

The Egyptian *kishk* (Iraqi *kushuk*) is a fermented milk-wheat mixture stored in the form of dried balls. Nutritionally, it contains low amounts of lysine and threonine. However, the NPU of *kishk* is on par with casein (59 and 60 respectively) and much higher than groundnut meal (42.8). The digestibility of *Kishk* is 90 and BV is 66. It is a fair source of iron.

The practical nutritional importance is its improvement of the basic cereal protein diet by adding animal protein in a highly acceptable form. A similar product is the Greek *Trahanas* (Turkish *Tarhanas*).

□ Russian Koumiss

It is an effervescent acid/alcoholic fermented milky white or grayish liquid made primarily from mare milk. It is a food high in nutritional quality and is considered to be therapeutic, especially in the treatment of pulmonary tuberculosis. A similar product is the Russian kefir. It has approximately the same nutritional value as the starting milk.

20.10 INDIGENOUS FERMENTED FOODS IN WHICH ETHANOL IS A MAJOR PRODUCT

Alcohol serves as a source of calories. Primitive wines are cloudy, effervescent slurries containing residues of the substrates and the fermenting yeasts and other microorganisms. Thus, primitive wines and beers provide not only calories but B-vitamins as well.

Since, people subsisting on polished rice are often deficient in vitamin B₁ and B₂, addition of these vitamins to the diet in the form of a primitive wine or beer can be life saving, preventing beriberi and B₂ deficiency. Maize diets are generally low in B₃ and frequently lead to pellagra, which is general not found among people subsisting on maize if they consume primitive wine or beer with its content of B₃.

Most primitive wine or beer contain small amount of protein and amino acids, which contribute to the protein nutrition of the consumer. For example honey wines, Ethiopian *Tej*, Sugarcane wines, palm wines (toddys), Mexican pulque, Indian Jackfruit wine, Kenyan *Urwaga*.

Certain alcoholic beverages used to be prepared by using saliva as a source for hydrolysis of starch to sugars, as in Japanese *sake* and South American fermented maize *chicha*.

Alcoholic beverages are also prepared in which starch hydrolysis is accomplished by malting (germination). For example, African *kaffir* (*kaffircorn*), (sorghum) beer, Mexican *Tesguino*, Egyptian *Buzo*, Nigerian *Pito*, Ethiopian *Talla* (*Tella*), Kenyan *Busaa*, Zambian *Munkoyo*. Most of these beverages are rich in carbohydrate, protein and most vitamins and minerals.

Alcoholic beverages in which starch is hydrolysed and fermented by amylolytic moulds and yeasts are clarified rice wines (Japanese *sake*), Malaysian wines, Japanese or Indonesian tea fungus.

20.11 SOYA SAUCES

The amino acid or peptide-rich meatlike flavouring of Chinese *Chiang-yiu* and Japanese *Shoyu* are traditional fermentations in the Orient. The Chinese have been using soya sauce for over 3000 years. Soya sauce making followed Buddhism and its vegetable diet into Japan over 1000 years ago. *Koji* preparation was introduced over 1700 years ago and is still used to make *sake* and *miso* as well as *shoyu*.

Sho or *Shoyu* are Japanese terms covering plant or animal proteins enzymatically hydrolyzed in the presence of high-salt concentrations. MSG (monosodium glutamate) is the active ingredient. Thus, *Sho* includes fish as the substrate for fish sauces in Thailand, Vietnam and other parts of South-East Asia, soybeans as the

substrate in China and Korea and mixtures of soybeans and wheat in Japan.

With fish sauces, the source of proteolytic enzymes is the fish tissue, particularly gut enzymes, while in the case of soya sauces, proteases, amylases and lipases of *Aspergillus* sp. hydrolyze the components of the soybean and wheat. At the same time vigorous lactic and yeast fermentations add acidity, ethanol, and various flavour compounds to the product.

Most of these products contribute protein, amino acids and peptides.

Miso made by using rice, barley and soyabean is a food product of almost infinite variety of colour and flavour. The protein content ranges from 11 to 21% in various types of *miso*. 60% of the total nitrogen is water soluble and easily digested. The NPU of *miso* is about 72 and higher than the NPU's of its ingredients (rice—70; barley—60; and soyabeans—61).

Fish sauces and paste involve hydrolysis in the presence of high salt concentrations. They generally have good keeping quality. The excellent nutritional value of the fish or shrimp used in its manufacture is preserved. The hydrolytic products of fish protein and partially hydrolyzed substrate are more readily assimilable than the native protein.

Examples of these are Philippine *bagoong*, Malaysian paste (*belachan*), Philippine fish sauce (*patis*), Thai *nampla*, Vietnamese *nuoc-mam*, Vietnamese *mam*, Malaysian *budu*, Cambodian *prahoc* and Indonesian *trassi*.

Tofu is soyabeans curd and resembles Indian *paneer*. *Sufu* is cheese made from *Tofu* and is better for digestion because it is aged.

20.12 UNCONVENTIONAL SOURCES OF PROTEINS

These sources are considered unconventional simply because there is no recorded history of prior extensive use by man.

The new sources of protein are “(i) oilseeds such as glandless cottonseed and oilseed protein concentrates, (ii) Fish Protein Concentrate (FPC), (iii) leaf protein, and (iv) single cell protein.”

The following are the unconventional proteins.

1. Cereals

- (a) *Wheat* is a staple product but its fortification with synthetic lysine or its complementation with other lysine-rich protein such as legumes is being practised.
- (b) *Rice* Fortification of rice with lysine and threonine is being attempted in many countries. The rice-legume dietaries of India offer an excellent example of mutual supplementation.

2. Oilseeds

- (a) Soyabeans and particularly soya-flour are protein rich (about 40 and 50% respectively). These are used widely in US and China. Its use as an extender of animal protein is increasing. Soya-flour may be used to complement cereal flours. Such complementation is promising especially for the nutritional upgrading of snack foods.

- (b) Cottonseed is second to soybean in production worldwide and it is popular in many countries including USA and USSR. Breeding has resulted in a new glandless cottonseed, the flour of which is nearly white. This variety does not contain the polyphenol gossypol, a natural toxicant present in the gilded variety.
- (c) Peanut protein is deficient in three amino acids—lysine, methionine and threonine—as compared to soyabean which is deficient principally in methionine but is a good source of lysine. Peanut protein must be supplemented with amino acids and/or other quality sources of protein to improve its food value.
- (d) Other oilseeds of significance are sunflower, coconut and sesame. Their main drawback is the indigestible fibre that exerts a cathartic effect, *in vivo*, limiting the benefits of these quality proteins.

3. Fish Protein Concentrates (FPC) Trash fish is fish caught from marine sources that are considered inedible and used for sun-drying to produce fish meal used in livestock foods or as manure. As it is rich in proteins, methods have been developed to produce creamy white flour without fishy odour. This shows promise for use in human foods.

4. Single Cell Protein (SCP) The principal new protein sources under the label of SCP are yeast, fungi, algae and bacteria. These fields of new developments are limited mainly to research laboratories at present.

5. Leaf Protein Concentrate (LPC) Concentrates have been prepared by pulping tender leaves and separating a juice containing protein, by filtering or centrifuging. The juice is heated to obtain the protein-rich fraction which is dried to get the protein concentrate. The extraction procedure is feasible at the village level. This field too is under development in our country and no commercial preparations are available.

Mushrooms and Single-Cell Microbial Protein

In the production of indigenous fermented foods, bacteria, yeast, or moulds, often in combination, convert edible and sometimes inedible substrates to new human foods with enhanced organoleptic characteristics, improved digestibility, and nutritive value, e.g. peanut or coconut presscakes are converted to Indonesian *ontjom* and *bongrek*. Hence, it is essential to include the production of edible mushrooms or SCP, which thrives on ligno-cellulosic or other food and agricultural wastes.

At one time wild mushrooms must have been a part of the human diet. But today, they are being cultivated commercially. The species *Agaricus campestris* or *A. bisporus* (button mushrooms) are being cultivated in US and Europe. In Asian countries the oyster mushroom species *Pleurotus ostreatus* and the straw (paddy) mushroom *Volvvariella volvacea* are favoured.

After the mushrooms are harvested in a series of flushes, the spent bed makes excellent compost. Nutritional compositions of two varieties of mushrooms is given in Table 20.3.

Table 20.3 Nutritional compositions of two varieties of mushrooms

	<i>Volvariella volvacea</i>	<i>Entoloma macrocarpon</i>
Water, %	88.0	88.5
Crude protein, g	3.54	4.6
Carbohydrate, g	7.29	4.3
Lipid, g	0.68	0.8
Crude fibre, g	1.24	0.4
Ash, g	0.58	1.4
Thiamine, mg	0.12	0.14
Riboflavin, mg	0.33	0.16
Niacin, mg	9.10	2.4
Ascorbic acid, mg	2.0	12.0
Calcium, mg	7.0	6.0
Phosphorus, mg	67	110
Iron, mg	1.7	1.5
Sodium, mg	37	—
Potassium, mg	342	—

20.13 ADDITIVES PRODUCED THROUGH BIOTECHNOLOGY

□ Enzymes

These are protein catalysts synthesized by living systems and are more important as synthetic and degradative catalysts. Microorganisms are able to carry out a number of stepwise chemical reactions necessary for the growth and maintenance of cells. Many microorganisms also synthesize additional, often complex substances. They do not have any role to play in the growth process. These “secondary metabolites” are flavours and fragrances.

Enzymes not only make important contribution to cellular activities but also have many applications in biotechnology as in the manufacture of cheese, beer, wine, bread, sweeteners, etc. In the chemical and pharmaceutical industries, enzymes are required for synthesizing amino acids and antibiotics.

Natural enzymes are advantageous in curing food products like cheese and meat to give desirable textures and flavours. However, natural enzymes also produce undesirable reactions such as lipases cause rancidity, Polyphenol oxidase (PPO) causes browning reactions. Enzymes in foods are also used as an index such as phosphatase or catalase to detect pasteurization of milk or cheese, peroxidase to indicate adequacy of blanching in vegetables, etc.

Of the more than 3000 enzymes known from plant, animal or microbial sources, fewer than 20 are industrially produced on a large scale for the production of foods and intermediates. The majority of enzymes are hydrolases such as amylases, cellulases, pectinases and proteases, which degrade polymeric substances to simple molecules.

Enzymes are necessary in the food industry for ingredient production and texture modification. The advantages of using microbial enzymes for industrial processes are due to the following reasons:

1. The existence of different types of enzymes activity.
2. The rapidity and stability of production through the inexpensive, reproducible and safe microbial fermentation route.
3. The improvement in yield that are obtained more easily with genetic or protein engineering than from plant or animal cultures.

Most food enzymes are produced by *Bacillus* and *Aspergillus* species, which are capable of secreting the enzymes and of growing in cheap media. Industrial enzymes, except those used in the amino acid and antibiotic industries, are rarely pure but the impurities do not interfere with the enzyme activity.

A general scheme for enzymes production is shown in Fig. 20.5.

□ Sweeteners

Carbohydrates-based nutritive sweeteners such as invert sugar, dextrose and corn syrups, high fructose corn syrups (HFCS) are used. All the enzymes involved in the manufacture of these natural sweeteners are produced from microorganisms, e.g. Invertase is produced by baker's yeast, *S. cerevisiae*, thermostable alpha-amylases are derived from *Bacillus stearothermophilus* and *B. licheniformis*.

The high intensity sweeteners, saccharin and cyclamates are still used in several countries and have been used in tabletop sweeteners, soft drinks, salad dressings, confections and processed foods. Aspartame, a dipeptide methyl ester of aspartic acid and phenylalanine, is known as L-aspartyl-L-phenylalanine 1 methyl ester (APM). Proteases, particularly thermolysin (a metalloprotein obtained from *Bacillus thermolyticus*), have been used in the synthesis of aspartame, instead of conventional chemical synthesis. Similarly, other high intensity sweeteners like Alitame, PS99 and PS 100, Acesulfame K, Thaumatin, Stevioside are being manufactured. Low calorie sweeteners such as maltitol, lactitol, isomalt and fructo-oligosaccharide have sweetness of sucrose but none of them are non-caloric. Enzymes such as fructosyltransferase derived from *Aspergillus niger* are used in their manufacture.

□ Flavours and Amino Acids

There are two principal routes for the production of microbial flavours: biosynthesis (also known as *de novo synthesis*) and bio-transformation-based processes. The yield is lower from the former process than the latter. Microorganisms or enzymes can be used to produce either complex multi-component flavour systems or individual flavour compounds. Enzyme-modified cheese, lipolized milk fats and blue cheese flavour are examples of complex , multi-component flavour systems being produced by enzymes and microbial fermentation.

One important development is the use of microbial cultures to produce flavour enhancers or potentiators. They include compounds inosine 5 monophosphate (5 IMP) and guanosine 5 monophosphate (5 GMP) as well as monosodium glutamate (MSG). Today MSG is produced from *Brevibacterium flavum*, *Corybacterium glutamicum* and *Brevibacterium divaricatum*.

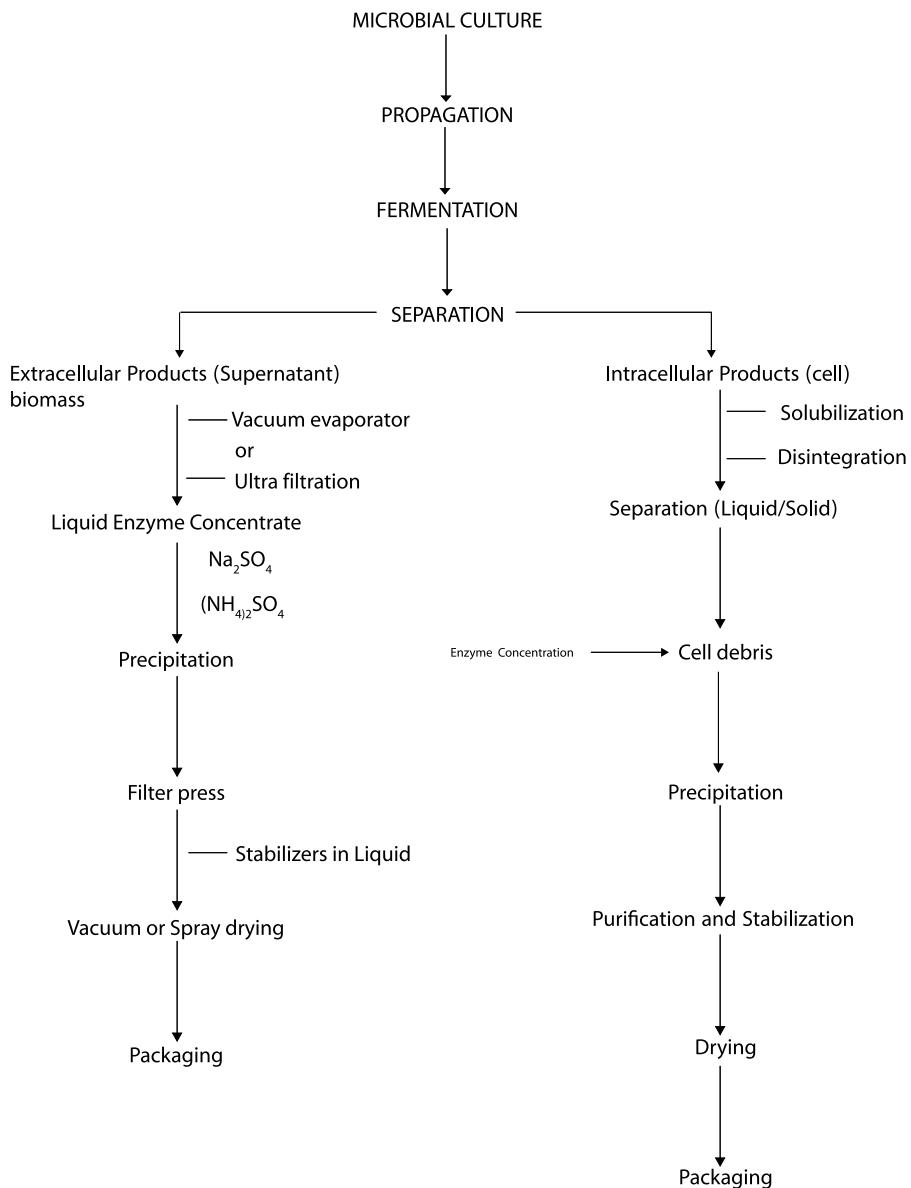


Fig. 20.5 A general scheme for enzyme production

Table 20.4 Applications of commercial lipases

Source	Applications
Pancreas	Digestive enzymes, Interesterification of fats
<i>Aspergillus niger</i>	Manufacture of cheese and butter flavour
<i>Mucor miehei</i>	Acceleration of cheese ripening; enzyme-modified cheese
<i>Rhizopus delemas</i>	Soap manufacture
<i>Candida cylindracea</i>	Soap manufacture

Table 20.5 Application of important commercial food enzymes

Enzymes	Source	Production*	Applications
<i>Starch Processing</i>			
a-Amylase	<i>Bacillus licheniformis</i> <i>Aspergillus</i> spp.	300	Starch liquefaction, alcohol production
b-Amylase	Plant (malt)	10,000	Maltose and alcohol production
Glucoamylase	<i>Aspergillus</i> spp.	300	Starch saccharification, brewing, baking
Glucose isomerase	<i>Bacillus coagulans</i>	50	High fructose corn syrup sweeteners
Invertase	<i>Saccharomyces cerevisiae</i>		Sugar confectionery, Invert sugar
Pullanase	<i>Klebsiella</i> spp.		Debranching of starch, brewing
<i>Dairy Processing</i>			
Rennet	Stomach of calves	2	Cheese manufacture (milk coagulation)
Microbial rennet	<i>Mucor miehei</i>	10	Cheese manufacture
Lipase/esterase	Fungal, bacterial, animal		Cheese ripening, milk fat production, sausage ripening
Protease/peptidase/ lactase	<i>Aspergillus niger</i> <i>Kluveromyces</i> , <i>aspergillus</i> spp.	10	Lactose hydrolysis
<i>Fruit / Vegetable Processing</i>			
Pectinase	<i>Aspergillus</i> spp.	15	Extraction clarification of fruit juices
Cellulase	<i>Trichoderma</i> , <i>Aspergillus</i> spp.		Fruit and vegetable processing

* 1991 world production, in tons of pure enzyme protein.

Ref.: *Fundamentals of food biotechnology* by Byong H. Lee, VCH Publishers, 1996.

The production of synthetic rennet produced by cloning and expressing the calf chymosin gene into microorganisms such as *E. coli* and *Kluveromyces fragilis* has helped to reduce the need to slaughter suckling calves for their rennet.

The manufacture of amino acids reflects the increased recognition of the nutritional and taste values of amino acids in many foods and beverages, such as fruit juices, cheese, beer, seafood, soup and tea. Besides being used as food additives, amino acids are also used as feed additives and components in pharmaceutical, cosmetics and other industrial raw materials. Several microorganisms such as *Corynebacterium* and *Brevibacterium* are used in the production of amino acids.

□ Vitamins and Pigments

Several vitamins, namely C and B₁, B₂, B₅ B₆ and B₁₂, H (Biotin), folic acid and P (nicotinamide), are essential for human life. Most vitamins are manufactured synthetically to meet the requirements of purity and stability but only vitamin B₁₂ and riboflavin are produced commercially by fermentation. Fungi such as *Eremethecium ashbyii* and *Ashbya gossypii*, *Candida species*, moulds such as *Penicillium chrysogenum* and *Fusarium* have been reported as flavin producers. *S. cerevisiae* grown on calcium acetate have been used to produce vitamin B₂.

Propionibacterium, *Pseudomonas denitrificans*, *Rhodopseudomonas* fused with *Protaminobacter* have been used in producing vitamin B₁₂.

Similarly, pigments like B-carotene, lycopene, xanthophylls are produced with the help of micro-organisms such as *Balkeslea trispora*, *Streptomyces*, *Dacrymyces deliquescens*.

□ Tea, Coffee and Cocoa

Fermentation processes involved in the preparation of cocoa beans produce a stable product with the qualities of flavour and aroma desirable for the manufacture of cocoa and chocolate. The coffee fermentation process is designed to improve the appearance of the finished green beans, resulting in a higher grading of the liquors. Tea fermentation is different in that it is an oxidative process initiated enzymatically and does not require any microflora involvement. However, leaf microflora such as bacteria and yeasts have an influence on the quality and taste of black tea. It is under optimum fermentation conditions that all three crops will develop a flavour of the desired standard.



SUMMARY

Microorganisms have been used by mankind to utilise the various foods when in glut, which could otherwise have been wasted. They are converted into products with not only a longer shelf-life but a better nutritive value and which could be consumed in the lean season. With the advances in the field of biotechnology mankind will have to depend on microbes to meet the increasing requirements of food and particularly protein, in future.



REVIEW QUESTIONS

1. List the main areas of foods in which growth of microorganisms is desirable.
2. Give five examples of products of microbial fermentation.
3. Write brief notes on beer manufacture and yogurt production.
4. What is the nutritional contribution of the following: Tempe Kedele, *idli/dosa*, *balao*, buttermilk, and Egyptian *kishk*
5. Which varieties of mushrooms are generally consumed? Write a brief note on their nutritional contribution to the diet.
6. Visit the nearby vegetable market and find out the varieties of mushrooms being sold and their prices per kilogram.

Chapter

21



Safety of Foods

21.1 FOOD ADDITIVES

An additive may be defined as a substance or mixture of substances other than the basic foodstuff, present in food for any aspect of production, processing, storage or packaging.

Additives are used to maintain or even improve the quality of food. At the beginning of the present century there were not more than 50 additives, but at present there are about 4000 items which are being currently used by food industries. This list includes antioxidants, mould inhibitors, bactericides, emulsifiers, stabilizers, humectants, sweeteners, colours, sequestering agents, flavours, enzymes, preservatives and micronutrients.

Food additives are used for the following purposes:

1. To increase the shelf-life of the food.
2. To improve the nutritive value of the food.
3. To enhance its appeal to the consumer.

The decision to use a substance as a food additive is based on the assurance that its use will be safe for the consumer. The safety of a food additive is assessed from long-term feeding trials conducted on animals.

The Acceptable Daily Intake (ADI) is based in relation to the body weight. Modern legislation (FSSAI, 2006) prescribes the following conditions:

1. Permitted list for most groups of additives: FSSAI, 2006 and Rules 2011 give the lists of additives to be added in foods, the quantities, and if restricted, the foods in which they are allowed to be added.
2. For many additives maximum levels of use are prescribed for different foods.
3. Rules for declaration of the use of such additives on labels are laid down.
4. The additives which are to be used for food have to be pure and free from any harmful impurities. The Indian Standards Institution now known as Bureau of Indian Standards (ISI) gives the specifications for purity of these additives.

There may be intentional or incidental additives.

□ Intentional Additives

Intentional additives perform a specific function. These are as follows:

1. Improve the nutritive value of the food—Amino acids, ascorbic acid, vitamins A, D, B-complex, minerals etc., e.g. iodine is added to salt to prevent iodine deficiency and goitre.

2. Improve the sensory appeal—substances such as colours, flavours, gelling and bodying agents are added to improve colour, flavour, texture, volume, etc. Acidulants, sweeteners, salt, astringents, flavour modifiers and enhancers improve taste.
3. To facilitate processing by adding emulsifiers, stabilisers, thickeners, buffers, anti-foaming agents, etc., e.g. anti-foaming agents are added to beer during its fermentation.

Some common intentional additives are shown in Table 21.1. Their use is carefully controlled by the FDA.

Incidental Additives

Incidental additives are present in small amounts in the final product after they have performed their functions. They are the following:

1. Pesticides and Insecticides These are carried over from the crop after harvesting or from stored products. However, the incidence of these additives is

Table 21.1 Intentional food additives

Function	Chemical compound	Common food uses
Acids, Alkalies, Buffers	Sodium bicarbonate Tartaric acid	Baking powder Carbonated drinks
Anti-caking agents	Aluminium silicate	Table salt
Antioxidants	Butylated hydroxy Anisole (BHA)	Fats and Oils
	Tertiary butyl hydroquinone (TBHQ)	Fat spread
Colouring Agents	Annatto Sunset yellow FCF	Table butter Ice-cream
Emulsifiers	Lecithin Mono and diglycerides Propylene glycol, alginate	Bakery goods Dairy goods Confectionery
Flavouring Agents	Amyl acetate Benzaldehyde Methyl salicylate Essential oils—natural extracts Monosodium glutamate (<i>Ajinomoto</i>)	Soft drinks Bakery goods Candy; ice-cream Canned meats
Non-nutritive Sweeteners	Saccharin Aspartame	Low calorie soft drinks
Nutrient supplements	Potassium iodate vitamin A and D, B vitamins, iron Lysine Ascorbic acid	Iodized salt Hydrogenated fat Bread Bread Fruit squash
Preservatives	Sulphur dioxide Benzoic acid	Sausages Tomato sauce

much less in processed foods. There is more chance of a residue on fresh food than a processed one. Hence, proper washing of a vegetable or fruit before consumption is very important.

This class also includes herbicides, fungicides, rodenticides, nematocides, weedicides etc.

2. Antibiotics and Growth Regulators These are used to regulate the growth of animals and plants. They include hormones, tranquillizers, sprouting inhibitors, etc.

It is important for a person who is health-conscious to read the label of any packed food that is bought from the market. Excessive intake of either intentional or incidental additives can be harmful.

Carbonated beverages/aerated beverages, commonly called *cold drinks*, are advertised as thirst-quenching aids, and a layman is misled as he feels they are the juices of fruits like lemon, lime, orange, etc. These cold drinks are water-based synthetic drinks containing additives like artificial sweeteners such as saccharin, artificial colours and flavours and clouding agents, and resemble natural fruit juices. Except for supplying sugar and some electrolytes and clean water to the body, these drinks have no nutritive value. The vulnerable group is young children and adolescents. The empty calories supplied by these soft drinks replace foods in their diet which are much more nutritious and satisfying. It should be noted that FDA requires the manufacturers of these beverages to declare that these drinks *do not contain any fruit juice or fruit pulp* and that they are artificially flavoured and coloured.

Wise parents should avoid the excessive intake of these by their children and under no circumstances should they replace nutritious meals. It is necessary to avoid food which is purely synthetic, e.g. soft drink concentrates contain several synthetic additives and do not necessarily contribute valuable nutrients.

Even the sweetmeats available in the market contain added colours such as green, pink, yellow, brown or red, only to please the eye. Hence avoiding a coloured *burfi* should not be difficult. Those without colour should be preferred.

Food in which a nutrient has been added to improve the nutritive value should be preferred as compared to that in which such supplementation is not done. Iodized salt should be preferred to non-iodized salt, especially by those living in endemic goitre-prone areas.

21.2 CONTAMINATION OF FOOD

As food undergoes various processes like treatment with insecticides pesticides, from growth to harvest, farm storage, transport, warehousing, distribution, processing, packing, etc. it may get contaminated with various types of foreign matter.

Contamination of food means presence of any foreign matter in it. Some contaminants may be toxic and may cause serious harm. Consumption of contaminated food can result in poisoning, infection or other types of health disorders. These may result in acute or cumulative effects or a food-borne illness.

Toxic factors or toxicants refer to those substances found in foods that produce deleterious effect on health when ingested by man or animals. The contaminants may include dust, dirt, plant material from the same plant or other sources, inedible parts of animal body in case of flesh foods, dirty water in case of milk, residues of pesticides and chemicals used in the farm or storage, chemicals used in feeds that may enter the meat or milk of animals, etc. Several types of foreign seeds enter grains or oilseeds during harvesting. Moulds, insects and rodents may also add to the contamination. Although, such contamination is difficult to avoid completely, a limit on the proportion of these is placed in food standard specifications and if it is exceeded, the food sample may be considered as adulterated. Many of these contaminants can be removed to a very great extent by sieving, manually removing the physical contaminants and washing before the raw food material is processed for food preparation and consumption.

21.3 CLASSIFICATION OF TOXIC CHEMICALS IN FOODS

Toxic chemicals that enter the food chain to be finally consumed by human beings can be classified in the following manner.

- A. *Natural toxicants*
- B. *Natural toxicants entering through contaminants*
 - 1. Plant origin
 - 2. Microbial origin
 - 3. Biological agents
- C. *Chemical toxicants of external origin*
 - 1. Toxic metals
 - 2. Pesticide residues and agro chemicals
 - 3. Contaminants from processing practices
 - 4. Contaminants from packing practices
 - 5. Accidental contaminants
 - 6. Contaminants from environment

□ Natural Toxicants in Foods

Plant species often naturally contain chemicals which when consumed in large quantities over long periods may prove toxic. Such naturally occurring toxicants are also called anti-nutritional principles. Examples of these include protease inhibitors mainly present in legumes, that inhibit digestion of proteins, haemagglutinins that agglutinate blood cells; goitrogens that may cause hypothyroidism, found in mustard, cabbage and such vegetables; cyanogenic glycosides that produce hydrocyanic acid, lathyrogens, saponins, oxalic acid or oxalates, solanins as in potatoes and such others. It may be necessary to inactivate these by heating, leaching or by special treatments, or by developing plant species that contain low concentrations of these.

Some vegetables grown with high levels of nitrogen fertilizers may contain high levels of nitrate which may prove toxic.

□ Toxicants of Natural Origin Entering through Contaminants

1. Plant Origin Toxin-containing seeds such as *dhatura* (argemone) may enter grains and oilseeds rendering them unsafe for human consumption.

2. Microbial Origin Foods with high moisture content are susceptible to contamination by bacteria and moulds. High counts of these in foods are necessarily due to poor hygiene and sanitation. The presence of enteric pathogens is highly objectionable as these may cause food-borne diseases like typhoid, paratyphoid, cholera, gastro-enteritis, diarrhoea, dysentery, or cases of food poisoning with symptoms of diarrhoea and vomiting. The infection often comes from persons carrying these contaminants or use of unclean vessels or contaminated water. Once contaminated, the microorganisms may grow and multiply speedily as food is a good medium for them to proliferate. Some bacteria grow in the intestines and cause diseases. Some grow in the food and produce toxins. The bacterial toxins are responsible for food poisoning. Botulinum is the most dreaded amongst all. Some moulds or fungi may grow in foods and produce toxins called mycotoxins some of which may, after chronic consumption, cause cancer of liver or kidney. The most potent carcinogens produced by a fungus are aflatoxins. These are produced by the mould which grows in ground nut meal which is being stored as fodder for cattle or feed for poultry. Ergot is a well-known fungal contaminant of grains.

3. Biological Agents Parasitic worms and flukes that may infect animals and human beings may enter through drinking water or flesh foods. The round worms, liver fluke and worms causing trichinosis are examples of these.

□ Chemical Toxicants of External Origin

1. Toxic Metals Toxic metals such as lead, antimony, cadmium, arsenic and mercury may enter processed foods through contact with metal containers, pipes, vessels or through chemicals and additives used in processing.

2. Residues of Pesticides and Agrochemicals These often remain in farm produce such as fruits and vegetables. Fumigants and pest control chemicals used in storages may enter the grains, nuts, oilseeds and other grain products.

Livestock feeds often contain antibiotics and fattening chemicals. The animals may receive drugs to control infections. These may enter their bodies and leave residues in meat, milk and even eggs.

3. Contaminants from Processing Practices Food often undergoes unpermitted processing treatments such as artificial ripening with lime, calcium carbide, methane; artificial colouring with non-permitted synthetic dyes; antimicrobial agents that may be toxic, pesticides; artificial sweeteners like saccharine, cyclamate; thickeners such as filter paper. All these practices come under the definition of food adulteration although they may be practised wilfully or out of ignorance.

Thermal processing such as roasting and frying may produce polycyclic hydrocarbons and cyclic polymers of fatty acids, whereas these and processes like fermentation produce nitrosamines. All these are suspected carcinogenic and mutagenic compounds.

4. Contaminants from Packaging Materials Processed foods are packed in containers of metal, glass, plastic, paper or laminations. Acidic foods are known to dissolve metals, e.g. zinc and tin levels are known to rise in fruit juices. Plastic films contain additives such as colours, plasticizers, fillers and monomer chemicals of polymers. These may get transferred to the food. Such contaminants can prove toxic.

5. Accidental Contaminants In warehouses where food materials are stored, or during transport where these may be accompanied by packs containing toxic materials such as containers of pesticides, paints, disinfectants, etc. chance contamination of the food product cannot be ruled out. If containers used for such materials are used without cleaning for storing food products such as edible oils, toxic chemicals may vitiate the food products. Cases of oil contamination with chemicals such as tri-o-cresyl phosphate and aniline derivatives have led to death and disabilities in a large number of people in many parts of the world.

6. Contaminants from Environment With increasing pollution of environment from industrial effluents, automobile exhausts and sewage, drinking water and processed water used for industries and growing crops are likely to get contaminated. Plants exposed to automobile exhausts are known to contain higher lead content. Non-biodegradable chemicals from industry, detergents, etc. may contaminate food materials. The Chernobyl accident in Russia has brought to light a new hazard of radioactive elements entering food chain through soil. Figure 21.1 outlines radioactive contamination.

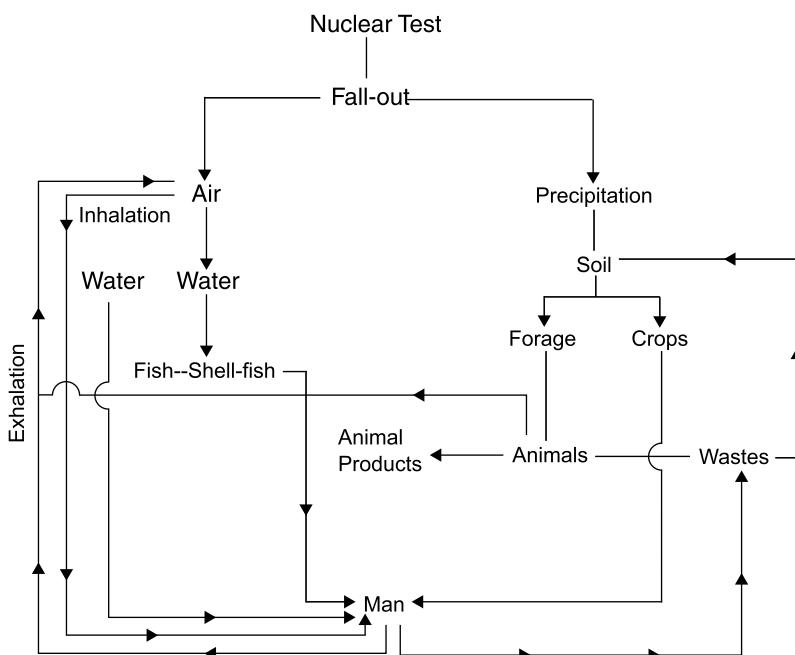


Fig. 21.1 Pathways of the transfer of nuclear fall-out to man

21.4 LATHYRISM

This crippling disease is responsible for life-long paraplegia in a large number of poor landless labourers and farmers. It does not kill but it cripples and is not curable. It has existed since ages. An ancient Ayurvedic book *Bhavprakash* calls the disease *Kalaykanj* and states that the *triputa* pulse causes a man to become crippled, and irritates the nerves.

Lathyrism is caused by a toxin B(N) oxalyl amino L-alanine (BOAA) present in the pulse *Lathyrus sativus*, which produces the toxic effects on the nervous system. Boiling the pulse in water and throwing the water away removes 90 percent of the toxin.

The onset of this disease is sudden. There is pain in the lumbar region and lower extremities and weakness and stiffness in the latter. The body may also suffer from low fever. Paraplegia develops a few days later. The legs become rigid and tremors may soon appear. There is severe loss of bladder and rectal control as well as impotence. The disease proceeds in four stages. These are as follows:

First stage (Non-stick Stage)—It is characterised by a typical manner of walking with short steps and jerky movements (scissors gait). The heels do not completely rest on the ground and there is marked swaying of hips and head to counterbalance.

Second stage (One Stick)—Muscular stiffness increases so that the person needs a stick to support and balance himself.

Third stage (Two Stick)—The muscular stiffness is so severe that the patient cannot support himself without two sticks.

Final stage (Crawling Stage)—The knees are much bent and cannot be extended so that the patient cannot stand. He has to crawl or drag, taking his weight on hands.

21.5 FOOD-BORNE DISEASES AND THEIR PREVENTION

Microbial contamination is one of the causes of food-borne diseases. Such a disease may occur due to:

1. Consumption of pathogens, the disease-producing bacteria which are present in food, or
2. Consumption of food containing bacterial toxins.

While the former is known as *food infection*, the latter is *food poisoning* or food intoxication. Both these cause illness in humans, which can easily be prevented if simple do's and don'ts about personal hygiene, food handling and food storage are followed.,

The main causes of food-borne illnesses are:

- Lack of sanitation and hygiene
- Insufficient cooking
- Improper storage

Food containing poisons of bacterial origin may be formed by *Clostridium botulinum* and *staphylococci*. Food-borne infections may be due to bacterial infections such as typhoid fever, dysentery and cholera as well as *Campylobacter jejuni* infection. Table 21.2 depicts the various organisms and food with which they are associated and the illnesses that they cause.

Table 21.2 Food-borne illnesses-causes, symptoms and control

Name of illness	Causes	Symptoms	Characteristics of illness	Control measures
1. Salmonellosis	Salmonellae bacteria, wide spread in nature, live and grow in intestinal tracts of human beings and animals. About 1200 species are known, one of its species causes typhoid fever. Bacteria grow and multiply at temperature between 44°F to 115°F.	Severe headache, followed by vomiting, diarrhoea, cramps and fever. Infants, the elderly and persons with low resistance are most susceptible. Severe infections cause high fever and may even cause death.	Transmitted by eating contaminated food or by contact with infected food or by contact with infected persons or carriers of the infection. Also transmitted by insects, rodents and pets. <i>Onset:</i> usually within 12 to 36 hours. <i>Duration:</i> two to seven days or more.	Salmonellae in food are destroyed by heating the food to a temperature of 140°F and holding for 10 minutes, or to a higher temperature for less time. Refrigeration at 45°F inhibits the increase of salmonellae, but they remain alive in the refrigerator or freezer and even in dried foods.
2. Staphylococcal Poisoning	<i>Staphylococcus aureus</i> Bacteria fairly resistant to heat. Bacteria growing in food produce a toxin which is extremely resistant to heat. Bacteria grow profusely with production of toxin at temperatures between 44°F and 115°F.	Vomiting, diarrhoea, prostration, abdominal cramps, generally mild and often attributed to other causes.	Transmitted by food handlers who carry the bacteria and by eating the food containing the toxin. <i>Onset:</i> Usually within three to eight hours. <i>Duration:</i> one to two days, or more.	Growth of bacteria that produce toxin is inhibited by keeping hot foods above 140°F and cold foods at or below 40°F. Toxin is destroyed by boiling for several hours or heating the food in pressure cooker at 240°F for 30 minutes.

(Contd.)

Table 21.2 (Contd.)

Name of Illness	Causes	Symptoms	Characteristics of Illness	Control Measures
3. Perfringens Poisoning	<i>Clostridium perfringens</i> Spore-forming bacteria that grow in the absence of oxygen. Spores can withstand temperatures usually reached in cooking most foods. Surviving bacteria continue to grow in cooked meat, gravies and meat dishes stored without proper refrigeration.	Nausea without vomiting; diarrhoea, acute inflammation of stomach and intestines.	Transmitted by eating food contaminated with abnormally large numbers of the bacteria. <i>Onset:</i> Usually within eight to 20 hours. <i>Duration:</i> May persist for one to three days.	To control growth of surviving bacteria on cooked meat that are to be eaten later, cool meat rapidly and refrigerate promptly at 40°F or below.
4. Botulism	<i>Clostridium botulinum</i> Spore-forming organisms that grow and produce toxin in the absence of oxygen, such as in a sealed container. The bacteria can produce a toxin in low-acid foods that have been kept in the refrigerator for two weeks or longer.	Double vision, inability to swallow, speech difficulty, progressive respiratory paralysis. Fatality rate is high in countries where consumption of canned food is high.	Transmitted by eating food containing the toxin. <i>Onset:</i> Usually within 12 to 36 hours or longer. <i>Duration:</i> three to six days.	Bacterial spores in food are destroyed by high temperatures obtained only in the pressure canner. More than six hours are needed to kill the spores at boiling temperature (212°F). The toxin is destroyed by boiling for 10 to 20 minutes; time required depends on kind of food.

□ Food-borne Infection

It results from eating food that contains a large number of living bacteria. These ingested bacteria multiply inside the digestive tract and cause infectious disease due to toxins produced by them. Each specific disease is caused by a specific bacterium. The incubation period is usually longer and, therefore, food-borne infections develop slowly. Three common food infections are those caused by salmonella, i.e. *Typhoid vibrio*, the agent causing cholera, *Campylobacter jejuni* causing enterocolitis.

Food-borne typhoid, dysentery and other diseases ordinarily occur on a small scale; the greater epidemics are water-borne and to a lesser extent milk-borne.

□ Food Poisoning

Food-borne intoxication, more commonly known as food poisoning, is caused by eating food in which bacterial toxins have been produced which on consumption by the host can poison him. Each bacterial toxin is produced by the growth of specific bacteria before the food is eaten. Since the powerful toxin is ingested directly, the symptoms of food-borne intoxication develop rapidly within a few hours. Staphylococcal poisoning and Botulism are such types.

Symptoms of food poisoning include abdominal pain, diarrhoea, nausea and vomiting and general discomfort. Headache, tiredness and dehydration suffered by the victim are symptoms mainly due to loss of body fluids and electrolytes. Individuals prone to such illness are the sick, the very young and the elderly. Most adults may tolerate the minor discomfort and intestinal upset due to food poisoning.

Bacteria grow in all kinds of foods; in the presence or even absence of oxygen; in dry and wet foods; in acidic or alkaline foods; and at very widely varying temperatures. However, under certain conditions, the growth of bacteria is *optimum*. If such conditions are provided, a very rapid growth in their number is observed. The time factor varies for different bacteria under different conditions. They can adapt and grow in a new environment within four hours. For this reason foods should not be left at room temperature for more than four hours. It is not safe to eat stale cooked rice even after reheating because it may contain *Bacillus cereus*, a dangerous bacteria.

□ Botulism

It is a severe form of food poisoning which was first described in Germany in 1817 as "sausage poisoning" (the latin word for sausage is *botulus*), the first food in which it was found.

Clostridium botulinum is a saprophyte, which is widespread and found in soils. It forms heat-resistant spores. If the latter are not destroyed by heat in cooking, vegetative forms may grow anaerobically and produce one of the most powerful toxins known, Botulism type A, which is the most lethal, is 10,000 times as deadly as cobra venom and millions of times more potent than strychnine or cyanide.

Symptoms usually begin 18 to 36 hours after the food is eaten. They are weakness of muscles and difficulty in swallowing, followed by paralysis of the muscles of respiration and death. If diagnosed early, emergency hospital care and antitoxins may save the patient's life.

The disease is transmitted primarily by eating inadequately cooked home canned meat and non-acid vegetables (beans, asparagus, corn and peas).

It is important to remember that botulinus-infected foods do not necessarily taste or smell spoiled.

Other agents of Food-borne Infection; Besides bacteria and their toxins, there are a number of agents which may cause disease. They include parasites, viruses and fungal toxins.

1. Parasites include worms and amoebas. Examples of these are roundworm trichina found in pork and beef or pork tapeworm which is found in animals that have eaten polluted garbage. These parasites live in the host and also reproduce there. It is, therefore, necessary to cook flesh foods thoroughly before consuming them.

The amoeba is another parasite of which the dysentery causing species *Entamoeba histolytica* is to be feared the most. This organism is ingested as cyst and faecal contamination of food or water is the means of transmission.

2. Viruses mainly cause the upper respiratory tract infections. Acute viral hepatitis, an inflammatory disease of the liver, is also caused by a virus. It may be carried through food or water supplies.
3. Fungi such as mucor, aspergillus and ergot are the most common contaminants of bread and cereal grains and, if consumed, cause various toxic reactions in the body.

21.6 SAFE FOOD-PREPARATION PRACTICES

In order to avoid food poisoning, personal hygiene is very important. The hands of the food handler must be very clean whenever food is handled. Use of hot water and soap in ample quantities ensures that the hands washed with these are clean. A person who is ill should not handle food. Hair should be tied and contact of the hands with hair, mouth and nose should be avoided. Disposable tissues or a clean handkerchief should be used to cover nose or mouth while sneezing or coughing. Food should be served using clean serving spoons and not with hands.

Kitchen equipment, utensils and appliances should be thoroughly cleaned before contact with any food. As far as possible, cooked food should not be allowed to stand for more than two to three hours at room temperature. Cooked food should be covered, rapidly cooled and then transferred to a refrigerator. Slow cooling permits entry and growth of bacteria. To cool foods rapidly for storage, a shallow pan, cold running water or icebath can be used, with the help of which food should be quickly cooled to 7°C (45°F) and stored in the fridge.

When leftovers are being used, they should be heated until all parts reach a temperature of 74°C (165F). Such leftovers should not be cooled and served but should be served hot.

Any stuffings which go into the preparation of pies, *samosas*, *kachoris* should be cooked separately and stuffed just before preparation. Avoid stuffing the night before and cooking the next day.

Gravies and broths are quite susceptible to bacterial contamination, especially as leftovers. Such foods should be placed in the refrigerator as soon as possible. They should be reheated and boiled for several minutes before consumption.

Any preparation containing eggs, meat, fish and poultry should be frozen and thawed, and heated thoroughly before consumption.

Milk products should not be stored for more than two to three days in the refrigerator, unless they are sugar-coated or dipped in heavy sugar syrup. Even then the storage period should not exceed a week.

Table 21.3 Food laws in force in india

<i>Nature of grievance</i>	<i>Main acts/regulations/orders applicable</i>
1. Quality and purity of foods	(i) FSSAI, 2006 and Rules 2011 (ii) Sugar (control) Order, 1966 (iii) Vegetable Oil, Products Order, 1947 (iv) Vegetable Oil Products (Standard of quality) Order, 1972 (v) Solvent Extracted and Oils, Deoiled Meal and Edible Flour Order, 1967 (vi) Packaged Commodities Act, 1975 (vii) The Edible Oils Packaging (Regulation) Order, 1998 (viii) The Atomic Energy (Control of Irradiation of Food) Rules, 1996 (ix) The Vegetable Oil Products (Regulation) Order, 1998 (x) The Recycled Plastics Manufacturing and Usage Rules, 1999
2. Hygiene in handling food in factories and restaurants	(i) FSSAI, 2006 and Rules 2011 (ii) State Municipal Act
3. Suspected adulteration or quality of goods, drawing samples for analysis	(i) FSSAI, 2006 and Rules 2011
4. Misleading and wrong labelling of foods and drugs	(i) FSSAI, 2006 and Rules 2011 (ii) Drug and Cosmetics Act, 1940 (iii) Standards of Weights and Measures Rules, 1977 (iv) Sale of Goods Act, 1930
5. Quality of sale, their measures, price marking	(i) Standards of Weights and Measures Rules, 1977 (ii) Standards of Weights and Measures Act, 1987 (iii) Sales of Goods Act, 1930
6. Quality of foods guaranteed under voluntary schemes	(i) ISI Act, 1952 and Rules and Regulations, 1956 (ii) Agricultural Produce (Grading and Marking) Act, 1937

21.7 DETECTION OF FOOD ADULTERATION

Food has been defined under the FSSAI, 2006 and Rules 2011 as whatever is consumed by the human body except drugs and water.

Adulteration means not only intentional addition or substitution or abstraction of substances which adversely affect the nature, substance and quality of foods, but also their incidental contamination during growth, harvesting, storage, processing, transportation and distribution.

To safeguard the consumer from the health hazards posed by the practice of adulteration, it is necessary to know that the government has enacted the FSSAI, 2006 and Rules 2011. This act is amended from time to time. Under this Act stringent rules have been framed to punish a person found to adulterate foodstuff.

Basic Purposes of Food Laws

The basic purposes of food laws are:

1. To prevent the sale of adulterated, impure and low quality food.
2. To prevent the sale of food which is of inadequate weight, measure or number.
3. To prevent extravagant claims from being made on labels of food items in advertisements.
4. To ensure that reasonable standards of hygiene are maintained on the premise where food is being handled.

However, as newer products arrive in the market, the consumer is more confused as to what he should choose. Since, the advertisements are constantly competing to catch the consumers ear, one is misled as to which product is genuine and which will benefit one's family and suit one's budget the most. An advertisement by the soft drink's manufacturer may tempt the consumer to replace fresh fruit juice with the synthetic carbonated beverage. But once the statutory warning that the soft drink *contains no fruit juice or fruit pulp* is read, the advertisement may no longer be tempting. One must, therefore, not only be vigilant as it safeguards the family's health, but in cases of doubt one should be able to conduct a few qualitative tests to detect adulteration in household food items, e.g. if it is doubted that the *rava* or the sugar contains added iron filings, a sample test like stirring a magnet in the *rava* or the sugar will clarify the doubt, since the iron filings can be observed sticking to the magnet.

Table 21.4 will guide us to detect adulteration in some food items. The tests can easily be carried out at home.

21.8 EFFECTS OF FOOD ADULTERATION

Whether food is adulterated intentionally or inadvertently, the net result is the consumption of substances which may or may not adversely affect the consumer.

These effects may be classified into three types:

1. No Effect There are certain adulterants used which may be categorized as "harmless" adulterants. For example, water added to adulterate milk may not affect

Table 21.4 Some simple tests for detecting food adulteration

S.No.	Substance	Adulterant	Test
1.	Asafoetida (<i>Hing</i>)	Resin or gum scented and coloured	(a) Pure asafoetida dissolves in water to form a milk-white solution. (b) Pure asafoetida burns with a bright flame on being ignited (burning).
2.	Bura sugar	Washing soda	(a) Gives effervescence with hydrochloric acid if washing soda is present. (b) If dissolved in water the washing soda will turn red litmus blue.
3.	Cardamom	Oil is removed and pods are coated with talcum powder	On rubbing, talcum will stick to the fingers. On testing, if there is hardly any aromatic flavour, it indicates removal of essential oil.
4.	Turmeric (<i>haldi</i>)	Metanil yellow colouring	When concentrated hydrochloric acid is added to a solution of turmeric powder, it turns magenta, if metanil yellow is present.
5.	Chilli powder	Sawdust and colour	Sprinkle on the surface of water: sawdust floats. Added colour will make the water coloured.
6.	Coffee	<i>Chicory</i>	Shake a small portion in cold water: coffee will float while chicory will sink, staining the water brownish.
7.	Coriander powder	Horse dung powdered	Soak in water. Horse dung will also float which can be easily detected.
8.	Cloves (<i>Lavang</i>)	Oil may be removed	If so, cloves may be shrunken in appearance.
9.	Cumin seeds (<i>Jeera</i>)	May contain grass seeds coloured with charcoal dust	If rubbed in hand, fingers will turn black.
10.	Ghee	<i>Vanaspati</i>	Dissolve one teaspoon of sugar in 10 ccs of hydrochloric acid and 10 ccs of the melted ghee and shake thoroughly for one minute. Allow it to stand for 10 minutes. If vanaspati has been added, the aqueous layer will be red in colour.
11.	Jaggery	Metanil yellow	Hydrochloric acid added to <i>gur</i> solution will turn its colour to magenta.

(Contd.)

Table 21.4 (Contd.)

S.No.	Substance	Adulterant	Test
12.	<i>Rawa</i>	Iron filings to add weight	Pass magnet through the rawa. Iron filings will cling to it.
13.	Betelnut powder (<i>Supari</i>)	Sawdust and artificial colour	Sprinkle in water. Sawdust will float and the added colour will dissolve in water.
14.	Tea dust	Used tea leaves dried, powdered and artificially coloured	Sprinkle the dust on a wet white filter paper. Spots of yellow, pink and red appearing on the paper, indicating tea is artificially coloured.
15.	Edible oil	Argemone	A reddish-brown precipitate is formed when oil and hydrochloric acid are gently mixed with ferric chloride solution, if argemone is present.
16.	Saffron	Maize fibres dried, coloured and scented	(a) Genuine saffron is tough. Spurious saffron is brittle and breaks easily. (b) Dissolves easily in water, giving aroma of saffron.
17.	Sago	Sand and talcum	Gritty feel in mouth. Pure sago swells on burning and leaves hardly any ash.
18.	Coconut	Any other oil	Place a small bottle of oil in refrigerator. Coconut oil solidifies leaving the adulterant as separate layer.
19.	<i>Bajra</i>	Fungus (Ergot-infested)	Immerse in salt water. Fungi will float to the top.
20.	Cinnamon (<i>dalchini</i>)	Cassia bark	Added colour comes off in water
21.	Olive oil	Peanut oil	1 ml oil + 5 ml of 1.5 M alcoholic potash. Saponify for 10 minutes. Add 50 ml alcohol + 0.8 ml hydrochloric acid and warm to obtain clear liquid. Cool to let temperature fall by 1°C per minute. Observe temperature at which turbidity is obtained. (Peanut oil 39.4°C)
22.	Peanut oil	Cottonseed oil	Mix 2.5 ml of oil or fat + 2.5 ml Halphen's reagent. Lightly screw cap and heat in boiling water for 30 minutes. The test is positive if a rose colour is obtained.

the consumer unless the quality of water used is poor. Certain substances which find their way into cereals, like sago, may irritate the teeth while eating. However, consumption of food containing such adulterants over a period of time may affect the overall health.

2. Acute Toxicity Effect Certain adulterants containing microorganisms or their toxins affect the consumer within hours or a few days. Microbial poisoning due to consumption of the organisms itself may cause symptoms such as double vision, muscular paralysis and death due to respiratory failure which need immediate attention. For example, *Clostridium botulinus* toxin causes botulism. *Staphylococcus aureus* enterotoxin from dairy products, baked foods, meat and meat products may bring about increased salivation, vomiting, abdominal cramps and diarrhoea.

3. Chronic Toxicity Effects These are the effects of consumption of adulterants over a long period of time. These substances, which are consumed through food, cause damage that is due to accumulation of the toxicant in the body. Metal contaminants like lead, mercury, cadmium cause systemic damage that ultimately leads to failure of the Central Nervous System and death. The Minamata and Niigata Bay diseases, caused in Japan due to mercury poisoning, are classic examples of this toxicity.

Pest and pesticide contaminants are also one of the major causes of toxicity among humans. Organic pesticides are commonly used in fields on crops, fruits and vegetables and, also at home. Certain organic pesticides like malathion cause acute poisoning but other inorganic pesticides can cause acute and chronic toxicity.

Several toxicants are naturally present in foods, such as fluorine, which gives rise to fluorosis; selenium causes acute toxicity as well as chronic poisoning. Solanine in potatoes, gossypol in cottonseed oil, trypsin inhibitors in soybean, erucic acid in mustard oil, cyanogenetic compounds in bitter almonds and apple seeds, certain beans like lima beans, and roots like cassava (tapioca) are examples of foods that can cause chronic toxicity.

Nuclear fallouts such as the Chernobyl disaster have added a new dimension to chronic toxicity. The effects are far reaching in terms of their gravity as well as magnitude.

In addition to the above, various food additives are being used in a number of foods consumed by children and adults alike. Although, newer additives are allowed after stringent considerations, yet a few such as BHT, saccharin and BVO have been withdrawn after their chronic effects were found out to be disastrous. Packaging materials and adjuncts used in their manufacture are found to migrate into various foods they come in contact with. "Shock lung" was one such problem of blood transfusion from plastic transfusion equipment. Angiosarcoma was traced to vinyl chloride gas that is used to make PVC.

Table 21.5 gives some examples of adulterants and their health hazards.

21.9 NUTRITIONAL LABELLING

Nutritional labelling regulations have now become mandatory in our country. It is felt that consumers must know what the nutritional contents of foods are, so that they can purchase foods that are of better quality. With this in mind, in 1990, the US Congress passed the Nutrition Labelling and Education Act (NLEA). This law required the FDA to develop requirements for the nutritional labelling of nearly all foods sold in grocery stores in the United States. Food sold in restaurants, and fresh meats and poultry were excluded, but the US Department of Agriculture has since proposed regulations to cover meats. Most of the regulations came into effect in 1994.

Table 21.5 Adulterants and their toxic effects

<i>Adulterant</i>	<i>Foods Commonly Involved</i>	<i>Disease or Health Effects</i>
Argemone seeds	Mustard seeds	Epidemic dropsy, glaucoma
Argemone oil	Edible oils and fats	Cardiac arrest
Mineral oil	Edible oils and fats, black pepper	Cancer
Orthotrichesyl phosphate	Edible oils and fats	Flaccid paralysis
<i>Lathyrus sativus</i>	<i>Khesari dal</i> , or mixed with other pulses	Lathyrism
Lead chromate	Tumeric whole and powdered, mixed spices	Anaemia, abortion, paralysis, brain damage
Arsenic	Fruits such as apples sprayed over with lead arsenate (pesticide)	Dizziness, chills, cramps, paralysis, death
Copper	Acid foods in contact with tarnished copperware	Vomiting, diarrhoea, astringent taste in mouth, abdominal pain
Mercury	Mercury fungicide treated seed grains or mercury contaminated fish	Brain damage, paralysis, death
Aflatoxins	<i>Aspergillus flavus</i> —contaminated foods such as groundnuts, cottonseed, etc.	Liver damage and cancer
Machupo virus	Foods contaminated with rodent's urine, such as cereals	Bolivian haemorrhagic fever
Gossypol	Cottonseed flour and cake	Cancer
Polychlorinated Biphenyl's	Fatty foods contaminated with PCB's from packaging or processing	Severe ache, eye discharge, skin darkening, liver damage, reproduction abnormalities
Nitrates and nitrites	Drinking water, spinach and meat products	Methhaemoglobinæmia, cancer and tumours in the liver, kidney, trachea, oesophagus and lungs
Pesticide residues	All types of foods	Acute or chronic poisoning with damage to nerves and vital organs like liver, kidney, etc.
Antibiotics	Meats from antibiotic-fed animals	Multiple drug resistance, hardening of arteries, heart disease

□ Need for Nutritional Labelling

Consumers whose interest in nutrition has been awakened should assess the nutritional value of the foods they consume. While purchasing any food item they must focus attention on the packaging label as a means of supplying this information.

The success of any kind of dietary modification, whether for the individual or as a public health measure, depends on the consumer having a good understanding of nutrition and a knowledge of which foods are important sources of particular nutrients.

Thus, it is important that any nutrition or ingredient information on a label should be backed up with an educational effort to ensure that consumers can apply their nutrition knowledge to make informed choice.

□ Effective Labelling System

An effective labelling system should provide nutrition information to enable people to select balanced diets and allow individual consumers to follow recommended diets. It should:

1. Help the selection of the most nutritious foods at the point of purchase
2. Encourage the production of nutritious foods
3. Stimulate nutrition education
4. Promote confidence in the food industry
5. Satisfy the consumer's right to know
6. Present information in a uniform fashion
7. Be meaningful and useful and not increase the price
8. Be consumer oriented
9. Be quantifiable and, hence, enforceable
10. Be designed in such a manner that meeting the nutrition goals for listed nutrients with a variety of foods ensures that the individual meets all of his other nutritional needs.

Surveys show that consumers are interested in having more foods nutritionally labelled and more informative or less confusing information provided on the labels. In the United States, a product or food would require nutritional labelling, provided that the food is a meaningful source of calories of nutrients. These are defined as foods that provide:

1. two percent or more of the RDI per serving for protein, vitamin A,C, iron or calcium;
2. more than 40 calories per serving; or
3. more than 0.4 calories per gram; or
4. more than 35 mg sodium per serving.

Previously the label included the following information:

1. Calorie content
2. Serving size
3. Number of servings per container
4. Grams of Protein, carbohydrates and fat
5. Milligrams of sodium
6. Percent of the US RDA for protein, vitamin A, C, B₁, B₂, B₃, calcium and iron
7. Other information such as: other vitamins, minerals, cholesterol and fatty acid content.

After amendments were introduced, the proposed compulsory information to be included on the label was:

1. Calories from fat
2. Saturated fatty acids
3. Cholesterol
4. Dietary fibre, while: B₁, B₂, and B₃, were optional.

Sodium labelling would no longer be permitted without full nutrition labelling. Daily Reference Values (DRV) would be established for proteins and 26 vitamins and minerals for infants, children under four years of age, children four years or more of age, adults, pregnant women and lactating women. The DRVs would be used as references in a voluntary *NUTRITION PROFILE*, which would appear on the label to help consumers evaluate the contribution of the product to their daily nutrition requirements as well as to compare products.

The nutrients for which RDI's would be established include protein, vitamins A, C, D, E, K, calcium, iron, thiamin, riboflavin, niacin, pyridoxine, folate, vitamin 12, biotin, pantothenic acid, phosphorus, magnesium zinc, iodine, selenium, copper, manganese, fluoride, chromium, molybdenum and chloride.

DRVs would also be established for fat, saturated fatty acids (SFA), unsaturated fatty acids (UFA), cholesterol, carbohydrate, fibre, sodium and potassium.

The RDIs and DRVs would also figure in claims. For a claim of nutritional superiority to be made, a product would have to contain 10 percent or more of the RDI or DRV for carbohydrates, fibre, PUFA, or potassium; or 25 percent or less of the RDI or DRV for fat, SFA, cholesterol, or sodium.

The “serving size”, is generally used to express the nutrient content of the product. A serving size, as defined by the US FDA, is the amount commonly consumed per eating occasion, whereas a portion is the amount of food customarily used only as an ingredient in the preparation of other foods.

A “single serving” size would be defined as 150 percent less of the standard serving size. The serving size would be stated in both US and metric units, e.g. ounces and grams respectively. Additional household measures such as cups, teaspoons and slices would also be allowed.

□ Nutrition Facts

Figure 21.2 shows a typical label with all its nutritional declarations.

“Nutrition Facts”, “Health Claims”, and “Nutrient Content Claims” are now closely regulated on nearly all foods in the US. “Nutrition Facts” contains required and voluntary information on dietary components and nutrients, already mentioned above. If a nutrient content or other type of claim is made about any voluntary component, then nutrition information for that component becomes mandatory. Only those components which are shown in Fig. 21.2, are permitted in the “Nutrition Facts” section. Information on other nutrients can be added in other parts of the label.

All nutrient amounts, which are mentioned in “Nutrition Facts” are based on a standard serving size. Most nutrients are labelled based on “percent (%)” value. This refers to the percent of a recommended amount of the nutrient in a total daily food intake of 2,000 calories that the standard serving of the product contributes. For example, the total daily value for fat based on 30 per cent of calories coming from fat and a 2000 cal/day food intake is 600 calories ($0.30 \times 2000 \text{ cal} = 600 \text{ cal}$). One standard serving of a food containing 13 g of fat would thus, represent 117 cal from

Nutrition Facts				
Serving size: 1 piece (400 g)				
Serving per container: About 5.5				
Amount per serving				
Calories: 180; Calories from Fat: 80				
Percent Daily Value *				
Total Fat: 9 g				14%
Saturated Fat: 3 g				15%
Cholesterol: 5 mg				02%
Sodium: 65 mg				03%
Total Carbohydrates: 25 g				08%
Dietary Fibre: 1 g				04%
Sugar: 22 g				
Proteins: 1 g				
Vitamin A: 0% Vitamin C:				0%
Calcium: 0% Iron				4%
<ul style="list-style-type: none"> Percent (%) Daily Values are based on a 2000 calorie diet. Your Daily Diet Values may vary higher or lower, depending on your calorie needs. 				
Calories			2000	5000
Total Fat	Less than		65 g	80 g
Saturated fat	Less than		20 g	25 g
Cholesterol	Less than		300 mg	300 mg
Sodium	Less than		2400 mg	2400 mg
Total Carbohydrate			300 g	375 g
Dietary Fibre			25 g	30 g
Calories per gram				
Fat: 9 Carbohydrates: 4 Protein: 4				

Fig. 21.2 A nutritional label

fat or 20 percent of the daily value of fat $[(117 \text{ cal} / 600 \text{ cal}) \times 100 = 20\%]$. Similarly, a standard serving of a food containing 140 mg of sodium would be labelled as 6 percent of the daily value, which is 2,400 mg for sodium in a 2,000 cal/day diet.

Serving size now is no longer at the discretion of the product manufacturer. The FDA has set some 139 reference serving sizes bases on what is believed to be an amount commonly consumed at a single time. For products where a single unit is more than 50 percent but less than 200 percent of the reference, the serving size is one unit (e.g. one can of cola) of the product. Thus, 350 ml of soda is one serving because it is less than 200 percent of the 250 ml reference value of soda.

A daily value takes into consideration not only the minimum recommended amount of required minerals and vitamins but also the recommended amount of macronutrients such as fats, carbohydrates and proteins, as well as cholesterol, sodium and potassium. Daily values for components, which contain calories (e.g.. fat, carbohydrates) are based on the recommended amount that should be contained in a 2000 cal/day intake. As pointed out above, the recommendation for fat based on 30 percent of calories per day from fat and a 2,000 cal/day diet is 600 cal/day from fat. At 9 cal/g this equals to approximately 67 g of fat per day. Other calorie containing components are similarly calculated.

□ Health Claims

In addition to the “Nutrition Facts”, regulations now dictate what nutrition-related terms or nutrient content claims can be used on labels and what those terms mean. For example, terms such as “free”, “light”, “low” and “high” have specific meanings. Some examples are as follows:

1. “Sugar free” means less than 0.5 g per serving
2. “Cholesterol free” means less than two milligram of cholesterol and two gram or less of saturated fat per serving
3. “High fibre” means five grams more per serving
4. “Calorie free” means fewer than five calories per serving
5. “Fat free” means less than 0.5 g of fat per serving
6. “Sodium free” means less than five milligram per serving.

In order to be labelled “low fat”, a product must have less than three gram of fat per standard reference serving; “light” means that a product contains one-third fewer calories than the reference product. Also, terms such as “good source of”, “more”, “contains or provides” and “modified” are now defined. Implied claims, which suggest that a nutrient or an ingredient is important in maintaining a healthy diet and which are made with an explicit claim such as “healthy—contains 3 g of fat”, are not allowed unless specifically permitted. Additionally, the term “fresh” can only be used on products that have not been frozen, heat processed, or otherwise preserved. “Fresh frozen” is a fresh food that was frozen quickly.

The last area of regulation of nutrition labelling relates to direct and implied health claims for foods. Traditionally, health benefit claims such as “reduces the risk of cancer or heart disease” have not been allowed for foods. Such claims are commonly made for drugs but not for foods. However, based on recent scientific findings, USFDA is now allowing six health-related claims for certain foods and has indicated that additional health claims may be allowed in the future. The major criterion for making such a claim is that it should be based on sound scientific evidence, which proves that it is true.

The six currently allowed claims all relate to the benefits of diet in preventing the major risk diseases such as cancer, coronary heart disease, osteoporosis or hypertension. When viewed together, these health claims suggest that one should eat diet high in fibre, fruits and vegetables and low in sodium and fat. The USFDA has suggested the type of wording that is acceptable for each claim. For example, while many factors affect heart disease, diets low in saturated fat and cholesterol may reduce the risk of this disease.

Mandatory Labelling Requirements Implemented From 19th March 2009 are given below: (Published in *Gazette of India No. 509, 2008*)

Ministry of Health and Family Welfare has introduced mandatory labelling for prepackaged food products vide Notification number 664 (E) effective 19th March 2009. According to this notification all prepackaged food products will have to carry the following additional information:

1. A list of ingredients with following features
2. An appropriate title like “INGREDIENTS”
3. Name of the ingredient and their weight or volume in descending order
4. If an ingredient is a combination of two or more ingredients (for example in a namkeen mixture) the compound ingredient has to be declared in the list accompanied by a list of its ingredients. This is not required if the compound ingredient is not a food additive and is less than 5% of the food.
5. Added water
6. Flavouring agents don't have to be disclosed
7. Nutritional information per 100 g or per 100 ml or per serving containing the following:
 - (a) Energy value in kcal
 - (b) Protein in grams
 - (c) Carbohydrate in grams
 - (d) Quantity of sugar in grams
 - (e) Fat in grams
8. If claim is made about the amount or type of fat or amount of cholesterol then the amount of following will have to be provided
 - (a) Saturated fatty acids in grams
 - (b) Monounsaturated fatty acids in grams
 - (c) Polyunsaturated fatty acids in grams
 - (d) Trans-fatty acid in grams
 - (e) Cholesterol in milligrams
 - (f) Any nutrient for which a nutrition or health claim is made
9. Foods prepared with hydrogenated vegetable fats or bakery shortening have to declare—“Hydrogenated vegetable fats or bakery shortening used—contains trans-fats”
10. Irradiated foods or foods with ingredients treated with radiation have to carry a statement indicating the treatment

For more detailed understanding of Food Labelling regulations, refer the Food Safety and Standards Act of India, 2006 and Regulations, 2011 which have now come into force.



SUMMARY

Safe food preparation practices help ensure that the food served is safe to eat. Because of the various processes it undergoes at different stages, food is liable to contamination and spoilage, and this can lead to food poisoning. Other man-made contaminants such as nuclear fall-out, can be minimized if each of us becomes aware of the disasters such contaminants can cause even to succeeding generations.



REVIEW QUESTIONS

1. What are intentional additives? Give examples.
2. What are contaminants? Give examples.
3. Write a short note on food poisoning. How is it different from food infection?
4. What are the causes and symptoms of botulism?
5. What are the causes and symptoms of lathyrism?
6. Which are the principal food laws in India, which protect the consumer from deleterious foods?
7. What is a nutritional label? Which nutrients are mandatory for the manufacturer to display on the label?
8. Collect a few labels displaying the nutrient content of the food and record your observations.

Section 5 APPENDICES

- **Appendix I** Registered Dietitian Examination Paper I—Sample Questions
- **Appendix II** Registered Dietitian Examination Paper II—Sample Questions
- **Appendix III** Recommended Dietary Allowances for Indians (1988)
- **Appendix IV** Normal Height, Weight and Overweight Underweight Limits for Indian (Males + Females)
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- **Appendix VII** Standard Weights and Measures
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- **Appendix XI** Statistical Data on Malnutrition
- **Appendix XII** Normal Values for Blood and Urine

Appendix I

Registered Dietitian Examination Paper I—Sample Questions (Physiology, Microbiology, and Biochemistry)

1. Calcium homeostasis is regulated by
 - (a) ACTH and TRH
 - (b) TRH and PTH
 - (c) PTH and calcitonin
 - (d) calcitonin and ACTH
2. Which of the following is an essential component of a balanced diet?
 - (a) Oleic acid
 - (b) Myristic acid
 - (c) Trans-linoleic acid
 - (d) Cis-linoleic acid
3. Water activity required for microbial growth decreases in foods by
 - (a) adding sugar
 - (b) adding salt
 - (c) both (a) and (b)
 - (d) neither (a) nor (b)
4. Aflatoxin resulting from spoilage of groundnuts is an
 - (a) neurotoxin
 - (b) enterotoxin
 - (c) hepatotoxin
 - (d) endotoxin
5. The holding temperature for frozen ice-cream is
 - (a) -13°C to -9°C
 - (b) -8°C to $+8^{\circ}\text{C}$
 - (c) -4°C to 0°C
 - (d) 0°C to 4°C
6. Water is considered potable if it contains
 - (a) zero *E.coli*
 - (b) less than 1000 *E.coli*
 - (c) less than 10,000 *E.coli*
 - (d) less than 15,000 *E.coli*
7. The function of Vitamin E in humans includes
 - (a) the synthesis of rhodopsin
 - (b) prevention of oxidation in cell membranes
 - (c) maintenance of calcium phosphate balance
 - (d) aiding reproduction
8. The regulatory proteins of muscle contraction are
 - (a) actin and myosin
 - (b) collagen and elastin
 - (c) troponin and tropomyosin
 - (d) actin and collagen
9. The BMR of an underweight girl compared with a normal weight girl will be
 - (a) less than the normal weight girl
 - (b) the same as the normal weight girl
 - (c) more than the normal weight girl
10. State whether the following statements are TRUE or FALSE.
 - (a) Heparin inhibits conversion of prothrombin.
 - (b) Insulin functions by promoting cellular oxidation of glucose.
 - (c) Aldosterone regulates calcium balance.
 - (d) One of the earliest indicators of iron deficiency anaemia is low levels of serum ferritin.
 - (e) The optimum pH for growth of bacteria is 2.0–3.5.
12. Fill in the blanks.
 - (a) The major amount of glycogen is found in _____.
 - (b) Multiple forms of an enzyme within a cell are called _____.

22. What are lipoproteins? Discuss the role of LDL and HDL in cholesterol metabolism.
23. (a) Which hormones are related to stress? Describe the effects of these hormones on the human body.
(b) Why is diabetes mellitus said to be precipitated by stress?
24. “Life of a person depends upon the liver”. Explain the key metabolic role played by this organ in the body.

Appendix II

Registered Dietitian Examination Paper II—Sample Questions (Nutrition, Dietetics, and Food Service Management)

Tick the correct answer

1. Sepsis, fever, infection and trauma accelerate the loss of
 - (a) nitrogen
 - (b) zinc
 - (c) calcium
 - (d) iron
2. The nutrient which needs to be carefully monitored for a patient having hepatic coma is
 - (a) carbohydrate
 - (b) fats
 - (c) protein
 - (d) branched-chain amino acids
3. Turmeric powder is commonly adulterated with
 - (a) chromium powder
 - (b) lead chromate
 - (c) chalk powder
 - (d) papaya seeds
4. The two advantages of line organisation in institutions are
 - (a) slow but steady decisions
 - (b) quick decisions and direct responsibility
 - (c) indirect response and hazy understanding
 - (d) unclear understanding and direct responsibility
5. The protein content of human milk per 100 ml is
 - (a) 3.2 g
 - (b) 1.8 g
 - (c) 2.3 g
 - (d) 4.3 g
6. The IDA was affiliated to the International Congress of Dietetics in
 - (a) 1963
 - (b) 1975
 - (c) 1971
 - (d) 1974
7. The average recommended height for a sink top is
 - (a) 70–80 cm
 - (b) 85–90 cm
 - (c) 90–100 cm
 - (d) 100–110 cm
8. Diabetes insipidus is due to the insufficiency of
 - (a) thyroxine
 - (b) insulin
 - (c) vasopressin
 - (d) ACTH

Answer the following questions

1. Define the physiological calorie and Joule.
2. Differentiate between hyperplastic and hypertrophic obesity.
3. Convert 3000 mg sodium to its mEq.
4. An infant's height is measured by measuring his _____.
5. Outline the major objectives of CARE.
6. Give one example of a sensitive test used in bio-chemical measurements to assess the nutritional status for the following:
 - (a) Protein
 - (b) Vitamin A
7. What is erythropoietin? What are its functions?
8. What is meant by oncotic pressure?
9. List four reasons for ensuring a proper intake of omega fatty acids.
10. Explain bulimia. Which is the age group it affects and why?
11. Mention 4 main steps involved in a work improvement programme.
12. Outline the steps in decision making for a supervisor.
13. Explain two measures for reducing noise in a dining room.
14. Give four reasons why a chronic alcoholic is also malnourished.
15. Name the first president and secretary of the IDA.
16. Which year did the RD Board start functioning?
17. There is no reason to restrict protein or potassium intake in acute glomerulo nephritis. Why?
18. Calculate the energy needs of a child admitted with burns.
19. Give the calcium content per 100 g of
 - (a) Curd made from cow's milk
 - (b) Tur dal.
20. Name the sulphur-containing amino acids.
21. Name 2 foods which should be avoided by a patient with dumping syndrome.
22. Give the BMI for an underweight individual.
23. Give the calorie and protein content of 50 g of Recupex.
24. What is spirulina ? What is its nutritional importance?
25. What is the requirement of saturated fats, PUFA and MUFA in the daily diet?

Problem Solving

1. Plan a vegetarian diet (ovo and lacto vegetarian) for a 68-year-old man suffering from CRF who is undergoing CAPD for the past 6 months. He weighs 65 kg and is 160 cm tall. His biochemical parameters are—Creatinine 3.2 mg/dl, urea 50 mg/dl, Blood Urea Nitrogen 30 mg/dl.
2. Plan and calculate a non-vegetarian diet for a woman who is 35 years old, weighs 85 kg, and is 160 cm tall. She is allergic to buttermilk and curds. She was admitted with symptoms of breathlessness, chest pain and tachycardia. She works as an information technology executive. Her biochemical parameters—LDL 210 mg/dl, Triglycerides 200 mg/dl, Total chol. 300 mg/dl, HDL 20 mg/dl.
3. A 46-yr-old male (height 5'5", weight. 64 kg), who is a chronic alcoholic is admitted with abdominal distension, blurred speech, ascites and dementia. His blood picture is—Glucose fasting 110 mg%, SGOT 88 IU/L, SGPT 38 IU /L, Bilirubin total 3.7 mg%, Albumin 2.2 g%, Total protein 6.8 g% Plan and Calculate the diet. Outline the basic principles.

For more information refer: http://www.idaindia.com/modelpaper_v1.jsp

Appendix III

Recommended Dietary Allowances for Indians (Macronutrients & Minerals) —2010

<i>Group</i>	<i>Particulars</i>	<i>Body wt. (kg)</i>	<i>Net energy (kcal/d)</i>	<i>Protein (g/d)</i>	<i>Visible fat (g/day)</i>	<i>Calcium (mg/d)</i>	<i>Iron (mg/d)</i>
Man	Sedentary work		2320		25		
	Moderate work	60	2730	60	30	600	17
	Heavy work		3490		40		
Woman	Sedentary work		1900		20		
	Moderate work		2230	55	25	600	21
	Heavy work		2850		30		
Infants	Pregnant woman	55	+350	82.2	30	1200	35
	Lactation		+600	77.9	30		
	0-6 months		+520	70.2	30	1200	25
Children	6-12 months	5.4	92 kcal/kg/day	1.16 kcal/kg/day	--	500	--
	1-3 years	8.4	80 kcal/kg/day	1.69 kcal/kg/day	19		
	4-6 years	12.9	1060	16.7	27		46 µg/kg/day
Boys	7-9 years	18.0	1350	20.1	25	600	09
	10-12 years	25.1	1690	29.5	30		13
	13-15 years	34.3	2190	39.9	35	800	16
Girls	10-12 years	35.0	2010	40.4	35	800	21
	13-15 years	47.6	2750	54.3	45	800	27
	16-17 years	46.6	2330	51.9	40	800	28
Boys	16-17 years	55.4	3020	61.5	50	800	26
	16-17 years	52.1	2440	55.5	35	800	

Recommended Dietary Allowances for Indians (Vitamins) —2010

Group	Particulars	Vit A ($\mu\text{g}/\text{d}$)	Thiamin (mg/d)	Riboflavin (mg/d)	Niacin-equivalent (mg/d)	Pyridoxin (mg/d)	Ascorbic acid (mg/d)	Dietary folate ($\mu\text{g}/\text{d}$)	Vit B ₁₂ ($\mu\text{g}/\text{d}$)	Magnesium (mg/d)	Zinc (mg/day)
Man	Sedentary work		1.2	1.4	16						
	Moderate work	600	4800	1.4	1.6	18	2.0	40	200	1	340
	Heavy work		1.7	2.1	21						
	Sedentary work		1.0	1.1	12						
	Moderate work	600	4800	1.1	1.3	14	2.0	40	200	1.0	10
	Heavy work		1.4	1.7	16						
Woman	Pregnant woman	800	6400	+0.2	+0.3	+2	2.5	60	500	1.2	310
	Lactation		+0.3	+0.4	+4						
	0-6 months	950	7600	+0.2	+0.3	+3	2.5	80	300	1.5	12
	6-12 months		+0.2	+0.3	+3						
Infants	0-6 months	--	--	0.2	0.3	710 $\mu\text{g}/\text{kg}$	0.1	25	25	0.2	30
	6-12 months	350	2800	0.3	0.4	650 $\mu\text{g}/\text{kg}$	0.4				--
Children	1-3 years	400	3200	0.5	0.6	8	0.9		80		50
	4-6 years		0.7	0.8	11	0.9		40	100		5
	7-9 years	600	4800	0.8	1.0	13	1.6		120		70
Boys	10-12 years		1.1	1.3	15	1.6		40	140	0.2-1.0	120
Girls	10-12 years		1.0	1.2	13	1.6				160	9
Boys	13-15 years		1.4	1.6	16	2.0		40	150	0.2-1.0	165
Girls	13-15 years	600	4800	1.2	1.4	14	2.0			210	11
Boys	16-17 years		1.5	1.8	17	2.0		40	200	0.2-1.0	195
Girls	16-17 years		1.0	1.2	14	2.0				235	12

Appendix IV

Normal Height, Weight and Overweight-Underweight Limits for Indian Males

<i>Height (cm)</i>	<i>Weight^{1,2} (kg)</i>	<i>Overweight³ limit (+20%) (kg)</i>	<i>Underweight³ limit (-20%) (kg)</i>
148	47.5	57.0	38.0
152	49.0	59.0	39.0
156	51.5	62.0	41.0
160	53.5	64.0	43.0
164	56.0	67.0	45.0
168	59.0	71.0	47.0
172	62.0	74.5	49.5
176	65.5	78.5	52.4
180	68.5	82.0	55.0
184	72.0	86.5	57.5
188	75.5	90.5	60.5
190	77.5	93.0	62.0

Normal Height, Weight and Overweight-Underweight Limits for Indian Females

<i>Height (cm)</i>	<i>Weight^{1,2} (kg)</i>	<i>Overweight³ limit (+20%) (kg)</i>	<i>Underweight³ limit (-20%) (kg)</i>
148	46.5	56.0	37.0
152	48.5	58.0	39.0
156	50.5	60.5	40.5
160	52.5	63.0	42.0
164	55.0	66.0	44.0
168	58.0	69.5	46.5
172	60.5	72.5	48.5
176	64.0	77.0	51.0
180	67.0	80.5	53.5
184	70.5	84.5	56.5
188	74.0	89.0	59.0

¹ From Life Insurance Corporation of India Agent's Manual.

² Weights have been rounded off to the nearest half kilogram.

³ Overweight and underweight limits have been calculated from weight in column 2, by adding or subtracting 20%.

Appendix V

There are various types of exchange lists followed in our country. As yet there are no standard exchange lists available as in other countries. However, the exchange list published by NIN, ICMR is best suited for planning a diet and hence, followed here. In the milk and fleshfood exchange lists we have computed the values of fat since it is necessary in planning of diets restricting fats.

□ I Milk Exchange

Calories—100; Protein—5 g; CHO—negligible.

<i>Food</i>	<i>Quantity</i>	<i>Fat (g)</i>
Buttermilk	650 ml	5.0
Cheese	30 g	7.5
Curd	210 g	10.0
<i>Khoa</i> (whole buffalo milk)	30 g	9.0
Milk (Buffalo)	90 ml	5.0
Milk (Cow)	180 ml	7.0
Milk (Skimmed)	260 ml	negligible
Milk (Skimmed Powder)*	30 g	negligible

□ II LEGUME AND PULSE EXCHANGE

30 g provide calories—100; Carbohydrates—15 g; Protein—6 g

Bengal gram	<i>Kabuli chana</i> (White gram)
Bengal gram (roasted)	Lentils
<i>Besan</i> (Bengal gram flour)	Moth beans
Black gram	Peas (dried)
Cow gram	<i>Rajma</i>
Green gram	
Horse gram	Red gram

* Adapted from *Some Therapeutic Diets* by Swaran Pasricha, NIN, ICMR, Hyderabad—500 007, 1985.

□ III Flesh Food Exchange

Calories—70; Protein—10 g

Food	Quantity	Fat (g)	Food	Quantity (g)	Fat (g)
Beef	60 g	1.5	Fowl	60 g	negligible
Crab	12 Nos	10.0	Liver, Sheep	60 g	5.0
Egg (duck)*	2 Nos	13.0	Mutton muscle*	60 g	10.0
Egg (hen)*	2 Nos	13.0	Pigeon	50 g	2.5
Fish (big)	60 g	negligible	Pork	60 g	3.0
Fish (small)	60 g	negligible	Prawn	60 g	negligible
Fish (<i>vajra</i>)	60 g	negligible			

* Provides 100 calories.

□ IV Vegetable Exchange A

These vegetables may be used as desired. Carbohydrates and calories are negligible.

<i>Leafy vegetables</i>	<i>Other vegetables</i>	<i>Leafy vegetables</i>	<i>Other vegetables</i>
Amaranth	Ash gourd	Lettuce	Knol-khol
<i>Bathu</i>	Bitter gourd	Mint	Ladies' fingers
Brussels sprouts	Brinjal	Rape leaves	Mango (green)
Cabbage	Calabash cucumber	Spinach	Onion stalks
		Soya leaves	<i>Parwar</i>
Celery	Cho-cho (marrow)		Plantain flower
Coriander leaves	Cauliflower Cucumber		Pumpkin
Curry leaves	Drumstick		Radish
Fenugreek leaves	French beans		Rhubarb stalks Ridge gourd Snake gourd <i>Tinda</i>
			Tomato (green) Turnip

□ V Vegetable Exchange B

Carbohydrates—10 g; Calories—50

<i>Root vegetables</i>	<i>Quantity (g)</i>	<i>Other vegetables</i>	<i>Quantity (g)</i>
Beetroot	75	Artichoke	60
Carrot	105	Broad-beans	90
Colocasia root (<i>arvi</i>)	45	Cluster-beans	90
Onion (big)	90	Double-beans	50
Onion (small)	75	Jackfruit (tender)	105
Potato	45	Jackfruit seeds	30
Sweet-potato	30	Leeks	60
Tapioca	30	Peas	45
Yam (elephant)	60	Plantain (green)	75
Yam	45	<i>Singhara</i>	45

□ VI Fruit Exchange

Carbohydrates—10 g; Calories—50

<i>Fruit</i>	<i>Quantity (g)</i>	<i>Approximate No. (Size)</i>
<i>Amla</i>	90	20 medium
Apple	75	1 small
Banana	30	1/4 medium
Cape gooseberry	150	40 small
Cashew fruit	90	6 medium
Custard-apple	15	2 nos
Dates	45	1 small
Figs	60	1/4 small
Grapes	105	20 nos
Grape fruit	150	1/2 big
Jackfruit	60	3 medium pieces
Jambu fruit	50	10 big
Lemon	90	1 medium
<i>Loquat</i>	105	6 big
Mango	90	1 small
Mangosteen	75	2 medium
Melon	270	1/4 medium
Orange	90	1 small
Papaya	120	1/4 medium
Peach	135	2 small
Pear	90	1 small
Pineapple	90	1 1/2 slices (round)
Plum	120	4 medium
Pomegranate	75	1 small
Strawberry	105	40
Sweetlime	150	1 medium
Tomato	240	4 small
Watermelon	175	1/4 small

□ VII Cereal Exchange

30 g provide calories—100; Carbohydrates—20 g; Protein—2 g

<i>Bajra</i>	Oatmeal	<i>Samai</i>
Barley	<i>Ragi</i>	Semolina (<i>Stiji</i>)
Bread*	Rice	Vermicelli (<i>Savian</i>)
<i>Cholam (Jowar)</i>	Rice flakes	Wheat flour
Cornflakes	Rice puffed	Wheat, broken (<i>dalia</i>)
Maize (dry)	Sago**	White flour (<i>maida</i>)

* To meet carbohydrates and calories, add 5 g sugar.

** Requires supplementation with other high-protein foods when used.

□ VIII Fat Exchange

Calories—100; Fat—11 g

Food	Quantity (g)
Almonds	15
Butter	15
Cashewnuts	20
Coconut	30
<i>Ghee</i>	11
Groundnuts (roasted)	20
Hydrogenated fat (vanaspati)	11
Oil .(Coconut, mustard)	11
Pistachio nut	15
Walnut	15

Appendix VI

Fibre Content of Foods (% Fibre/100 g of edible portion)

Cereals and Pulses			
<i>Bajra</i>	1.2	Green gram dal	0.8
<i>Jowar</i>	1.6	Lentil	0.7
Tender maize	1.9	Barley	3.9
Rice (Parboiled, milled)	0.2	Maize	2.7
Rice (raw, handpounded)	0.6	<i>Ragi</i>	3.6
Rice (raw, milled)	0.2	<i>Samai</i>	7.6
Rice flakes	0.7	Bengal gram (whole)	3.9
Rice puffed	0.3	Cow pea	3.8
Semolina	0.2	Green gram (whole)	4.1
Wheat flour (whole)	1.9	Horse gram	5.3
<i>Maida</i> or refined wheat flour	0.3	Moth beans	4.5
Bengal gram dal	1.2	Dry peas	4.5
Black gram dal	0.9	Soya bean	3.7
Leafy Vegetables			
Tender amaranth	1.0	Lettuce	0.5
<i>Ambat Chuka</i>	0.6	Mustard leaves	0.8
Beet leaves	0.7	<i>Shepu</i>	1.1
Cabbage	1.0	Spinach	0.6
Colocasia leaves (black variety)	1.8	Radish leaves	0.6
Coriander leaves	1.2	Cauliflower greens	2.0
Fenugreek leaves	1.1	Colocasia leaves (green variety)	2.9
Knol-khol greens	1.8		
Roots and Tubers			
Banana rhizome	1.1	White radish	0.8
Beetroot	0.9	Sweet potato	0.8
Carrot	1.2	Tapioca	0.6
Onion (big)	0.6	Yam	1.0
Potato	0.4		
Other Vegetables			
Ash gourd	0.8	Field beans	1.8
Bitter gourd	0.8	French beans	1.8
Bottle gourd	0.6	Capsicum	1.0
Brinjal	1.3	<i>Kankoda</i>	3.0
Broad beans	2.0	Knol-khol	1.5
Cauliflower	1.2	Ladies' fingers	1.2

(Contd)

Cluster beans	3.2	Parwar	3.0
Cucumber	0.4	Peas	4.0
Double beans	4.3	Pumpkin	0.7
Drumsticks	4.8	Green tomato	0.7
Nuts and Oilseeds			
Almond	1.7	Gingelly-seeds	2.9
Cashewnut	1.3	Groundnut	3.1
Coconut (dry)	6.6	Mustard seeds	1.8
Coconut (fresh)	3.6	Sunflower seeds	1.0
Gardener's seeds	7.6	Walnut	2.6
Fruits			
Amla	3.4	Musk melon	3.3
Apple	1.0	Water melon	3.5
Apricots (dried)	2.1	Papaya	0.8
Banana (ripe)	0.4	Peaches	1.2
Dates (dried)	3.9	Plum	0.4
Figs	2.2	Pears	1.0
Grapes (pale green variety)	2.9	Pomegranate	5.1
Guava	5.2	Sapota	2.6
Jackfruit	1.1	Custard-apple	3.1
Mango (ripe)	0.7	Tomato (ripe)	0.8
Miscellaneous			
Brown bread	1.2		
White bread	0.2		
Poppy seeds	8.0		

Appendix VI A

Fibre Content of Foods (% Fibre/100 g of edible portion)

Sr. No.	Name of the food stuff	TDF (g)	IDF (g)	SDF (g)
Cereals, Grains and Products				
1	Bajra	11.3	9.1	2.2
4	Jowar	9.7	8.0	1.7
5	Maize, dry	11.9	11.0	0.9
8	Ragi	11.5	9.9	1.6
12	Rice	4.1	3.2	0.9
20	Wheat	12.5	9.6	2.9
Pulses And Legumes				
28	Bengal gram, whole	28.3	25.2	3.1
29	Bengal gram, <i>dhal</i>	15.3	12.7	2.6
31	Black gram, <i>dhal</i>	11.7	7.6	4.1
	Black gram, whole	20.3	15.4	4.9
34	Green gram, whole	166.7	14.7	2.0
35	Green gram, <i>dhal</i>	8.2	6.5	1.7
38	Lentil, whole	15.8	13.5	2.3
	Lentil, <i>dhal</i>	10.3	8.3	2.0
44	Red gram, <i>dhal</i>	9.1	6.8	2.3
45	Red gram, whole	22.6	19.8	2.8
Leafy Vegetables				
49	Amaranth	4.0	3.1	0.9
66	Cabbage	2.8	2.0	0.8
73	Colocasia, green	6.6	5.1	1.5
75	Coriander	4.3	3.0	1.3
77	Curry leaves	16.3	13.4	2.9
78	Drumstick	9.0	6.8	2.2
79	Fenugreek	4.7	3.2	1.5
94	Mint	6.3	5.0	1.3
110	Spinach	2.5	1.8	0.7
Roots and Tubers				
117	Beetroot	3.5	2.6	0.9
118	Carrot	4.4	3.0	1.4
125	Potato	1.7	1.1	0.6

(Contd)

128	Radish	2.3	1.8	0.5
130	Sweet potato	3.9	2.6	1.3
135	Yam	4.2	3.2	1.0
147	Colocasia	3.0	2.3	0.7
Other Vegetables				
139	Bitter gourd	4.3	3.2	1.1
141	Bottle gourd	2.0	1.7	0.3
142	Brinjal	6.3	4.6	1.7
144	Cauliflower	3.7	2.6	1.1
146	Cluster bean	5.7	4.2	1.5
149	Cucumber	2.6	2.0	0.6
151	Drumstick	5.8	4.8	1.0
157	Giant chillies	2.2	2.0	0.2
166	Ladies fingers	3.6	2.6	1.0
170	Mango, raw	3.0	1.4	1.6
40	Peas, green	8.6	7.2	1.4
176	Plantain, green	3.5	2.6	0.9
180	Ridge gourd	1.9	1.4	0.5
181	Snake gourd	2.1	1.6	0.5
306	Tomato	1.7	1.2	0.5
Nuts And Oilseeds				
46	Soyabean	23.0	17.9	5.1
195	Coconut, fresh	13.6	12.7	0.9
201	Gingelly seeds	16.8	13.6	3.2
202	Groundnut	11.0	8.5	2.5
206	Mustard	13.6	10.2	3.4
Condiments And Spices				
214	Aniseed	43.4	34.3	9.1
223	Fenugreek	48.6	28.6	20.0
235	Poppy seeds	33.6	22.4	11.2
Fruits				
207	Papaya	2.6	1.3	1.3
213	Zizyphus	3.8	2.8	1.0
239	<i>Amla</i>	7.3	5.8	1.5
240	Apple	3.2	2.3	0.9

(Contd)

245	Banana	1.8	1.1	0.7
252	Cherry	1.5	0.9	0.6
254	Dates, dry	8.3	6.9	1.5
255	Dates, fresh	7.7	6.9	0.8
256	Fig	5.0	2.6	2.4
258	Grapes, green	1.2	0.8	0.4
261	Guava	8.5	7.1	1.
264	Jackfruit	3.5	2.1	1.4
266	<i>Jambu</i>	3.5	2.6	0.9
274	Sweet lime	2.7	1.3	1.4
278	Mango	2.0	1.0	1.0
280	Muskmelon	0.8	0.5	0.3
251	Watermelon	0.6	0.3	0.3
283	Orange	1.1	0.6	0.5
290	Peach	1.6	1.1	0.5
291	Pear	4.3	4.0	0.3
294	Pineapple	2.8	2.3	0.5
295	Plum	2.8	1.7	1.1
296	Pomegranate	2.8	2.3	0.5
303	Sapota	10.9	9.1	1.8
304	Custard apple	5.5	4.0	1.5
305	Strawberry	2.3	1.6	0.7

TDF: Total Dietary Fibre; IDF: Insoluble Dietary Fibre; SDF: Soluble Dietary Fibre

FOODS RICH IN POTASSIUM

(mg per 100 g Edible Portion)

CEREAL GRAINS AND PRODUCTS		ROOTS AND TUBERS		FRUITS	
Bajra	307	Carrot	108	Amla	225
Barley	253	Colocasia	550	Apricots, fresh	430
Jowar	131	Onion	127	Bael fruit	600
Maize, dry	286	Radish, white	138	Cherries, red	320
Maize, fresh	151	Sweet potato	393	Jackfruit	191
Ragi	408	Tapioca chips, dried	764	Lemon	270
Rice, parboiled, milled	117	Yam	237	Lemon, sweet	210
Riceflakes	154			Lichies	159
Samai	129	OTHER VEGETABLES		Lime, sweet	490
Vermicelli	138		Mango, ripe	205	
Wheat, whole	284	Bitter gourd	152	Melon, musk	341
Wheat flour	315	Brinjal	200	Melon, water	160
Wheat flour (refined)	130	Cauliflower	138	Peaches	453
		Drumstick	259	Plums	247
PULSES AND LEGUMES		French beans	120	Pomegranate	133
		Jackfruit, tender	328	Sapota (Chikoo)	269
Bengalgram (whole)	808	Ladies finger	103	Sitaphal	340
Bengalgram dal	720	Onion stalks	109	Tomato, ripe	146
Blackgram dal	800	Papaya, green	216	MILK AND ITS PRODUCTS	
Cowpea	1131	Plantain flower	185		
Green gram (whole)	843	Plantain, green	193		
Green gram dal	1150	Pumpkin	139		
Lentil	629	Red gram, tender	463		
Mothbeans	1096	Tomato, green	114	Milk, cow's	140
Peas, dry	725			Milk, goat's	110
Peas, roasted	750	CONDIMENT AND SPICES		Curds	130
Red gram dal	1104		MISCELLANEOUS FOODS		
LEAFY VEGETABLES		Chillies, dry	530	Coconut meal (deoiled)	2003
Amaranth (Tender)	341	Chillies, green	217	Jackfruit seeds	246
Cabbage	114	Coriander	990		
Celery leaves	210	Cumin seeds	980		
Coriander leaves	256	Fenugreek seeds	530		
Drumstick leaves	259	Omum	1390		
Spinach	206	Turmeric	3300		

Appendix VII

Standard Weights and Measures

Liquids

(Tbsp.—Tablespoon)

1 Tbsp. oil = 10 g

1 Tbsp. butter = 10 g

1 Tbsp. cream = 15 g

1 cup milk = 160 g

1 cup curds = 185 g

Solids

1 cup wheat flour = 70 g

1 cup uncooked (raw) rice = 135 g

1 cup puffed rice = 15 g

1 cup rice flakes = 75 g

1 cup sugar = 150 g

1 Tbsp. sugar = 10 g

Fruits

1 medium-sized banana = 70 g

1 medium-sized peeled orange = 110 g

1 medium-sized sapota (without skin and seeds) = 80

1 medium-sized apple = 70 g

1 medium-sized papaya (without skin and seeds) = 80 g

1 whole mango (with skin and seed) = 180 g

1 whole sweet lime = 140 g

Appendix VIII

(I) Weight for Height for Age, 6-18 Years, Girls

Translated and extended from the Baldwin-Wood tables in the English system of measurement by B. T. Baldwin. Issued by the Iowa Child Welfare Research Station, State University of Iowa, September 1924
 (Baldwin, 1925; Baldwin & Wood, 1923)

<i>Height (cm)</i>	<i>6 years</i>	<i>7 years</i>	<i>8 years</i>	<i>9 years</i>	<i>10 years</i>	<i>11 years</i>	<i>12 years</i>	<i>13 years</i>	<i>14 years</i>	<i>15 years</i>	<i>16 years</i>	<i>17 years</i>	<i>18 years</i>	<i>Height (cm)</i>
100	15.3													100
101	15.7													101
102	16.0	*16.0												102
103	16.1	*16.1												103
104	16.3	*16.3												104
105	16.6	*16.6												105
106	16.8	*16.8												106
107	17.1	17.1												107
108	17.6	17.5												108
109	18.0	17.8												109
110	18.2	18.1	*18.2											110
111	18.4	18.5	*18.4											111
112	18.6	18.8	*18.6											112
113	19.2	19.3	*19.1											113
114	19.7	19.8	*19.7											114
115	20.2	20.1	20.2											115
116	20.6	20.3	20.8											116

(Contd.)

Height (cm)	Weight (kg)										Height (cm)			
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	17 years	18 years	Height (cm)
117	21.0	20.5	21.3	*21.2	*21.2									117
118	21.4	21.1	21.5	*21.5	*21.5									118
119	21.8	21.8	21.8	*21.9	*21.9									119
120	22.3	22.3	22.2	*22.3	*22.3									120
121	22.7	22.7	22.7	*22.7	*22.9									121
122	23.1	23.1	23.1		23.2	23.4	*23.4							122
123	23.3	23.4	23.5		23.6	23.8	*23.7							123
124	23.4	23.7	23.8		24.2	24.1	*24.0							124
125	23.7	24.1	24.3		24.7	24.6	*24.7							125
126	*24.2	24.4	24.8		25.2	25.3	*25.8							126
127	*24.7	24.8	25.4		25.8	26.0	26.9	26.9						127
128		25.2	25.8		26.2	26.4		27.2	*27.1					128
129		25.7	26.2		26.6	26.7		27.5	*27.3					129
130	*26.3	26.7	27.0		27.1	27.9		27.3						130
131		*27.1	27.4		27.5	27.7		28.2	28.4					131
132		*27.8	28.1		28.0	28.2		28.6	29.5					132
133		*28.4	28.6		28.6	28.8		29.1	29.9					133
134		*28.9	29.1		29.2	29.5		29.6	30.3					134
135			29.6		29.8	30.1		30.1	30.7	*31.5				135
136			30.0		30.4	30.5		30.7	31.0	*31.9				136
137			30.4		31.0	31.0		31.3	31.4	*32.2				137
138			*30.9		31.6	31.6		31.9	32.0	*32.8				138
139			*31.4		32.3	32.3		32.5	*32.6	*33.4				139
140					32.9	32.9		33.1	33.2	34.1	*34.8			140
141					33.3	33.6		33.7	34.0	34.9	*35.6			141
142					33.6	34.4		34.3	34.8	35.8	*36.5			142

(Contd.)

Height (cm)	Weight (kg)										Height (cm)
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	
143			*34.2	35.1					36.7	*38.4	
144			*34.2	35.9	35.6	36.0					143
145			*34.9	36.6	36.4	36.6	37.2	39.3	*41.1		144
146			36.8	37.3	37.3	37.3	38.0	40.3	*42.0		145
147			37.1	38.2	37.9	38.8	41.4	*42.8			146
148			37.6	38.9	38.6	39.5	42.0	*43.5	*45.1		147
149			38.2	39.5	39.2	40.3	42.5	*44.0	*45.5		148
150			38.8	40.2	39.9	41.1	43.0	44.6	*45.9	*46.4	
151			*39.5	41.0	40.8	41.9	43.8	45.5	*46.8	*47.3	
152			*40.2	41.8	41.7	42.7	44.6	46.4	*47.7	48.1	
153			42.6	42.7	43.5	45.4	47.1	48.6	48.9	*49.9	
154			43.4	43.8	44.2	46.2	47.6	49.4	49.7	*50.7	
155			44.0	44.8	45.0	47.0	48.1	50.2	50.4	51.4	
156			*44.1	45.5	45.7	47.5	48.9	50.7	51.1	51.7	
157			*44.2	46.2	46.5	48.1	49.8	51.1	51.8	52.0	
158				47.0	47.4	48.7	50.5	51.4	52.2	52.4	
159				47.9	48.3	49.2	51.0	51.7	52.5	52.7	
160				48.9	49.2	49.8	51.5	51.9	52.8	53.1	
161				*49.6	49.9	50.7	52.1	52.6	53.3	53.6	
162				*50.3	50.6	51.5	52.7	53.2	53.7	54.0	
163				*51.0	51.4	52.3	53.3	53.8	54.2	54.6	
164				*51.7	52.2	53.2	53.7	54.3	54.8	55.3	
165				*52.4	53.1	54.0	54.2	54.8	55.4	55.9	
166					54.0	54.5	54.6	55.7	56.1	56.6	
167					54.9	54.9	55.0	56.6	56.9	57.4	
168					*55.6	55.5	55.7	57.4	57.6	58.2	

(Contd.)

Height (cm)	Weight (kg)										Height (cm)		
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	17 years	18 years
169						*56.8	57.6	58.0	58.9	58.9			169
170						*57.2	58.2	58.8	59.5	59.7			170
171						*57.8	58.7	59.5	60.0	60.7			171
172							59.1	60.1	60.5	61.4			172
173							*59.6	*60.5	*60.9	*61.8			173
174								*60.0	*61.2	*62.1			174
175									*60.2	*61.0			175
176										*61.6	*62.5		176
177										*62.0	*62.8		177
178										*62.4	*63.2		178
179										*62.7	*63.5		179
180										*63.0	*63.9		180

Starred (*) figures represent values based on theoretical computations rather than on exact average. Age is taken at the nearest birthday, height at the nearest centimetre, weight at the nearest tenth of a kilogram.

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(2) Weight for Height, Boys*

Height (cm)	Standard	Weight (kg)			
		90% standard	80% standard	70% standard	60% standard
112	19.7	17.7	15.8	13.8	11.8
114	20.6	18.5	16.5	14.4	12.4
116	21.3	19.2	17.0	14.9	12.8
118	22.1	19.9	17.7	15.5	13.3
120	22.9	20.6	18.3	16.0	13.7
122	23.7	21.3	19.0	16.6	14.2
124	24.5	22.1	19.6	17.2	14.7
126	25.4	22.9	20.3	17.8	15.2
128	26.4	23.8	21.1	18.5	15.8
130	27.3	24.6	21.8	19.1	16.4
132	28.2	25.4	22.6	19.7	16.9
134	29.2	26.3	23.4	20.4	17.5
136	30.2	27.2	24.2	21.1	18.1
138	31.4	28.3	25.1	22.0	18.8
140	32.5	29.3	26.0	22.8	19.5
142	33.7	30.3	27.0	23.6	20.2
144	35.1	31.3	28.1	24.6	21.1
146	36.2	32.6	29.0	25.3	21.7
148	37.4	33.7	29.9	26.2	22.4
150	38.6	34.7	30.9	27.0	23.2
152	40.0	36.0	32.0	28.0	24.0
154	41.4	37.4	33.1	29.0	24.8
156	43.1	38.8	34.5	30.2	25.9
158	44.7	40.2	35.8	31.3	26.8
160	46.5	41.9	37.2	32.6	27.9
162	48.2	43.4	38.6	33.7	28.9
164	50.2	45.2	40.2	35.1	30.1
166	52.5	47.3	42.0	36.8	31.5
168	54.8	49.3	43.8	38.4	32.9
170	57.0	51.3	45.6	40.0	34.2
172	59.4	53.5	47.5	41.6	35.6
174	62.2	56.0	49.8	43.6	37.3

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(3) Weight for Height, Girls*

Height (cm)	Weight (kg)				
	Standard	90% standard	80% standard	70% standard	60% standard
110	18.8	16.9	15.0	13.2	11.3
112	19.6	17.6	15.7	13.7	11.8
114	20.4	18.4	16.3	14.3	12.2
116	21.2	19.1	17.0	14.8	12.7
118	22.0	19.8	17.6	15.4	13.2
120	22.8	20.5	18.2	16.0	13.7
122	23.6	21.2	18.9	16.5	14.2
124	24.5	22.1	19.6	17.2	14.7
126	25.4	22.9	20.3	17.8	15.3
128	26.4	23.8	12.1	18.5	15.8
130	27.4	24.7	21.9	19.2	16.4
132	28.5	25.7	22.8	20.0	17.1
134	29.5	26.6	23.6	20.7	17.7
136	30.6	27.5	24.5	21.4	18.4
138	31.6	28.4	25.3	22.1	19.0
140	32.8	29.5	26.2	23.0	19.7
142	34.0	30.6	27.2	23.8	20.4
144	35.3	31.8	28.2	24.7	21.2
146	36.5	32.9	29.2	25.6	21.9
148	37.7	33.9	30.2	26.4	22.6
150	38.7	34.8	31.0	27.1	23.2
152	39.8	35.8	31.8	27.9	23.9
154	42.0	37.8	33.6	29.4	25.2
156	43.9	39.5	35.1	30.7	26.3
158	46.4	41.8	37.1	32.5	27.8
160	49.7	44.7	39.8	34.8	29.8
162	52.7	47.4	42.2	36.9	31.6

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(4) Triceps Skin-Fold, 5–15 Years, Sexes Separate*

Age (years)	Triceps skin-fold (mm)									
	Standard		90% standard		80% standard		70% standard		60% standard	
	M	F	M	F	M	F	M	F	M	F
5	9.1	9.4	8.2	8.5	7.3	7.5	6.4	6.6	5.5	5.7
6	8.2	9.6	7.4	8.6	6.6	7.7	5.8	6.7	4.9	5.8
7	7.9	9.4	7.1	8.5	6.3	7.5	5.5	6.6	4.7	5.7
8	7.6	10.1	6.8	9.1	6.1	8.1	5.3	7.1	4.5	6.1
9	8.2	10.3	7.4	9.2	6.6	8.2	5.8	7.2	4.9	6.2
10	8.2	10.4	7.4	9.3	6.6	8.3	5.7	7.3	4.9	6.2
11	8.9	10.6	8.1	9.6	7.2	8.5	6.3	7.5	5.4	6.4
12	8.5	10.1	7.6	9.1	6.8	8.1	5.9	7.0	5.1	6.0
13	8.1	10.4	7.3	9.4	6.5	8.3	5.7	7.3	4.9	6.2
14	7.9	11.3	7.1	10.1	6.3	9.0	5.5	7.9	4.8	6.8
15	6.3	11.4	5.7	10.2	5.0	9.1	4.4	8.0	3.8	6.8

* Adapted from Hammond (1955a)

(5) Arm Circumference, 6–17 Years, Sexes Separate*

Age (years)	Arm circumference (cm)									
	Standard		90% standard		80% standard		70% standard		60% standard	
	M	F	M	F	M	F	M	F	M	F
6	17.3	17.3	15.6	15.5	13.8	13.8	12.1	12.1	10.4	10.4
7	17.8	17.8	16.0	16.0	14.2	14.2	12.5	12.5	10.7	10.7
8	18.4	18.4	16.5	16.6	14.7	14.7	12.9	12.9	11.0	11.1
9	19.0	19.1	17.1	17.2	15.2	15.3	13.3	13.4	11.4	11.5
10	19.7	19.9	17.7	17.9	15.8	15.9	13.8	13.9	11.8	11.9
11	20.4	20.7	18.4	18.6	16.3	16.5	14.3	14.5	12.2	12.4
12	21.2	21.5	19.1	19.3	16.9	17.2	14.8	15.0	12.7	12.9
13	22.2	22.4	20.0	20.2	17.7	17.9	15.5	15.7	13.3	13.4
14	23.2	23.2	20.9	20.9	18.6	18.5	16.3	16.2	13.9	13.9
15	25.0	24.4	22.5	22.0	20.0	19.5	17.5	17.1	15.0	14.6
16	26.0	24.7	23.4	22.2	20.8	17.9	18.2	17.3	15.6	14.8
17	26.8	24.9	24.1	22.3	21.4	19.9	18.8	17.4	16.1	14.9

* Adapted from O'Brien, Girshik & Hunt (1941).

(6) Muscle Circumference, 6–15 Years, Sexes Separate*

Age (years)	<i>Muscle circumference (cm)</i>									
	<i>Standard</i>		<i>90% standard</i>		<i>80% standard</i>		<i>70% standard</i>		<i>60% standard</i>	
	<i>M</i>	<i>F</i>	<i>M</i>	<i>F</i>	<i>M</i>	<i>F</i>	<i>M</i>	<i>F</i>	<i>M</i>	<i>F</i>
6	14.7	14.2	13.2	12.8	11.8	11.4	10.3	9.9	8.8	8.5
7	15.3	14.8	13.8	13.3	12.2	11.8	10.7	10.4	9.2	8.9
8	16.0	15.3	14.4	13.8	12.8	12.2	11.2	10.7	9.6	9.2
9	16.5	15.9	14.9	14.3	13.2	12.7	11.6	11.1	9.9	9.5
10	17.1	16.6	15.4	14.9	13.7	13.3	12.0	11.6	10.3	10.0
11	17.6	17.3	15.8	15.6	14.1	14.1	12.3	12.1	10.6	10.4
12	18.5	18.3	16.6	16.5	14.8	14.6	12.9	12.8	11.1	11.0
13	19.6	19.1	17.6	17.2	15.7	15.3	13.7	13.4	11.8	11.5
14	20.8	19.6	18.7	17.6	16.6	15.7	14.6	13.7	12.5	11.8
15	23.0	20.8	20.7	18.7	18.4	16.6	16.1	14.6	13.8	12.5

* Calculated from Tables (4) and (5) of this Annex.

(7) Weight for Height, Adult Males*

Percentage of standard weight	Weight ranges (kg), corresponding to the percentages given in the first column, for the heights shown						
	145 cm	146 cm	147 cm	148 cm	149 cm	150 cm	151 cm
50-54	26.0-28.5	26.2-28.7	26.5-29.0	26.8-29.4	27.0-29.6	27.3-29.9	27.5-30.2
55-59	28.6-31.1	28.8-31.4	29.1-31.7	29.5-32.0	29.7-32.3	30.0-32.6	30.3-32.9
60-64	31.2-33.7	31.5-34.0	31.8-34.3	32.1-34.7	32.4-35.0	32.7-35.4	33.0-35.7
65-69	33.8-36.3	34.1-36.6	34.4-37.0	34.8-37.4	35.1-37.7	35.5-38.1	35.8-38.4
70-74	36.4-38.9	36.7-39.2	37.1-39.6	37.5-40.1	37.8-40.4	38.2-40.8	38.5-41.2
75-79	39.0-41.5	39.3-41.9	39.7-42.3	40.2-42.7	40.5-43.1	40.9-43.5	41.3-43.9
80-84	41.6-44.1	42.0-44.5	42.4-44.9	42.8-45.4	43.2-45.8	43.6-46.3	44.0-46.7
85-89	44.2-46.7	44.6-47.1	45.0-47.6	45.5-48.1	45.9-48.5	46.4-49.0	46.8-49.4
90-94	46.8-49.3	47.2-49.7	47.7-50.2	48.2-50.8	48.6-51.2	49.1-51.7	49.5-52.2
95-99	49.4-51.8	49.8-52.3	50.3-52.8	50.9-53.4	51.3-53.9	51.8-54.4	52.3-54.9
100-104	51.9-54.4	52.4-55.0	52.9-55.5	53.5-56.1	54.0-56.7	54.5-57.2	55.0-57.7
105-109	54.5-57.0	55.1-57.6	55.6-58.1	56.2-58.8	56.8-59.3	57.3-59.9	57.8-60.5
110-114	57.1-59.6	57.7-60.2	58.2-60.8	58.9-61.5	59.4-62.1	60.0-62.6	60.6-63.2
						61.2-63.9	61.8-64.5
						62.3-65.0	63.0-65.7

* Adapted by permission from Society of Actuaries (1959)—modified for average frame size and nude measurements (ICNND, 1963; Bridforth—personal communication, 1965).

	<i>156 cm</i>	<i>157 cm</i>	<i>158 cm</i>	<i>159 cm</i>	<i>160 cm</i>	<i>161 cm</i>	<i>162 cm</i>	<i>163 cm</i>	<i>164 cm</i>	<i>165 cm</i>	<i>166 cm</i>
50–54	29.0–31.8	29.3–32.2	29.7–32.5	30.0–32.9	30.3–33.2	30.6–33.5	30.9–33.9	31.2–34.2	31.5–34.5	31.8–34.9	32.0–35.1
55–59	31.9–34.7	32.3–35.1	32.6–35.5	33.0–35.9	33.3–36.2	33.6–36.6	34.0–36.9	34.3–37.3	34.6–37.7	35.0–38.0	35.2–38.3
60–64	34.8–37.6	35.2–38.0	35.6–38.5	36.0–38.9	36.3–39.3	36.7–39.6	37.0–40.0	37.4–40.4	37.8–40.8	38.1–41.2	38.4–41.5
65–69	37.7–40.5	38.1–41.0	38.6–41.4	39.0–41.9	39.4–42.3	39.7–42.7	40.1–43.1	40.5–43.5	40.9–44.0	41.3–44.4	41.6–44.7
70–74	40.6–43.4	41.1–43.9	41.5–44.4	42.0–44.9	42.4–45.3	42.8–45.8	43.2–46.2	43.6–46.7	44.1–47.1	44.5–47.6	44.8–47.9
75–79	43.5–46.3	44.0–46.8	44.5–47.4	45.0–47.9	45.4–48.3	45.9–48.8	46.3–49.3	46.8–49.8	47.2–50.3	47.7–50.7	48.0–51.1
80–84	46.4–49.1	46.9–49.7	47.5–50.3	48.0–50.9	48.4–51.4	48.9–51.9	49.4–52.4	49.9–52.9	50.4–53.4	50.8–53.9	51.2–54.3
85–89	49.2–52.1	49.8–52.7	50.4–53.3	51.0–53.9	51.5–54.4	52.0–54.9	52.5–55.5	53.0–56.0	53.5–56.5	54.0–57.1	54.4–57.5
90–94	52.2–54.9	52.8–55.6	53.4–56.3	54.0–56.9	54.5–57.4	55.0–58.0	55.6–58.8	56.1–59.1	56.6–59.7	57.2–60.3	57.6–60.7
95–99	55.0–57.8	55.7–58.5	56.4–59.2	57.0–59.8	57.5–60.4	58.1–61.0	58.9–61.6	59.2–62.2	59.8–62.8	60.4–63.4	60.8–63.9
100–104	57.9–60.7	58.6–61.5	59.3–62.2	59.9–62.8	60.5–63.5	61.1–64.1	61.7–64.7	62.3–65.4	62.9–66.0	63.5–66.6	64.0–67.1
105–109	60.8–63.6	61.6–64.4	62.3–65.2	62.9–65.8	63.6–66.5	64.2–67.2	64.8–67.8	65.5–68.5	66.1–69.1	66.7–69.8	67.2–70.3
110–114	63.7–66.5	64.5–67.3	65.3–68.1	65.9–68.8	66.6–69.5	67.3–70.2	67.9–70.9	68.6–71.6	69.2–72.3	69.9–73.0	70.4–73.6

	<i>167 cm</i>	<i>168 cm</i>	<i>169 cm</i>	<i>170 cm</i>	<i>171 cm</i>	<i>172 cm</i>	<i>173 cm</i>	<i>174 cm</i>	<i>175 cm`</i>	<i>176 cm</i>
50–54	32.3–35.5	32.6–35.8	33.0–36.2	33.3–36.5	33.7–36.9	34.0–37.3	34.4–37.7	34.7–38.1	35.1–38.5	35.4–38.9
55–59	35.6–38.7	35.9–39.1	36.3–39.5	36.6–39.9	37.0–40.3	37.4–40.7	37.8–41.1	38.2–41.6	38.6–42.0	39.0–42.4
60–64	38.8–41.9	39.2–42.3	39.6–42.8	40.0–43.2	40.4–43.7	40.8–44.1	41.2–44.6	41.7–45.0	42.1–45.5	42.5–5.9
65–69	42.0–45.2	42.4–45.6	42.9–46.1	43.3–46.5	43.8–47.0	44.2–47.5	44.7–48.0	45.1–48.5	45.6–49.0	46.0–49.5
70–74	45.3–48.4	45.7–48.8	46.2–49.4	46.6–49.9	47.1–50.4	47.6–50.9	48.1–51.5	48.6–52.0	49.1–52.5	49.6–53.0
75–79	48.5–51.6	48.9–52.1	49.5–52.7	50.0–53.2	50.5–53.8	51.0–54.3	51.6–54.9	52.1–55.5	52.6–56.0	53.1–56.6
80–84	51.7–54.9	52.2–55.4	52.8–56.0	53.3–56.5	53.9–57.1	54.4–57.7	55.0–58.3	55.6–58.9	56.1–59.5	56.7–60.1
85–89	55.0–58.1	55.5–58.6	56.1–59.3	56.6–59.9	57.2–60.5	57.8–61.1	58.4–61.8	59.0–62.4	59.6–63.0	60.2–63.7
90–94	58.2–61.3	58.7–61.9	59.4–62.5	60.0–63.2	60.6–63.9	61.2–64.5	61.9–65.2	62.5–65.9	63.1–66.5	63.8–67.2
95–99	61.4–64.5	62.0–65.1	62.6–65.8	63.3–66.5	64.0–67.2	64.6–67.9	65.3–68.6	66.0–69.3	66.6–70.0	67.3–70.7
100–104	64.6–67.8	65.2–68.4	65.9–69.1	66.6–69.9	67.3–70.6	68.0–71.3	68.7–72.1	69.4–72.8	70.1–73.6	70.8–74.3
105–109	67.9–71.0	68.5–71.7	69.2–72.4	70.0–73.2	70.7–74.0	71.4–74.7	72.2–75.5	72.9–76.3	73.7–77.1	74.4–77.8
110–114	71.1–74.2	71.8–74.9	72.5–75.7	73.3–76.5	74.1–77.3	74.8–78.2	75.6–79.0	76.4–79.8	77.2–80.6	77.9–81.4

	<i>177 cm</i>	<i>178 cm</i>	<i>179 cm</i>	<i>180 cm</i>	<i>181 cm</i>	<i>182 cm</i>	<i>183 cm</i>	<i>184 cm</i>	<i>185 cm</i>	<i>186 cm</i>
50–54	35.8–39.3	36.2–39.7	36.7–40.2	37.1–40.7	37.5–41.2	37.9–41.6	38.3–42.0	38.9–42.4	39.1–42.9	39.5–43.3
55–59	39.4–42.9	39.8–43.4	40.3–43.9	40.8–44.5	41.3–44.9	41.7–45.4	42.1–45.8	42.5–46.3	43.0–46.8	43.4–47.3
60–64	43.0–46.5	43.5–47.0	44.0–47.6	44.6–48.2	45.0–48.7	45.5–49.2	45.9–49.7	46.4–50.2	46.9–50.7	47.4–51.2
65–69	46.6–50.1	47.1–50.6	47.7–51.2	48.3–51.9	48.8–52.4	49.3–53.0	49.8–53.5	50.3–54.0	50.8–54.6	51.3–55.2
70–74	50.2–53.6	50.7–54.2	51.3–54.9	52.0–55.6	52.5–56.2	53.1–56.8	53.6–57.3	54.1–57.9	54.7–58.5	55.3–59.1
75–79	53.7–57.2	54.3–57.9	55.0–58.6	55.7–59.3	56.3–59.9	56.9–60.6	57.4–61.1	58.0–61.8	58.6–62.4	59.2–63.1
80–84	57.3–60.8	58.0–61.5	58.7–62.2	59.4–63.0	60.0–63.7	60.7–64.4	61.2–65.0	61.9–65.6	62.5–66.3	63.2–67.0
85–89	60.9–64.4	61.6–65.1	62.3–65.9	63.1–66.7	63.8–67.4	64.5–68.2	65.1–68.8	65.7–69.5	66.4–70.2	67.1–70.9
90–94	64.5–68.0	65.2–68.7	66.0–69.6	66.8–70.4	67.5–71.2	68.3–71.9	68.9–72.6	69.6–73.4	70.3–74.1	71.0–74.9
95–99	68.1–71.5	68.8–72.3	69.7–73.2	70.5–74.1	71.3–74.9	72.0–75.7	72.7–76.4	73.5–77.2	74.2–78.0	75.0–78.8
100–104	71.6–75.1	72.4–76.0	73.3–76.9	74.2–77.9	75.0–78.7	75.8–79.5	76.5–80.3	77.3–81.1	78.1–81.9	78.9–82.8
105–109	75.2–78.7	76.1–79.6	77.0–80.6	78.0–81.6	78.8–82.5	79.6–83.3	80.4–84.1	81.2–84.9	82.0–85.9	82.9–86.7
110–114	78.8–82.3	79.7–83.2	80.7–84.3	81.7–85.3	82.6–86.2	83.4–87.1	84.2–87.9	85.0–88.9	86.0–89.8	86.8–90.7

(8) Weight for Height, Adult Females*

Percentage of standard weight	Weight ranges (kg), corresponding to the percentages given in the first column, for the heights shown					
	140 cm	141 cm	142 cm	143 cm	144 cm	145 cm
50–54	22.5–24.6	22.7–24.9	23.0–25.2	23.2–25.4	23.5–25.8	23.8–26.1
55–59	24.7–26.9	25.0–27.2	25.3–27.5	25.5–27.8	25.9–28.1	26.2–28.4
60–64	27.0–29.1	27.3–29.4	27.6–29.8	27.9–30.1	28.2–30.5	28.5–30.8
65–69	29.2–31.4	29.5–31.7	29.9–32.1	30.2–32.4	30.6–32.8	30.9–33.2
70–74	31.5–33.6	31.8–34.0	32.2–34.4	32.5–34.7	32.9–35.2	33.3–35.6
75–79	33.7–35.9	34.1–36.3	34.5–36.7	34.8–37.1	35.3–37.5	35.7–37.9
80–84	36.0–38.1	36.4–38.5	36.8–39.0	37.2–39.4	37.6–39.9	38.0–40.3
85–89	38.2–40.3	38.6–40.8	39.1–41.3	39.5–41.7	40.0–42.2	40.4–42.7
90–94	40.4–42.6	40.9–43.1	41.4–43.5	41.8–44.0	42.3–44.6	42.8–45.1
95–99	42.7–44.8	43.2–45.3	43.6–45.8	44.1–46.3	44.7–46.9	45.2–47.4
100–104	44.9–47.1	45.4–47.6	45.9–48.1	46.4–48.7	47.0–49.3	47.5–49.8
105–109	47.2–49.3	47.7–49.9	48.2–50.4	48.8–51.0	49.4–51.7	49.9–52.2
110–114	49.4–51.6	50.0–52.2	50.5–52.7	51.1–53.3	51.8–54.0	52.3–54.6

	<i>150 cm</i>	<i>151 cm</i>	<i>152 cm</i>	<i>153 cm</i>	<i>154 cm</i>	<i>155 cm</i>	<i>156 cm</i>	<i>157 cm</i>	<i>158 cm</i>	<i>159 cm</i>
50–54	25.2–27.6	25.5–28.0	25.8–28.3	26.0–28.5	26.3–28.8	26.6–29.1	26.9–29.5	27.7–29.8	27.5–30.1	27.8–30.5
55–59	27.7–30.2	28.1–30.5	28.4–30.8	28.6–31.1	28.9–31.4	29.2–31.8	29.6–32.1	29.9–32.5	30.2–32.9	30.6–32.2
60–64	30.3–32.7	30.6–33.1	30.9–33.4	31.2–33.7	31.5–34.1	31.9–34.4	32.2–34.8	32.6–35.2	33.0–35.6	33.3–36.0
65–69	32.8–35.2	33.2–35.6	33.5–36.0	33.8–36.3	34.2–36.7	34.5–37.1	34.9–37.5	35.3–37.9	35.7–38.4	36.1–38.8
70–74	35.3–37.7	35.7–38.2	36.1–38.8	36.4–38.9	36.8–39.3	37.2–39.8	37.6–40.2	38.0–40.7	38.5–41.1	38.9–41.6
75–79	37.8–40.3	38.3–40.7	38.9–41.1	39.0–41.5	39.4–41.9	39.9–42.4	40.3–42.9	40.8–43.4	41.2–43.9	41.7–44.3
80–84	40.4–42.8	40.8–43.3	41.2–43.7	41.6–44.1	42.0–44.6	42.5–45.1	43.0–45.6	43.5–46.1	44.0–46.6	44.4–47.1
85–89	42.9–45.3	43.4–45.8	43.8–46.3	44.2–46.7	44.7–47.2	45.2–47.7	45.7–48.3	46.2–48.8	46.7–49.3	47.2–49.9
90–94	45.4–47.8	45.9–48.4	46.4–48.9	46.8–49.3	47.3–49.8	47.8–50.4	48.4–51.4	48.9–51.5	49.4–52.1	50.0–52.7
95–99	47.9–50.3	48.5–50.9	49.0–51.4	49.4–51.9	49.9–52.4	50.5–53.0	51.5–53.6	51.6–54.2	52.2–54.8	52.8–55.4
100–104	50.4–52.9	51.0–53.5	51.5–54.0	52.0–54.5	52.5–55.1	53.1–55.7	53.7–56.3	54.3–57.0	54.9–57.6	55.5–58.2
105–109	53.0–55.4	53.6–56.1	54.1–56.6	54.6–57.1	55.2–57.7	55.8–58.4	56.4–59.0	57.1–59.7	57.7–60.3	58.3–61.0
110–114	55.5–57.9	56.2–58.6	56.7–59.2	57.2–59.8	57.8–60.3	58.5–61.0	59.1–61.7	59.8–65.4	60.4–63.1	61.1–63.8

	<i>160 cm</i>	<i>161 cm</i>	<i>162 cm</i>	<i>163 cm</i>	<i>164 cm</i>	<i>165 cm</i>	<i>166 cm</i>	<i>167 cm</i>	<i>168 cm</i>	<i>169 cm</i>
50–54	28.1–30.8	28.5–31.2	28.8–31.6	29.2–32.0	29.5–32.3	29.8–32.7	30.1–33.0	30.4–33.3	30.7–33.7	31.1–34.1
55–59	30.9–33.7	31.3–34.1	31.7–34.5	32.1–34.9	32.4–35.3	32.8–35.6	33.1–36.0	33.4–36.3	33.8–36.8	34.2–37.2
60–64	33.8–36.5	34.2–36.9	34.6–37.4	35.0–37.8	35.4–38.2	35.7–38.6	36.1–39.0	36.4–39.4	36.9–39.8	37.3–40.3
65–69	36.6–39.3	37.0–39.8	37.5–40.3	37.9–40.7	38.3–41.2	38.7–41.6	39.1–42.0	39.5–42.4	39.9–42.9	40.4–43.4
70–74	39.4–42.1	39.9–42.6	40.4–43.1	40.8–43.7	41.3–44.1	41.7–44.6	42.1–45.0	42.5–45.5	43.0–46.0	43.5–46.5
75–79	42.2–44.9	42.7–45.5	43.2–46.0	43.8–46.6	44.2–47.1	44.7–47.5	45.1–48.0	45.6–48.5	46.1–49.1	46.6–49.6
80–84	45.0–47.7	45.6–48.3	46.1–48.9	46.7–49.5	47.2–50.0	47.6–50.5	48.1–51.0	48.6–51.5	49.2–52.1	49.7–52.7
85–89	47.8–50.5	48.4–51.1	49.0–51.8	49.6–52.4	50.1–52.9	50.6–53.5	51.1–54.0	51.6–54.6	52.2–55.2	52.8–55.8
90–94	50.6–53.3	51.2–54.0	51.9–54.7	52.5–55.3	53.0–55.9	53.6–6.5	54.1–57.0	54.7–57.6	55.3–58.3	55.9–58.9
95–99	53.4–56.1	54.1–56.8	54.8–57.5	55.4–58.2	56.0–58.8	56.6–59.4	57.1–60.0	57.7–60.6	58.4–61.3	59.0–62.0
100–104	56.2–59.0	55.9–59.7	57.6–60.4	58.3–61.2	58.9–61.8	59.5–62.4	60.1–63.1	60.7–63.7	61.4–64.4	62.1–65.1
105–109	59.1–61.8	59.8–62.5	60.5–63.3	61.3–64.1	61.9–64.7	62.5–65.4	63.2–66.1	63.8–66.7	64.5–67.5	65.2–68.3
110–114	61.9–64.6	62.6–65.4	63.4–66.2	64.2–67.0	64.8–67.7	65.5–68.4	66.2–69.1	66.8–69.8	67.6–70.6	68.4–71.4

* Adapted by permission from Society of Actuaries (1959) — modified for average frame size and nude measurements (ICNND, 1963; Bridgforth—personal communication, 1965).

(9) Triceps Skin-Fold, Adults, Sexes Separate

Sex	<i>Triceps skin-fold (mm)</i>				
	<i>Standard</i>	<i>90% standard</i>	<i>80% standard</i>	<i>70% standard</i>	<i>60% standard</i>
Male	12.5	11.3	10.0	8.8	7.5
Female	16.5	14.9	13.2	11.6	9.9

(10) Arm Circumference, Adults, Sexes Separate*

Sex	<i>Arm circumference (cm)</i>				
	<i>Standard</i>	<i>90% standard</i>	<i>80% standard</i>	<i>70% standard</i>	<i>60% standard</i>
Male	29.3	26.3	23.4	20.5	17.6
Female	28.5	25.7	22.8	20.0	17.1

* Adapted from O'Brien & Shelton (1941); Hertzberg et al. (1963).

(11) Muscle Circumference, Adults, Sexes Separate*

Sex	<i>Muscle circumference (cm)</i>				
	<i>Standard</i>	<i>90% standard</i>	<i>80% standard</i>	<i>70% standard</i>	<i>60% standard</i>
Male	25.3	22.8	20.2	17.7	15.2
Female	23.2	20.9	18.6	16.2	13.9

* Calculated from Tables (9) and (10) of this Annex.

Appendix IX

ICMR DATA ON SPORTS NUTRITION

□ Definitions as given by NIN, ICMR, 1985

Reference Sportsman: One aged between 20–39 years, weight 60 kg in body weight and having 7–15% fat. He is thus different from ICMR Reference Man being heavier and with higher level of physical activity during working hours. He is free from disease and physically fit for higher level of exertion for a reasonable period of time. On each working day he spends 4 hours of practice of his sport or game which involves more than moderate activity. While not at work he spends 8 hours in bed, 8 hours in sitting, reading, writing, listening and eating and 4 hours in attending to personal necessities like washing, changing dress, toilet, leisure walking and other allied activities.

Energy needs of Reference Sportsman: He needs 3600 kcal energy per day at physiological level, which can be obtained with reasonable confidence if retail level for the provision is placed at 4320 kcal including an allowance of 20% for losses during purchase and processing and kitchen and plate wastage.

Reference Sportswoman: One aged between 20–39 years, weighing 50 kg in body weight. She differs from Reference Woman used in nutrition studies (ICMR 1981) by having 5 kg extra body weight with a higher level of physical activity during occupational hours. She is free from disease and physically fit for higher level of exertion for a reasonable period of time. On each working day she spends 4 hours of practice of her sport or game, 8 hours in bed, 8 hours in sitting, reading, writing, listening and eating and 4 hours in attending to personal necessities like washing, changing dress, toilet, leisure walking and other allied activities.

Energy needs of Reference Sportswoman: She needs 2900 kcal energy per day at physiological level, which she can obtain with reasonable confidence if retail level for the provision is placed at 3480 or 3500 kcal per day including an allowance of 20% for losses during purchase and processing and kitchen and plate wastage.

Energy requirements of men and women engaged in different types of activities recommended by ICMR at physiological levels and recommended physiological and retail level allowances for sportsmen and women is as follows:

Activity category	Recommended Energy Allowances					
	kcals per day					
	Men		Women		kcal / kg / day	
	50 kg	55 kg	60 kg	40 kg	45 kg	50 kg
Light ¹	2182	2400	2618	1689	1900	2111
Moderate ¹	2546	2800	3055	1955	2200	2445
Heavy	3546	3900	4255	2667	3000	3334
Sports activity, physiological level	3000	3300	3600	2320	2610	2900
Daily ration allowance ²	3600	3960	4320	2784	3132	3480

¹ ICMR, 1981² Recommended allowances at retail level after allowing for 20% to take care of wastages and losses at the purchase, processing, kitchen and serving levels.

Recommended Dietary Intake of Nutrients at Ration Level

Group	Net Calories (kcal)	Proteins (g)	Calcium (g)	Iron (mg)	Retinol (µg)	Thiamine (mg)	Riboflavin (mg)	Ascorbic Acid (mg)	Nicotine (mg)
Reference Sportsman	4320	100–120	1–2	50–75	1000–2000	3–4	3–4	100–200	40–50
Reference Sportswoman	3480	80–100	1–2	60–100	1000–2000	2–3	2–3	100–200	40–50

Range of the Daily Energy Consumption in the Training Process of Different Sport Disciplines¹

<i>Sport Discipline</i>	<i>Gymnastics</i>	<i>Athletics</i>	<i>Sprint and middle distance runners</i>	<i>Long distance and marathon runners</i>	<i>Rowing</i>	<i>Sport/Games</i>	<i>Skiing</i>
Energy consumption kcal/kg/day	52–68	55–70	65–80	60–80	60–70	60–70	62–80

We are aiming at 72 kcal/kg/day retail level ration which can supply 60 kcal/kg/day at physiological level. Long distance runners, rowers and throwers must be considered separately.

1. N.N. Jakolev, I.R.P.C. Leningrad, U.S.S.R. 1975.

Appendix X

Nutritive Value of Some Indian Food Commodities
Cereals and Products

Name of Food	Edible portion %	Moisture g	Protein g	Fat g	Minerals g	Carbo-hydrates g	Energy Kcal	Calcium mg	phosphorus mg	Iron mg	Thiamine mg	Carotene mg	Riboflavin mg	Niacin mg	Vitamin C mg	
Bajra	84	12.4	11.6	5	2.3	1.2	67.5	361	42	296	5	132	0.33	0.25	2.3	0
Jowar	100	11.9	10.4	1.9	1.6	1.6	72.6	349	25	222	5.	47	0.37	0.13	3.1	0
Maize dry	100	14.9	11.1	3.6	1.5	2.7	66.2	342	10	348	2	90	0.42	0.1	1.8	0
Maize tender	37	67.1	4.7	0.9	0.8	1.9	24.6	125	9	121	1.	32	0.11	0.17	0.6	6
Oatmeal	100	10.7	13.6	7.6	1.8	3.5	62.8	374	50	380	3.8	0	0.98	0.16	1.1	0
Ragi	100	13.1	7.3	1.3	2.7	3.6	72	328	344	283	6.	42	0.42	0.19	1.1	0
Rice parboiled	100	12.6	8.5	0.6	0.9	—	77.4	349	10	280	2.	9	0.27	0.12	4	
Handpounded																
Rice parboiled	100	13.3	6.4	0.4	0.7	0.2	79	346	9	143	4	—	0.21	0.05	3.8	0
Milled																
Rice raw	100	13.3	7.5	1	0.9	0.6	76.7	346	10	190	3.2	2	0.21	0.16	3.9	0
Handpounded																
Rice raw milled	100	13.7	6.8	0.5	0.6	0.2	78.2	345	10	160	3.1	0	0.06	0.06	1.9	0
Rice bran	—	11	13.5	16.2	6.6	4.3	48.4	393	67	1410	35	—	2.1	0.48	—	0
Rice flakes	100	12.2	6.6	1.2	2	0.7	77.3	346	20	238	20	0	0.21	0.05	4	0
Rice puffed	100	14.7	7.5	0.1	3.8	0.3	73.6	325	23	150	6.6	0	0.21	0.01	4.1	0
Samai	—	11.5	7.7	4.7	1.5	7.6	67	341	17	220	5.2	0	0.3	0.09	3.2	0
Sanwa millet	—	11.9	6.2	2.2	4.4	9.8	65.5	307	20	280	2.9	0	—	—	4.2	0
Semolina	100	—	10.4	0.8	—	0.2	74.8	348	16	102	1.6	—	0.12	0.03	1.06	
Wheat whole	100	12.8	11.8	1.5	1.5	1.2	71.2	346	41	306	4.9	64	0.45	0.17	5.5	0
Wheatflour whole	100	12.2	12.1	1.7	2.7	1.9	69.4	341	48	355	11.5	29	0.49	0.17	4.3	0
Wheatflour refined	100	13.3	11	0.9	0.6	0.3	73.9	348	23	121	2.5	25	0.12	0.07	2.4	0
Wheatgerm	100	5.2	29.2	7.4	3.5	1.4	53.3	397	40	846	6	—	1.4	0.54	2.9	0
Vermicelli	100	11.7	8.7	0.4	0.7	0.2	78.3	352	22	92	2	0	0.19	0.05	1.8	0

PULSES AND LEGUMES

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbohydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carnosine	Thiamine	Riboflavin	Niacin g	Vitamin C g
Bangalgram whole	100	9.8	17.1	5.3	3	3.9	60.9	360	202	312	10.2	189	0.3	0.15	2.9	3
Bengalgram <i>dal</i>	100	9.9	20.8	5.6	2.7	1.2	59.8	372	56	331	9.1	129	0.48	0.18	2.4	1
Bengalgram roasted	100	10.7	22.5	5.2	2.5	1	58.1	369	58	340	9.5	113	0.2	—	1.3	0
Blackgram <i>dal</i>	100	10.9	24	1.4	3.2	0.9	59.6	347	154	385	9.1	38	0.42	0.2	2	0
Cowpea	97	13.4	24.1	1	3.2	3.8	54.5	323	77	414	5.9	12	0.51	0.2	1.3	0
Fieldbean dry	—	9.6	24.9	0.8	3.2	1.4	60.1	347	60	433	2.7	0	0.52	0.16	1.8	0
Greengram whole	100	10.4	24	1.3	3.5	4.1	56.7	334	124	326	7.3	94	0.47	0.27	2.1	0
Greengram <i>dal</i>	100	10.1	24.5	1.2	3.5	0.8	59.9	348	75	405	8.5	49	0.47	0.21	2.4	0
Lentil	100	12.4	25.1	0.7	2.1	0.7	59	343	69	293	4.8	270	0.45	0.2	2.6	0
Mothbeans	100	10.8	23.6	1.1	3.5	4.5	56.5	330	202	230	9.5	9	0.45	0.09	1.5	2
Peas dry	100	16	19.7	1.1	2.2	4.5	56.5	315	75	298	5.1	39	0.47	0.19	3.4	0
Peas roasted	100	10.1	22.9	1.4	2.4	4.4	58.8	340	81	345	6.4	18	0.47	0.21	3.5	0
Rajma	—	12	22.9	1.3	3.2	—	60.6	346	260	410	5.8	—	—	—	—	—
Redgram <i>dal</i>	100	13.4	22.3	1.7	3.5	1.5	57.6	335	73	304	5.8	132	0.45	0.19	2.9	0
Soybeans	—	8.1	43.2	19.5	4.6	3.7	20.9	432	240	690	11.5	426	0.73	0.39	3.2	—

LEAFY VEGETABLES

ROOTS AND TUBERS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Vitamin C
Arwa gadda	—	74.3	1.4	0.1	0.6		23.6	101	30	2(1	2.2	—	—	—	—	—
Banana rhizome	35	85.1	0.4	0.2	1.4	1.1	11.8	51	25	10	1.1	16	0	0.03	0.2	1
Beetroot	85	87.7	1.7	0.1	0.8	0.9	8.8	43	18.3	55	1	0	0.04	0.09	0.4	10
Carrot	95	86	0.9	0.2	1.1	1.2	10.6	48	80	530	2.2	1890	0.04	0.02	0.6	3
Colocasia	—	73.1	3	0.1	1.7	1	21.1	97	40	140	1.7	24	0.09	0.03	0.4	0
Onion big	95	86.6	1.2	0.1	0.4	0.6	11.1	50	46.9	50	0.7	0	0.08	0.01	0.4	11
Onion small	—	84.3	1.8	0.1	0.6	0.6	12.6	59	40	60	1.2	15	0.08	0.02	0.5	2
Potato	85	74.7	1.6	0.1	0.6	0.4	22.6	97	10	40	0.7	24	0.1	0.01	1.2	17
Radish pink	98	90.8	0.6	0.3	0.9	0.6	6.8	32	50	20	0.5	3	0.06	0.02	0.4	17
Radish white	99	94.4	0.7	0.1	0.6	0.8	3.4	17	35	22	0.4	3	0.06	0.02	0.5	15
Sweet potato	97	68.5	1.2	0.3	1	0.8	28.2	120	46	50	0.8	6	0.08	0.04	0.7	24
Tapioca	—	59.4	0.7	0.2	1	0.6	38.1	157	50	40	0.9	—	0.05	0.1	0.3	25
Yam elephant	—	78.7	1.2	0.1	0.8	0.8	18.4	79	50	34	0.6	260	0.06	0.07	0.7	0
Yam ordinary	92	69.9	0.4	0.1	1.6	1	26	111	35	20	1.3	78	0.07	—	0.7	

OTHER VEGETABLES

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phos-phorus mg	Iron mg	Caro-tene mg	Thia-mine mg	Ribo-flavin mg	Niacin mg	Vitamin C mg
Ash gourd	67	96.5	0.4	0.1	0.3	0.8	1.9	10	30	20	0.8	0	0.06	0.01	0.4	1
Beans scarlet	59	58.3	7.4	1	1.6	1.9	29.8	158	50	160	2.6	34	0.34	0.19	0	27
Bitter gourd	97	92.4	1.6	0.2	0.8	0.8	4.2	25	20	70	1.8	126	0.07	0.09	0.5	88
Bitter gourd small	93	83.2	2.1	1	1.4	1.7	10.6	60	23	38	2	126	0.07	0.06	0.4	96
Bottle gourd	86	96.1	0.2	0.1	0.5	2.5	12	20	10	0.7	0	0.03	0.01	0.2	0	0
Brinjal	91	92.7	1.4	0.3	0.3	1.3	4	24	18	47	0.9	74	0.04	0.11	0.9	12
Broad beans	88	85.4	4.5	0.1	0.8	2	7.2	48	50	64	1.4	9	0.08	—	0.8	12
Cauliflower	70	90.8	2.6	0.4	1	1.2	4	30	33	51	1.5	30	0.04	0.1	1	56
Cluster beans	—	81	3.2	0.4	1.4	3.2	10.8	16	130	57	4.5	198	0.09	0.03	0.6	49
Colocasia stem	86	94	0.3	0.3	1.2	0.6	3.6	18	60	20	0.5	104	0.07	0.07	0.1	3
Cowpea pods	—	85.3	3.5	0.2	0.9	2	8.1	48	72	59	2.5	564	0.07	0.09	0.9	14
Cucumber	83	96.3	0.4	0.1	0.3	0.4	2.5	13	10	25	1.5	0	0.03	0	0.2	7
Double beans	—	73.8	8.3	0.3	1	4.3	12.3	85	40	140	2.3	—	—	—	—	22
Drumstick	83	86.9	2.5	0.1	2	4.8	3.7	26	30	110	5.3	11.0	0.05	0.07	0.2	120
Drumstick flowers	—	85.9	3.6	0.8	1.3	1.3	7.1	50	51	90	—	—	—	—	—	—
Field beans tender	93	86.1	3.8	0.7	0.9	1.8	6.7	48	210	68	1.7	1.87	0.1	0.06	0.7	9
French beans	94	91.4	1.7	0.1	0.5	1.8	4.5	26	50	28	1.7	132	0.08	0.06	0.3	24
Giant chillies (capsicum)	97	92.4	1.3	0.3	0.7	1	4.3	24	10	30	1.2	427	0.55	0.05	0.1	137
Kankoda	—	84.1	3.1	1	1.1	3	7.7	52	33	42	4.6	1620	0.05	0.18	0.6	—
Karonda fresh	98	91	1.1	29	0.6	1.5	2.9	42	21	28	—	—	—	—	—	—

(Contd.)

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phos-phorus mg	Iron mg	Caro-tene mg	Thia-mine mg	Riboflavin mg	Niacin mg	Vitamin C mg
Karonda dry	—	18.2	2.3	9.6	2.8	—	67.1	364	160	60	39.1	—	—	—	—	—
Knol-khol	74	92.7	1.1	0.2	0.7	1.5	3.8	21	20	35	0.4	21	0.05	0.09	0.5	85
Ladies fingers	84	89.6	1.9	0.2	0.7	1.2	6.4	35	66	56	1.5	52	0.07	0.1	0.6	13
Mango green	72	87.5	0.7	0.1	(J.4)	1.2	10.1	44	10	19	5.4	90	0.04	0.01	0.2	3
Papaya green	—	92	0.7	0.2	0.5	0.9	5.7	27	28	40	0.9	0	0.01	0.01	0.1	12
Parvar	95	92	2	0.3	0.5	3	2.2	20	30	40	1.7	153	0.05	0.06	0.5	29
Peas	53	72.1	7.2	0.1	0.8	4	15.9	93	20	139	1.5	83	0.25	0.01	0.8	9
Pink beans	94	86.8	3.1	0.4	0.6	2.1	7	44	54	70	1.5	453	0.06	0.02	0.6	12
Plantain flower	43	89.9	1.7	0.7	1.3	1.3	5.1	34	32	42	1.6	27	0.05	0.02	0.4	16
Plantain green	58	83.2	1.4	0.2	0.5	0.7	14	64	10	29	0.6	30	0.05	0.02	0.3	24
Plantain stem	—	88.3	0.5	0.1	0.6	0.8	9.7	42	10	10	1.1	0	0.02	0.01	0.2	7
Pumpkin	79	92.6	1.4	0.1	0.6	0.7	4.6	25	10	30	0.7	50	0.06	0.04	0.5	2
Leeks	—	78.9	1.8	0.1	0.7	1.3	17.2	77	50	70	2.3	18	0.23	—	—	11
Redgram tender	72	65.1	9.8	1	1	6.2	16.9	116	57	164	1.1	469	0.32	0.33	3	25
Ridge gourd	82	95.2	0.5	0.1	0.3	0.5	3.4	17	18	26	0.5	33	—	0.01	0.2	5
Snake gourd	96	94.6	0.5	0.3	0.5	0.8	3.3	18	26	20	0.3	96	0.04	0.06	0.3	0
Sword beans	98	87.2	2.7	0.2	0.6	1.5	7.8	44	60	40	2	24	0.08	0.08	0.5	12
Tinda tender	99	93.5	1.4	0.2	0.5	1	3.4	21	25	24	0.9	13	0.04	0.08	0.3	18
Tomato green	98	93.1	1.9	0.1	0.6	0.7	3.6	23	20	36	1.8	192	0.07	0.01	0.4	31
Vegetable marrow	94	94.8	0.5	0.1	0.3	0.8	3.5	17	10	30	0.6	—	0.02	0	0.4	18
Water chestnut fresh	38	70	4.7	0.3	1.1	0.6	23.3	115	20	150	0.8	12	0.05	0.07	0.6	9
Water chestnut dry	—	13.8	13.4	0.8	3.1	—	68.9	336	70	440	24	—	—	—	—	—

NUTS AND OIL SEEDS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamin mg	Riboflavin mg	Niacin mg	Vitamin C mg
Almond	—	5.2	20.8	58.9	2.9	1.7	10.5	655	230	490	4.5	0	0.24	0.57	4.4	0
Cashewnut	—	5.9	21.2	46.9	2.4	1.3	22.3	596	50	450	5	60	0.63	0.19	1.2	0
Chilgoza	—	4	13.9	49.3	2.8	1	29	615	91	494	3.6	—	0.32	0.3	3.6	0
Coconut dry	—	4.3	6.8	62.3	1.6	6.6	18.4	662	400	210	2.7	0	0.08	0.01	3	7
Coconut fresh	100	36.3	4.5	41.6	1	3.6	13	444	10	240	1.7	0	0.05	0.1	0.8	1
Garden cress seeds	100	3.2	25.3	24.5	6.4	7.6	33	454	377	723	100	27	0.59	0.61	14	0
Gingelly seeds	100	5.3	18.3	43.3	5.2	2.9	25	563	1450	570	10.5	60	1.01	0.34	4.44	0
Groundnut	73	3	25.3	40.1	2.4	3.1	26.1	567	90	350	2.8	37	0.9	0.13	20	0
Groundnut roasted	69	1.7	26.2	39.8	2.5	3.1	26.7	570	77	370	3.1	0	0.39	0.13	22	0
Mustard seeds	—	8.5	20	39.7	4.2	1.8	23.8	541	490	700	7.0	162	0.65	0.26	4	0
Niger seeds	—	42	23.9	39	4.9	11	17.1	515	300	224	56.6	—	0.07	0.97	8.4	0
Oyster nuts	—	4.4	29.7	63.3	2.6	—	0	689	10	570	4.1	—	—	—	—	—
Pistachio nuts	—	5.6	19.8	53.5	2.8	2.1	16.2	626	140	430	7.7	144	0.67	0.28	0.2	—
Walnut	45	4.5	15.6	64.5	1.8	2.6	11	687	100	380	4.8	6	0.45	0.4	1	0

CONDIMENTS AND SPICES

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Vitamin C mg
Asafoetida	—	16	4	1.1	7	4.1	67.8	297	690	50	22.2	4	0	0.04	(1.3	0
Cardamom	—	20	10.2	2.2	5.4	20	42.1	229	130	160	5	0	0.22	0.17	0.8	0
Chillies dry	—	10	15.9	6.2	6.1	30	31.6	246	160	370	2.3	345	0.93	0.43	9.5	50
Chillies green	90	85.7	2.9	0.6	1	6.8	3	29	30	80	1.2	15	0.19	0.39	0.9	111
Cloves	100	25.2	5.2	8.9	5.2	9.5	46	286	740	100	4.9	253	0.08	0.13	0	0
Garlic	85	62	6.3	0.1	1	0.8	29.8	145	30	310	1.3	0	0.06	0.23	0.4	13
Ginger fresh	—	80.9	2.3	0.9	1.2	2.4	12.3	67	20	60	2.6	40	0.06	0.03	0.6	6
Mace	—	15.9	6.5	24.4	1.6	3.8	47.8	437	180	100	12.6	3027	0.25	0.42	1.4	0
Nutmeg	—	14.3	7.5	36.4	1.7	1.2	28.5	472	120	240	4.6	0	0.33	0.01	1.4	0
Onum	—	7.4	17.1	21.8	7.9	21	24.5	363	1525	443	27.7	71	0.21	0.28	2.1	—
Pepper dry	95	13.2	11.5	6.8	4.4	1.5	49.2	304	460	198	16.8	1080	0.09	0.14	1.4	—
Pepper green	81	70.6	4.8	2.7	1.8	6.4	13.7	98	270	70	2.4	540	0.05	0.04	0.2	1
Tamarind pulp	—	20.9	3.1	0.1	2.9	5.6	67.4	283	170	110	10.9	60	—	0.07	0.7	3
Turmeric	100	13.1	6.3	5.1	3.5	2.6	69.4	349	150	282	14.8	30	0.03	0	2.3	0

FRUITS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Vitamin C mg
Ambada	—	90.3	0.7	3	0.5	1	4.5	48	36	11	3.9	270	0.02	0.02	0.3	21
Amla	89	81.8	0.5	0.1	0.5	3.4	13.7	58	50	20	1.2	9	0.03	0.01	0.2	600
Apple	90	84.6	0.2	0.5	0.3	1	13.4	59	10	14	1	0	—	—	0	1
Apricots fresh	86	85.3	1	0.3	0.7	1.1	11.6	53	20	25	2.2	2160	0.04	0.13	0.6	6
Apricots dried	93	19.4	1.6	0.7	2.8	2.1	73.4	306	110	70	4.6	58	0.22	—	2.3	2
Banana ripe	71	70.1	1.2	0.3	0.8	0.4	27.2	116	17	36	0.9	78	0.05	0.08	0.5	7
Bullock's heart	72	76.8	1.4	0.2	0.7	5.2	15.7	70	10	10	0.6	67	—	0.07	0.6	5
Cashew fruit	77	86.3	0.2	0.1	0.2	0.9	12.3	51	10	10	0.2	23	0.02	0.05	0.4	180
Cherries red	88	83.4	1.1	0.5	0.8	0.4	13.8	64	24	25	1.3	0	0.08	0.08	0.03	7
Currents black	98	18.4	2.7	0.5	2.2	1	75.2	32	130	110	8.5	21	0.03	0.14	0.4	1
Dates dried	86	15.3	2.5	0.4	2.1	3.9	75.8	317	120	50	7.3	26	0.01	0.02	0.9	3
Dates fresh	—	59.2	1.2	0.4	1.7	3.7	33.8	144	22	38	—	—	—	—	—	—
Figs	99	88.1	1.3	0.2	0.6	2.2	7.6	37	80	30	1	162	0.06	0.05	0.06	5
Grapes blue	95	82.2	0.6	0.4	0.9	2.8	13.1	58	20	23	0.5	3	0.04	0.03	0.2	1
Grapes pale green	—	79.2	0.5	0.3	0.6	2.9	16.5	71	20	30	0.5	0	—	0	—	—
Grapefruit seedless	—	88.5	1	0.1	0.4	—	10	45	30	30	0.2	—	0.12	0.02	0.3	—
Grapefruit triumph	—	92	0.7	0.1	0.2	—	7	32	20	20	0.2	—	0.12	0.02	0.3	31
Guava	100	81.7	0.9	0.3	0.7	5.2	11.2	51	10	28	1.4	0	0.03	0.03	0.4	212
Jackfruit	30	76.2	1.9	0.1	0.9	1.1	19.8	88	20	41	0.5	175	0.03	0.13	0.4	7
Jamb safed	—	93.5	0.1	0.4	0.1	2.2	3.7	19	17	3	0.1	0.01	0.02	0.2	30	
Lime	—	84.6	1.5	1.6	0.7	1.3	10.9	59	90	20	0.3	15	0.02	0.03	0.1	63
Lime sweet malta	67	90.3	0.7	0.2	0.4	0.6	7.8	36	30	20	1	0	—	—	0	54

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phos-phorus mg	Iron mg	Caro-tene mg	Thia-mine mg	Ribo-flavin mg	Niacin mg	Vitamin C mg
Lime sweet mosambi	71	88.4	0.8	0.3	0.7	0.5	9.3	43	40	30	0.7	0	—	—	0	50
Lemon	—	85	1	0.9	0.3	1.7	11.1	57	70	10	2.3	0	0.02	0.01	0.1	39
Lemon sweet	79	90.5	0.7	0.3	0.5	0.7	7.3	35	30	20	0.7	0	—	0.04	0	45
Litchi	68	84.1	1.1	0.2	0.5	0.5	13.6	61	10	35	0.7	0	0.02	0.06	0.4	31
Mango ripe	74	81	0.6	0.4	0.4	0.7	16.9	74	14	16	1.3	2743	0.08	0.09	0.9	16
Mango steen	—	84.9	0.5	0.1	0.2	—	14.3	60	10	20	0.2	—	—	—	—	—
Melon musk	78	95.2	0.3	0.2	0.4	0.4	3.5	17	32	14	1.4	169	0.11	0.08	0.3	26
Melon water	78	95.8	0.2	0.2	0.3	0.2	3.3	16	11	12	7.9	0	0.02	0.04	0.1	1
Orange	67	87.6	0.7	0.2	0.3	0.3	10.9	48	26	20	0.32	1104	—	—	—	30
Orange juice	—	97.7	0.2	0.1	0.1	—	1.9	9	5	9	0.7	15	0.06	0.02	0.4	64
Papaya ripe	75	90.8	0.6	0.1	0.5	0.8	7.2	32	17	13	0.5	666	0.04	0.25	0.2	57
Peaches	88	86	1.2	0.3	0.8	1.2	10.5	50	15	41	2.4	0	0.02	0.03	0.5	6
Pears	85	86	0.6	0.2	0.3	1	11.9	52	8	15	0.5	28	0.06	0.03	0.2	0
Pineapple	60	87.8	0.4	0.1	0.4	0.5	10.8	46	20	9	1.2	18	0.2	0.12	0.1	39
Pomegranate	68	78	1.6	0.1	0.7	5.1	14.5	65	10	70	0.3	0	0.06	0.1	0.3	16
Prunes	—	85.3	0.5	0.3	0.6	0.5	12.8	56	10	18	—	—	—	—	—	—
Plum	90	86.9	0.7	0.5	0.4	0.4	11.1	52	10	12	0.6	166	0.04	0.1	0.3	5
Raisins	100	20.2	1.8	0.3	2	1.1	4	308	87	80	7.7	2.4	0.07	0.19	0.7	1
Raspberry	—	84.8	1	0.6	0.9	1	11.7	56	40	110	2.3	1248	—	—	0.8	30
Sapota	83	73.7	0.7	1.1	0.5	2.6	21.4	98	28	27	2	97	0.02	0.03	0.2	6
<i>Sitaphal</i>	45	70.5	1.6	0.4	0.9	3.1	23.5	104	17	47	1.5	0	0.07	0.17	1.3	37
Strawberry	96	87.8	0.7	0.2	0.4	1.1	9.8	44	30	30	1.8	18	0.03	0.02	0.2	52
Tomato ripe	100	94	0.9	0.2	0.5	0.8	3.6	20	48	20	0.4	351	0.12	0.06	0.4	27
Tree tomato	90	86.2	1.5	0.2	1.2	4.2	6.7	35	124	469	11.8	324	0.11	0.06	2.1	0
Zizyphus (<i>Ber</i>)	—	81.6	0.8	0.3	0.3	—	17	74	4	9	1.8	21	0.02	0.05	0.7	76

FISHES AND OTHER SEA FOODS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium g	Phosphorus g	Iron mg	Carotene g	Thiamine g	Riboflavin g	Niacin g	Vitamin C g
Bombay duck dried	75	16.7	61.7	4	15	—	2.5	293	1389	240	19.1	—	—	—	—	—
Cat fish	—	77.1	21.4	—	—	—	—	86	10	230	—	—	—	—	2.5	—
Crab muscles	83.5	8.9	1.1	3.2	—	3.3	59	1370	150	21.2	780	—	—	—	3.1	—
Crab small	—	65.3	11.2	9.8	4.6	—	9.1	19	1606	253	—	—	—	—	—	—
Ghol	—	69.7	18.4	0.9	—	—	—	82	90	150	2.1	—	—	—	—	—
Lobster	—	77.3	20.5	0.9	1.4	—	0	90	16	279	—	—	—	—	—	—
Mackerel	61	77.3	18.9	1.7	1.6	—	0.5	93	429	305	4.5	—	—	—	—	—
Mandeli dried	67	31.1	52.5	5.4	—	—	—	259	143	259	11.9	—	—	—	—	—
Pomfret black	70	74.5	20.3	2.6	1.1	—	1.5	111	286	306	2.3	—	—	—	—	—
Pomfret white	68	78.4	17	1.3	1.5	—	1.8	87	200	290	0.9	—	—	0.15	2.6	—
Prawns	45	77.4	19.1	1	1.7	—	0.8	89	323	278	5.3	0	0.01	0.1	4.8	—
Rawas	77	71.4	22.2	1.1	2	—	3.3	112	405	335	2	—	—	—	—	—
Rohu	78	76.7	16.6	1.4	0.9	—	4.4	97	650	175	1	—	0.05	0.07	0.7	22
Sardine	60	78.1	21	1.9	1.7	—	—	101	90	360	2.5	—	—	—	2.6	—
Shark	67	76	21.6	0.4	1.2	—	0.8	93	257	262	1.4	—	—	—	2.5	—
Shrimp small dry	—	6	68.1	8.5	17	—	—	349	4384	1160	—	—	—	—	—	—
Surmai fresh	63	19.9	1.4	—	—	—	—	92	92	161	1	—	—	—	—	—
Surmai dried	91	43.3	38.6	6.2	—	—	—	210	148	172	4.4	—	—	—	—	—

OTHER FLESH FOODS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium g	Phos-phorus g	Iron mg	Caro-teno g	Thia-mine g	Ribo-flavin g	Niacin g	Vitamin C g
Beef meal	100	8.2	79.2	10.3	1.6	0.5	0.2	410	68	324	18.8	0	0.03	0.44	5.8	0
Beef muscle	—	74.3	22.6	2.6	1	—	—	114	10	190	0.8	0	0.15	0.04	6.4	2
Egg hen	—	73.7	13.3	13.3	1	—	—	173	60	220	2.1	600	0.4	0.4	0.1	0
Fowl (Chicken)	—	72.2	25.9	0.6	1.3	—	—	109	25	245	—	—	—	0.14	—	—
Goat meat	—	74.2	21.4	3.6	1.1	—	—	118	12	193	—	—	—	—	—	—
Liver goat	—	76.3	20	3	1.3	—	—	107	17	279	—	—	—	—	—	—
Liver sheep	—	70.4	19.3	7.5	1.5	—	1.3	150	10	380	6.3	0	0.36	1.7	18	20
Mutton muscle	—	71.5	18.5	13.3	1.3	—	—	194	150	150	2.5	0	0.18	0.14	6.8	—
Pork muscle	—	77.4	18.7	4.4	1	—	—	114	30	200	2.2	0	0.54	0.09	2.8	2

MILK AND MILK PRODUCTS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbo-hydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Vitamin C mg
Milk buffalo	100	81	4.3	8.8	0.8	—	5	117	210	130	0.2	160	0.04	0.1	0.1	1
Milk cow	100	87.5	3.2	4.1	0.8	—	4.4	67	120	90	0.2	174	0.05	0.19	0.1	2
Milk goat	100	86.8	3.3	4.5	0.8	—	4.6	72	127	120	0.3	182	0.05	0.04	0.3	1
Milk human	100	88	1.1	3.4	0.1	—	7.4	65	28	11	—	137	0.02	0.02	—	3
Curds cowmilk	100	89.1	3.1	4	0.8	—	3	60	149	93	0.2	102	0.05	0.16	0.1	1
Skimmed milk	100	92.1	2.5	0.1	0.7	—	4.6	29	120	90	0.2	—	—	—	0.1	1
Channa cow	100	57.1	18.3	20.8	2.6	—	1.2	265	208	138	—	366	0.07	0.02	—	3
Channa buffalo	100	54.1	13.4	23	1.6	—	7.9	292	480	111	—	—	—	—	—	—
Cheese	100	40.3	24.1	25.1	4.2	—	6.3	348	790	520	2.1	273	—	—	—	—
Kheer	100	69	6.9	12.2	2.3	—	9.6	176	388	237	—	242	0.12	0.35	0.3	3
Khoa buffalo whole	100	30.6	14.6	31.2	3.1	—	20.5	421	650	420	5.8	—	—	—	—	—
Khoa buffalo skim	100	46.1	22.3	1.6	4.3	—	25.7	206	990	650	2.7	—	—	—	—	—
Khoa cow	100	25.2	20	25.9	4	—	24.9	413	956	613	—	497	0.23	0.41	0.4	6
Skim milk powder (cow)	100	4.1	38	0.1	6.8	—	51	357	1370	1000	1.4	0	0.45	1.64	1	5
Whole milk powder (buffalo)	100	3.5	25.8	26.7	6	—	38	496	950	730	0.6	1400	0.31	1.36	0.8	4

FATS AND OILS

Name of Food	Edible portion	Moisture%	Protein g	Fat g	Minerals g	Carbohydrates g	Energy kcal	Calcium g	Phosphorus g	Iron mg	Carotene mg	Thiamine g	Riboflavin g	Niacin g	Vitamin C g
	%	g	g	g	g	g	—	—	—	—	—	—	—	—	—
Butter	100	19	—	81	2.5	—	—	729	—	—	—	3200	—	—	—
Ghee cow	100	—	—	100	—	—	—	900	—	—	—	2000	—	—	—
Ghee buffalo	100	—	—	100	—	—	—	900	—	—	—	900	—	—	—
Vanaspati	100	—	—	100	—	—	—	900	—	—	—	2500	—	—	—
Cooking oil	100	—	—	100	—	—	—	900	—	—	—	0	—	—	—

MISCELLANEOUS

Name of Food	Edible portion	Moisture %	Protein g	Fat g	Minerals g	Fibre g	Carbohydrates g	Energy kcal	Calcium mg	Phosphorus mg	Iron mg	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Vitamin C mg
Arrow root flour	100	16	0.2	0.1	0.1	83.1	334	10	20	1						
Biscuits salted	100	4.5	6.6	32.4	1.9	—	54.6	534	—	—	—	—	—	—	—	—
Biscuits sweet	100	5.4	6.4	15.2	1.1	—	71.9	450	—	—	—	—	—	—	—	—
Bread brown	100	39	8.8	1.4	—	1.2	49	244	18	—	2.2	—	0.21	—	2.5	—
Bread white	100	39	7.8	0.7	—	0.2	51.9	245	11	—	1.1	—	0.07	—	0.7	—
Cane sugar	100	0.4	0.1	0	0.1	0	99.4	398	12	1	—	—	—	—	—	—
Coconut tender	—	90.8	0.9	1.4	0.6	—	6.3	41	30	0.9	—	—	—	—	2	—
Coconut milk	100	42.8	3.4	41	0.9	0	11.9	430	15	140	1.6	0	0.08	0.04	0.6	3
Coconut water	100	93.8	1.4	0.1	0.3	0	4.4	24	10	0.1	0	0.01	0	0.1	2	
Coconut meal de-oiled	100	8.7	23.8	2.8	7	9.8	47.9	312	112	646	69.4	0	0.13	0.57	6	5
Honey	—	20.6	0.3	0	0.2	—	79.5	319	5	16	0.9	0	0	0.01	0.2	4
Jackfruit seeds	—	64.5	6.6	0.4	1.2	1.5	25.8	133	50	97	1.5	10	0.25	0.11	0.3	11
Jaggery cane	—	3.9	0.4	0.1	0.6	—	95	383	80	40	11.4	168	0.02	0.04	0.5	0
Mango powder	—	6.8	2.8	7.8	4.9	14	64	337	180	160	45.2	0	—	—	0.7	41
Mushroom	88	88.5	3.1	0.8	1.4	0.4	4.3	43	6	110	1.5	0	0.14	0.16	2.4	12
Neera	—	—	0.4	—	0.5	—	10.9	45	0	140	0.1	—	0.02	0	0	13
Poppy seeds	—	4.3	21.7	19.3	9.9	8	36.8	408	1584	432	—	—	—	—	—	—
Rajgira seeds	100	9.3	16.5	5.3	3.5	2.7	62.7	364	223	355	17.6	—	0.17	0.2	3.6	0
Sago	—	12.2	0.2	0.2	0.3	—	87.1	10	10	1.3	—	0.01	—	0.2	—	—
Sugar cane juice	—	90.2	0.1	0.2	0.4	—	9.1	39	10	10	1.1	6	—	0.04	—	—
Yeast dried brewer	—	13.6	39.5	0.6	7	0.2	39.1	320	440	1490	43.7	6	40	0	0	
Yeast dried as food	—	7.8	35.7	1.8	8.4	—	46.3	344	160	2090	21.5	66	3.2	4	27	0

Appendix XI

(1) Per cent Prevalence of Malnutrition among Children Aged 1–4 Years in India and Selected States (1992–93)

Country or State	Underweight (Weight-for-age below 2SD of the median)		Stunted (Height-for-age below 2SD of the median)		Wasted (Weight-height below 2SD of the median)		Total
	Rural	Urban	Total	Rural	Urban	Total	
INDIA	59.9	45.2	53.1	54.1	44.8	52.0	18.0
Andhra Pradesh	52.1	40.	49.1	—	—	—	—
Assam	51.8	37.3	50.4	53.5	39.6	52.5	11.4
Bihar	64.1	53.8	62.6	61.8	55.2	60.9	22.7
Gujarat	45.8	40.5	44.1	44.6	41.6	43.6	20.3
Haryana	39.4	33.0	37.9	48.0	42.4	46.7	5.7
Himachal Pradesh	48.3	30.2	47.0	—	—	—	—
Jammu & Kashmir	—	—	44.5	—	—	—	—
Karnataka	—	—	54.3	—	—	47.6	—
Kerala	30.6	22.9	28.5	29.6	21.5	27.4	11.5
Madhya Pradesh	59.4	50.1	57.4	—	—	—	—
Maharashtra	57.5	45.5	52.6	50.8	39.1	46.0	21.5
Orissa	—	—	53.3	—	—	48.2	—
Punjab	47.4	40.0	45.9	40.4	38.4	40.0	21.4
Rajasthan	41.1	43.9	41.6	43.0	43.5	43.1	17.7
Tamil Nadu	52.1	37.3	46.6	—	—	—	—
Uttar Pradesh	—	—	49.8	—	—	49.2	—
West Bengal	—	—	56.8	—	—	43.2	—

— Not available.

Notes: Children below two standard deviations of the International Reference Population Median are considered malnourished.

Source: International Institute for Population Sciences 1995, *National Family Health Survey: India, 1992–93*, Bombay.

(2) Prevalence of Anaemia among Pregnant Women in Selected States of India, various years

State	Percent of Women with Haemoglobin	
	Below 11 grams per decilitre	Below 8 grams per decilitre
Andhra Pradesh	47.0	14.0
Bihar	81.0	—
Delhi	61.0	—
Gujarat	84.0	21.0
Haryana	95.0	—
Maharashtra	87.0	41.0
Rajasthan	98.0	—
Tamil Nadu	54.0	—
Uttar Pradesh	80.0	—

—Not available:

Source: Government of India 1996. *Report of the Task Force on Micronutrients (Vitamin A and Iron)*. New Delhi: Ministry of Human Resource Development, Department of Women and Child Development.

(3) Prevalence of Anaemia among Lactating Women in Selected Urban Areas of India, Various Years

Location	Percent of Women with Haemoglobin	
	Below 12 grams per decilitre	Below 8 grams per decilitre
Baroda	77.0	13.0
Mumbai	90.0	10.0
Kolkata	95.0	15.0
Chennai	81.0	14.0

Source: Government of India 1996. *Report of the Task Force on Micronutrients (Vitamin A and Iron)*. New Delhi: Ministry of Human Resource Development, Department of Women and Child Development.

(4) Average Nutrient Intake of Children and Adults as a Percentage of Recommended Dietary Intakes in India, 1988–90

	<i>Protein</i>	<i>Energy</i>	<i>Calcium</i>	<i>Iron</i>	<i>Vitamin A</i>	<i>Riboflavin</i>	<i>Niacin</i>	<i>Vitamin C</i>
Children								
1–3 yrs	94.5	62.8	61.2	71.7	35.2	66.7	51.4	60.0
7–9 yrs	90.7	71.8	92.7	67.7	34.8	82.0	46.7	70.0
Adolescents								
(13–15 yrs)								
Boys	72.0	81.3	71.8	58.3	48.0	87.5	47.3	78.1
Girls	74.9	91.8	65.8	78.6	37.8	101.0	58.3	87.1
Adults								
Males	108.0	87.5	144.2	109.6	48.5	100.0	73.7	90.5
Females			1					101.0
NPNL ^a	108.0	90.6	113.7	87.3	40.5	103.6	56.9	93.6
Pregnant	65.0	75.6	48.3	35.5	63.0	89.1	53.0	80.0
Lactating	75.2	89.1	51.5	87.0	32.9	103.0	59.3	90.0
								47.5

a. NPNL=Non-Pregnant and Non-Lactating.
Source: Banji, M., and A.V. Lakshmi (1993), Less Recognized Micronutrient Deficiencies in India. *NFI Bulletin*, Vol. 19, No.2, p.5.

(5) Nutrition Expenditure per Malnourished Child in Selected States of India, 1993–94

State	Number of 0–6 year-old children (millions)	Percent of children malnourished in 1992–93	Number of malnourished children in 1992–93 (millions)	Total expenditure in 1992–93 (Rupees (million))	Expenditure per malnourished child (Rupees)
Andhra Pradesh	11	49.1	5.4	444	82.21
Assam	4	50.4	2.0	148	73.41
Bihar	18	62.6	11.3	—	—
Gujarat	7	44.1	3.1	902	292.19
Haryana	3	37.9	1.1	206	181.18
Karnataka	7	54.3	3.8	133	34.99
Kerala	3	28.5	0.9	156	182.46
Madhya Pradesh	13	57.4	7.5	344	46.10
Maharashtra	14	52.6	7.4	801	108.77
Orissa	5	53.3	2.7	361	135.46
Punjab	3	45.9	1.4	—	—
Rajasthan	9	41.6	3.7	167	44.60
Tamil Nadu	7	46.6	3.3	2389	732.37
Uttar Pradesh	29	49.8	14.4	—	—
West Bengal	12	56.8	6.8	244	35.80
All 12 States	95	50.0	47.6	6294	132.20

—Not available

Notes: The numbers of children ages 0–6 years were estimated from data from the Registrar General of India for the given years. Data on the percent of malnourished children are from the National Family Health Survey, 1992–93, which pertain to 1–4 year olds. Rates of malnutrition among 0–6 years-olds are assumed to be similar. Children below two Standard Deviations from the International Reference Population median are considered malnourished.

Source: Radhakrishna, R.S. Indrakant and C. Ravi. 1998 India's Integrated Child Development Services Program Assessment and Options for Reform. Centre for Economic and Social Studies, Hyderabad.

(6) Prevalence of Vitamin A Deficiency in Preschoolers between 1965–69 and 1994

Survey	Period	Percent
ICMR	1965–69	4.2
NNMB 1975–79	1975–79	1.8
NNMB 1988–90	1988–90	0.7
NNMB 1992–93 ^a	1992–93	1.9
NNMB 1994	1994	1.1
NNMB Slum ^b	1993–94	0.9 to 1.5

Notes: Vitamin A deficiency was estimated on the basis of the presence of Bitot's spots.

- a. This survey included two additional states (Uttar Pradesh and West Bengal) that were not in other NNMB surveys.
- b. Data from only three of six cities that were surveyed.

Source: Sachdev, H.P.S. (1997). Nutritional Status of Children and Women in India: Recent Trends. NFI Bulletin. Vol.18, No.3 p.4

(7) Per cent Prevalence of Goitre among Males and Females in Various Districts of India, 1984–86

<i>Districts</i>	<i>All Persons</i>	<i>Male</i>	<i>Female</i>	<i>Ratio (F/M)</i>
Visakhapatnam, Andhra Pradesh	15.8	7.0	24.6	3.5
Dibrugarh, Assam	65.8	51.4	77.6	1.5
Muzaffarpur, Bihar	33.8	29.8	36.9	1.2
Sitamarhi, Bihar	31.8	27.6	35.4	1.3
Surat, Gujarat	22.7	14.6	29.7	2.0
Mandla, Gujarat	34.4	29.9	39.4	1.3
Dhule, Maharashtra	16.5	11.6	20.9	1.8
Central Manipur	10.4	5.2	15.7	3.0
West Manipur	19.8	14.8	23.7	1.6
Nilgiri, Tamil Nadu	6.9	2.9	10.5	3.6
Bahraich, Uttar Pradesh	20.2	18.0	22.5	1.3
Basti, Uttar Pradesh	20.0	16.0	24.3	1.5
Gorakhpur, Uttar Pradesh	18.6	12.2	26.2	2.1
Mirzapur, Uttar Pradesh	6.2	3.9	8.9	2.3
All 14 Districts	21.1	15.5	26.8	1.7

Source: Indian Council of Medical Research (1989). *Epidemiological Survey of Endemic-Goitre and Endemic Cretinism. An ICMR Task Force Study*, p. 29. New Delhi.

Appendix XII

Normal Values for Blood

<i>Parameter</i>	<i>Reference Values*</i>
Acid phosphatase	Up to 4.0 U/L
Albumin	3.0–5.0 g%
Alkaline phosphatase	Up to 117.0 U/L
Calcium	9.0–10.5 mg%
Chloride	96–105 mEq/L
Cholesterol	150–200 mg/dl
Creatinine	1.0–2.0 mg%
D. Bilirubin	Up to 0.5 mg%
FSH	5.0–25.0 mU/ml
Glucose (fasting)	60–110 mg/l
Haemoglobin	M: 13.5–18.0 g% F: 11.5–16.5 g%
Iron	M: 78–174 ug/L F: 62–168 ug/dl
Luteinising hormone	5.0–25.0 mU/ml
Phosphorus	2.5–5.0 mg%
Potassium	3.6–4.8 mEq/L
Prolactin	5.0–25.0 ng/ml
Protein (Total)	6.0–7.5 gm%
Sensitive TSH (ELFA method)	0.25–5.0 micro IU/ml
Serum thyroxine (T4)	4.5–12.5 ug/dl
Serum triiodothyronine (T3)	90.0–190.0 ng/dl
SGOT (AST)	Up to 40.0 U/L
SGPT (ALT)	Up to 40.0 U/L
Sodium	132–144 mEq/L
T. Bilirubin	Up to 1.0 mg%
Testosterone	M: 4.0–11.0 ng/ml F: 0.2–0.8 ng/ml
Thyroid stimulating hormone (TSH)	0.3–5.0 uIU/ml
Total Iron Binding Capacity (TIBC)	250–420 ug/dl
Urea	15–40 mg/dl
Urea nitrogen	10.0–15.0 mg%
Uric acid	2.5–7.0 mg%

* All values are in blood plasma except Iron and TIBC which are in serum.

Normal Values for Urine

<i>Parameter</i>	<i>Unit of results</i>
Albumin	Less than 80 mg/24 hours
Creatinine: Male	1.0–1.8 g/24 hours
Creatinine: Female	0.8–1.2g/24 hours
Glucose	1.1–15.1 mg/dl
Potassium	20–60 mEq/L
Protein	Less than 120 mg/24 hours
Protein-pregnancy	Less than 300 mg/24 hours
Sodium	50–150 mEq/24 hours
Urea	15–30 g/24 hours
Uric acid	Less than 0.84 g/24 hours

Lipid Profile of Blood

<i>Parameter</i>	<i>Unit</i>
Total Cholesterol	150–200 mg%
Triglycerides	Below 150 mg%
HDL Cholesterol	Below 35.0 mg%
LDL Cholesterol	Below 100.0 mg%
LDL: HDL Ratio	2.5–3.5
Total Cholesterol : HDL Ratio	Up to 5.0

Appendix XIII

NON-NUTRIENT COMPONENTS OF FOODS AND THEIR SIGNIFICANCE

The common foods we eat are the main source of most of the nutrients. These foods also contain a wide range of organic chemical compounds having no nutritional function. Some of these compounds, however, act as anti-nutritional factors interfering with the utilization of some of the nutrients present in these foods. Some of the compounds like lathyrogens may be toxic and others, like fibre, beneficial. These compounds can be collectively called non-nutrient components. These natural substances occur more widely in plant foods than in animal foods and determine the overall quality of the food. Many of these compounds are designed by nature to protect plants against external predators. Some of these compounds present in small amounts, particularly in spices, act as flavour, aroma and some of them have certain pharmacological properties. These anti-nutritional factors, toxins and dietary fibre are important for assessing the overall quality of a food. The physiological roles of these anti-nutritional components must also be considered besides their nutrient content while considering the health impact of diets based on natural foods.

Anti-nutritional Factors

Many foods, particularly those of plant origin, contain a wide range of anti-nutritional factors, which interfere with the assimilation of nutrients contained in them. The important anti-nutritional factors are trypsin inhibitors, phytates, oxalates, tannins, lectins and goitrogens. They interfere with the utilization of other nutrients like protein, minerals like iron, zinc, calcium and iodine.

1. Trypsin Inhibitors Trypsin inhibitors are proteins distributed widely in plant foods like legumes and certain animal foods like egg whites. They generally inhibit the activity of trypsin in the gut and interfere with digestibility of dietary proteins and reduce their utilization. They are heat labile; the extent and ease of heat inactivation varies from one trypsin to another. Some are more resistant than the others. However, autoclaving at 120°C for 15-30 minutes inactivates almost all trypsin inhibitors. Although the presence of trypsin inhibitor has been demonstrated in many legumes and egg white, those present in soya beans, lima and kidney beans, duck egg white are easily inactivated and do not pose any problem. More drastic heat treatment is necessary to inactivate trypsin inhibitors and improve considerably the utilization of protein present in these foods. Foods also contain other protease inhibitors which do not pose any nutritional hazard.

2. Phytate Phytate is a hexa phosphate of inositol. It is widely distributed in seeds. Unrefined cereals and millets are the richest source of phytates. Phytates act as a source of bound phosphorus for the seeds during germination. These phytates bind iron, zinc, calcium and magnesium. In presence of Ca and Mg, phytates form insoluble complexes with iron and thus make iron unavailable. Phytates present in cereals contribute significantly to poor absorption of iron from cereal-based diets. Unrefined

cereals contain more phytates than refined or polished cereals (rice). Widespread occurrence of zinc deficiency in Iran and Egypt is attributed to consumption of whole-wheat flour with high phytate content by the local population. On germination of the grains, the phytate content reduces due to enzymatic breakdown of phytate. Improved iron availability in germinated grains can be partly attributed to a reduction in phytate content.

3. Tannins Tannins are condensed polyphenolic compounds, which are widely distributed in the plant kingdom. They are present in high amounts in the seed coats of most legumes, spices, tamarind, turmeric, in certain vegetables and fruits. Millets like *bajra*, *ragi* and sorghum also contain a fair amount of tannin. Tannins bind with iron irreversibly and interfere with iron absorption. Studies have shown that tannins derived from different sources in Indian diets are potent inhibiting agents of iron absorption. A typical Indian diet based on cereals, legumes, vegetables and spices may contain as much as 2-3g of tannin. Removal of seed coats of legumes, exclusion of tamarind, turmeric, etc., from a diet can reduce content of the diet and improve iron absorption. Tannins are also known to bind proteins and reduce their availability.

4. Oxalates Oxalic acid, a dicarboxylic acid or its salts (oxalates) are widely distributed in plant foods. These oxalates are mostly calcium salts. Rich sources of oxalates are green leafy vegetables and green vegetables and some legumes. Horsegram and *khesaridal* among grains have a high content of oxalates. Oxalates are known to interfere with calcium absorption by forming insoluble salts with calcium. Dietary oxalates can be absorbed and contribute to increased excretion of oxalates in urine. High oxalate excretion may predispose to oxalate crystals leading to urinary stones. Kidney-stone patients are advised to avoid high oxalate containing foods. However, diets containing foods rich in insoluble calcium oxalate are not likely to be harmful.

5. Goitrogens/Anti-thyroid Substances Although goitre develops due to low iodine intake, it has been recognized for a long time that certain substances present in plant foods interfere with iodine uptake by thyroid gland and may contribute to development of iodine-deficiency disorders when iodine intakes are marginal. Such compounds are termed 'goitrogens'. Thiocyanate, isothiocyanates and their derivatives like chemline (glycoside of 3-methyl-sulphonyl propyl isothiocyanate, gluconolactones), etc. These compounds occur in leaves and vegetables belonging to the Brassica genus and family Cruciferae, like cabbage, cauliflower, rape leaves, radish, rapeseed-mustard, (watercress broccoli) Brussels sprouts, turnips, etc. Soyabean and other legumes, *bajra*, peanut, lentils, common bean also contain goitrogens. All these foods are known to contain one or the other goitrogenic substance and demonstrated to block uptake of iodine by the thyroid gland. Excessive intake of these foods in the face of marginal intake of iodine from foods and water may lead to precipitation of goitre.

6. Other Toxic Agents in Foods Examples of foods containing toxic substances leading to disease in humans are *Lathyrus sativus* (*khesari dal*), *Vicia faba* and cassava. The lathyrus seeds contain toxic amino acid (BOAA), which is considered

responsible for the disease lathyrism. The disease favism accompanied by haemolysis is caused by the consumption of *Vicia faba* (broad beans). Some of these foods can be rendered safe by appropriate treatment. The toxic amino acid from *L. sativus* can be removed by steeping the seeds in water and discarding the steep water, or using a process similar to parboiling of paddy. However, the process of rendering *L. sativus* safe has not been widely used as yet. Similarly, cyanogenic glycosides can be removed from cassava by leaching out with water. In fact, cassava is consumed after treatment this way.

7. Other Xenobiotics Foods contain a large number of other compounds, some of which impart flavour/taste to foods, while others have pharmacological activity. These compounds can be classified as compounds foreign to our body (xenobiotics). Normally, when ingested in small amounts, the body can metabolize and dispose off these compounds. Some of these xenobiotics naturally present in foods are considered to play a positive role in the sense that they can induce the body enzymes to metabolize them. The same enzyme system will be useful for the body to dispose off other dangerous xenobiotics which are potential carcinogens present in foods due to environmental contamination.

8. Dietary Fibre *Dietary Fibre (DF)* is the term given collectively to indigestible carbohydrates present in plant foods. The DF is the sum of the polysaccharides and lignins which are not digested by the endogenous secretions of the human gastrointestinal tract. Depending on the solubility in water, DF is further divided into Insoluble (non-viscous, slowly fermentable) Dietary Fibre (IDF) and Soluble (viscous and fermentable) Dietary Fibre (SDF). The sum of these two fractions is also known as Total Dietary fibre (TDF). The IDF fractions are cellulose, lignin and some portions of hemicelluloses whereas SDF fractions are pectins, gums, β -glucans, mucilages and major portions.

Earlier, only the fibre which is insoluble on boiling with dilute acid, and alkali was reported as Crude Fibre (CF). These may include highly insoluble structural fibres, viz. cellulose, lignin and hemicelluloses. The CF refers to a component defined by an analytical procedure involving digestion with dilute acid and alkali, while the DF refers to the components, which are not digested by the enzymes of the stomach and small intestine where most of the other carbohydrates like long-chain sugars, starch and proteins are digested by heat stable α -amylase, amyloglucosidase and protease respectively.

The DF has physical properties such as Water-Holding Capacity (WHC), Cation-Binding Capacity (CBS) and viscosity, whereas physiological properties include hypoglycemic and hypolipidemic effects. The DF in the diet holds water and behaves like a sponge as it passes through the gastrointestinal (GI) tract. The DF adds bulk to the diet and increases transit time of food in the gut. The SDF fractions such as pectins, gums and mucilages may undergo fermentation in the colon by microflora present in the colon. The IDF is known to reduce constipation and diverticulosis while the SDF is effective in reducing the incidence of coronary heart disease (CHD), type II diabetes [non-insulin dependent diabetes mellitus (NIDDM)] and obesity. The possible mechanisms of hypoglycemic effects of SDF are:

1. SDF binds to large quantity of water and becomes viscous in the stomach. It delays the secretions of GI tract to reduce digestion of food material and finally delaying the glucose absorption.
2. As a result of delayed absorption of glucose, secretion of insulin by the pancreas is also delayed, as evidenced by circulating levels of insulin.
3. The decreased circulating levels of insulin activate the receptors in target organs, which will result in increased insulin sensitivity.

The possible mechanism of action of SDF on reduced incidence of CHD could be due to either its hypolipidemic or its hypocholesterolemic effects. These effects are attributed to the following processes:

1. It delays digestion of food particles in stomach resulting in the delay in cholesterol absorption.
2. It binds to bile salts and prevents its reabsorption resulting in a decrease in circulating levels of cholesterol.
3. It removes bile acids and neutral sterols by excretion through faeces.
4. The SDF yields Short-Chain Fatty Acids (SCFA) due to fermentation in the colon. The SCFA are carried to liver by bile circulation and inhibit cholesterol biosynthesis.

Recent studies with fenugreek seeds, which have high levels of IDF (48.6g%) and SDF (20.0g%) have shown that it is very effective in reducing the blood glucose and cholesterol levels. Some supplements such as psyllium, gum karaya and gum acacia which have SDF, showed a reduction in body weights. Since TDF contributes bulk to diets, it may help in reducing energy intake and thus useful for reducing obesity. The DF could also have some adverse effects on human nutrition by binding to trace minerals and preventing their absorption. This may be an important constraint for high TDF containing diets when they have marginal levels of trace minerals. The suggested intake of TDF is 25-40g/day or 12g-14g TDF/1000 kcal energy.

Glossary

Absorption	The transfer of nutrients across cell membranes: following digestion, nutrients are transferred from the intestinal lumen across the mucosa and into the blood and lymph circulation.
Achlorhydria	Absence of hydrochloric acid in gastric juice.
Acidity	The state of being acid or sour. It is denoted by the pH. pH in the range of one to two is severely acid, pH around six mildly acid. The pH of gastric secretion is around two (containing about 0.5% hydrochloric acid). When it is not properly utilised by food or when secreted in excess, causes acidity in stomach, resulting into burning sensation and pain.
Acid regurgitation	Backward flow of acid, resulting in burning sensation in cardiac stomach, cardiac sphincter, and oesophagus.
Acidosis	Condition caused by accumulation of an excess of acids (anions) in the body, or by excessive loss of base (mineral cations) from the body.
Acidulant	Substance that renders a sour or acid reaction, e.g. citric acid, ascorbic acid, fumaric acid, tartaric acid, etc.
Acrolein	An irritating odour which is a volatile decomposition product of glycerol that results from overheating fat.
Active transport	The movement of particles, in combination with a carrier protein, across cell membranes and epithelial layers. This procedure requires expenditure of energy.
Adenosine triphosphate (ATP)	A compound consisting of one molecule each of adenine and ribose and three molecules of phosphoric acid: two of the phosphate groups are held by high-energy bonds.
Adlibitum	At pleasure: the amount desired (consumption without specific restrictions).
Aerobic	Living in the presence of air, usually organisms carrying out metabolism in the presence of oxygen.
Age-associated osteoporosis	Loss of bone mineral density in both cortical and trabecular bone that occurs in the elderly of both sexes after age 70; fractures of hip and vertebra are common.
Aldehyde	Any of a large group of compounds containing the grouping-CHO.
Aldosterone	A steroid hormone produced by the adrenal cortex: increases sodium retention.
Aleurone layer	The single layer of large cells between the bran coat and the endosperm of cereal grains. Rich in protein, minerals and vitamins.
Alkaloids	Compounds containing nitrogen found in plant food such as potato, tomato (solanum alkaloids) ergot, animal foods (tetrodotoxin in puffer fish, tetramine in shell-

Alkalosis	fish), decarboxylated amino acids (tryptamine, tyramine, histamine). They are used in drug treatment such as as morphine, colchicine, quinine, atropine.
Amaranth	A condition caused by an accumulation of an excess of bases (cations) in the body, or by an excessive loss of acid (anions) from the body.
Ambulatory	Burgundy red, permitted food colour.
Amniotic fluid	Walking or able to walk; of or relating to patient not confined to bed, but requiring medical care.
Amphoteric	The transparent, almost colourless, fluid contained within the amniotic sac surrounding the foetus, composed of albumin, urea, creatinine, water and various salts.
Amylase	A compound having both an acid and a basic group simultaneously.
Anaemia	Enzyme that hydrolyzes starch, e.g. ptyalin, amylopsin mostly present in saliva and pancreatic juice.
Anaerobic	Deficiency in the circulating haemoglobin, red blood cells, or packed cell volume.
Anaphylactic	Anaerobic literally means “living without air”
Anion	Pertaining to the production of state of anaphylaxis; increasing sensitivity. Sometimes fatal.
Anoxia	An ion that contains a negative charge of electricity and, therefore, goes to a positively charged anode.
Antacid	Absence of oxygen; a condition harmful to many forms of life
Anorexia	Bases or buffers that neutralize acid; used generally in relation to the partial neutralization of stomach acidity.
Anthropometry	Loss of appetite.
Antibody	Branch of anthropology dealing with comparative measurements of the parts of human body.
Anticholinergic	A protein substance produced in an organism as a response to the presence of an antigen mainly as a defence mechanism.
Antigen	Pertaining to acting as or caused by a cholinergic (chemical activity characteristic of acetylcholine) blocking agent.
Antioxidant	Any substance such as bacteria or foreign protein that, as a result of contact with tissues of the animal body, produces an immune response.
Antispasmodic	A substance that prevents oxidation, e.g. tocopherols prevent oxidation and, therefore, deterioration of fats due to rancidity.
Anti-vitamin	An agent that relieves or prevents convulsions or spasmodic pains.
Anuria	A drug that counteracts the effects of another drug.
Aplastic anaemia	Lack of urinary secretion (i.e. urine formation).
	A normochromic-normocytic anaemia accompanied by a deficiency of all the formed elements in the blood, can be

Appendicitis	caused by exposure to toxic chemicals, ionising radiations or medications. Most often the cause is unknown.
Arrhythmia	Inflammation of the veriform appendix, the terminal worm-like appendage present on the caecum, having no known function.
Arrowroot	Unrhythymical; absence of rhythm, used to designate an alteration or abnormality of normal cardiac rhythm.
Arteriosclerosis	Starchy substance obtained from the root of arrow-root plant, almost pure starch.
Ascites	Sclerosis (hardening) and thickening of the arterial wall with a loss of elasticity.
Aseptic	Accumulation of fluid serum protein and electrolytes in the abdominal cavity.
Assimilation	Method of handling which prevents entry of micro-organisms (into food).
Asthma	The conversion of nutrient into a useable form (e.g., liquid or solid) that is incorporated into the tissues and organs following the processes of digestion. The chemical alteration of substances in the bloodstream by the liver or cellular secretions.
Ataxia	A disease characterized by an increased sensitivity of the trachea and bronchi to various stimuli and manifested by widespread narrowing of air passages that changes in severity either spontaneously or as a result of therapy; present as episodic dyspnoea, cough and wheezing.
Atherosclerosis	Loss of ability of muscular coordination.
Atopic allergy	Thickening of the walls of blood vessels by deposits of fatty materials, including cholesterol.
Atrophy	A constitutional habitus, based on heredity to acquire certain allergic states that express themselves clinically as atopic dermatitis, seasonal rhinitis (fever) and asthma (as a phenomenon of sensitization).
Ayurveda	A wasting away of cell, tissue, or organ resulting in the reduction in size.
Azotemia	Ancient medical practice developed by Hindu sages.
Bajra	Elevated levels of nitrogenous constituents in the blood; uremia.
Basal Metabolism	Pearl millet, spiked millet.
Beriberi	Energy expenditure of the body at rest in the post-absorptive state. Expressed as kcal/kg body weight/hr.
Betel	A deficiency disease caused by lack of thiamin and characterized by extreme weakness, polyneuritis, emaciation, oedema, and cardiac failure.
	Leaf of the creeper <i>Piper betel</i> or betel, which is chewed in some parts of the world for its stimulating effect (due to presence of the alkaloids arecoline and guacoline). The leaves are chewed with nuts of the areca palm called the

Bhakri	betel palm, areca catechu, lime and other ingredients and the nut is called the betel nut.
Bio-assay	Thick unleavened flat bread made generally from <i>jowar</i> or <i>bajra</i> flour, with a little salt and without fat.
Bio-availability	Testing of activity or potency, as of a vitamin or hormone, on an animal or microorganisms.
Bio-transformation	The degree to which a drug or other substance becomes available to the target tissue.
Bitot's spots	Hepatic metabolism of drugs by oxidation, reduction, hydrolysis, acetylation and sulphuration.
Botulism	Gray, shiny spots on the conjunctiva (inner surface and eyelid) resulting from malnutrition, especially vitamin A deficiency.
Brine	Frequently fatal poisoning caused by toxin produced in inadequately sterilized canned food by the bacteria <i>Clostridium botulinum</i> .
Broil	Salt solution (common salt solution) above one (excluding isotonic and normal saline).
Buffer	US term for grill.
Burfi	A mixture of an acid and its conjugate base that is capable of neutralizing either an acid or a base without appreciably changing the original acidity or alkalinity, i.e. pH.
Buttermilk	US term for grill.
Coeliac disease	A sweetmeat prepared with milk or <i>mawa</i> .
Calcification	Residue left after churning butter, 0.1–2.0% fat with the other milk constituents proportionately increased. Has a slightly acid flavour and a distinctive flavour due to diacetyl and related substances. It is a nutritious and refreshing drink.
Calorie	Common term for gluten sensitive enteropathy.
Caramel	Hardening of tissue by a deposit of calcium and also magnesium salts.
Carcinogen	A unit of heat measurement; in nutrition, the kilo-calorie is the amount of heat required to raise the temperature of 1 kg water through 1°C (conventionally from 15°C to 16°C).
Carnitine	Amorphous brown material formed by heating carbohydrates in the presence of acid or alkali. Also known as burnt sugar.
Casein	Substance able to induce cancer.
Cathartic	A cofactor derived from methionine and lysine; carnitine facilitates transfer of long chain fatty acids across the mitochondrial membranes for use as an energy source.
Catheter	The principal protein in milk.
	A medicine used to produce evacuations of the bowels, a purgative.
	A very fine tube that can be threaded into the lumen of a blood vessel for infusion of fluids or withdrawal of blood.

Cation	An ion that carries a positive charge and migrates to the negatively charged pole, i.e. cathode.
Cellulose	Cellulose is composed of long chain beta-D-Glucose units linked by “beta-1-4 Glycosidic bonds”; It has no branches.
Ceriod pigment	Any of a variety of yellow to brown acid-fast pigments, insoluble in lipid solvents, representing end products of peroxidation of unsaturated fatty acids; they occur in many tissues and in a variety of physiological and pathological states.
Cheilosis	Lesions of the lips and the angles of the mouth.
Chemotherapy	Treatment of disease using chemical agents (drugs).
Chikoo	Sapota.
Chiwda	A spicy snack prepared using puffed rice or rice flakes. May also contain seasoning, groundnuts, sesame seeds, cashewnuts, raisins, dry coconut, etc.
Cholesterol	The commonest member of the sterol group; found in animal fats and also made within the body; a constituent of gallstones and of atheroma.
Chyme	The semi-fluid material produced by the gastric digestion of food.
Claudication	Lameness or limping.
Collagen	Widely distributed fibrous protein that makes up the matrix of bone, cartilage and connective tissue. Used in the production of gelatin.
Colocasia	Edible leafy vegetable, which is heart-shaped with broad leaf (usually single leaf with long thick stalk)
Colon	The part of the large intestine beginning at the caecum and terminating at the end of the sigmoid flexure.
Colostrum	The thin, yellow, milky fluid secreted by the mammary gland a few days before and after birth, prior to secretion of mature milk.
Comminduted	Finely divided; used with reference to minced-meat products and fruit drinks made from crushed whole fruit, including the peel.
Conjunctiva	The mucous membrane covering the anterior portion of the eyeball, reflected upon the lids and extending to their free edges.
Cowpeas	Legume of the plant <i>Vigna catjang</i> commonly referred to as <i>chavli</i> or <i>lobia</i> .
Cramp	Painful, involuntary contraction of a muscle, generally occurs at night in normal individuals in a foot or a leg, and in swimmers; spasm of certain muscles which may be intermittent as in tetany, or occupational, resulting from their excessive use.
Creatine	A nitrogenous constituent of muscle; phosphorylated form essential for muscle contraction.

Creatinine	A nitrogen-containing substance derived from catabolism of creatine and present in the urine.
Creatinuria	An excess of creatine in the urine.
Curing	Method of preservation by treating with salt and sodium nitrate (and nitrite), which serves to inhibit growth of pathogenic organisms while salt-tolerant bacteria develop. During the pickling process the nitrate is converted into nitrite, which combines with the muscle pigment, myoglobin, to form the red coloured nitrosomyoglobin characteristic of pickled meat products.
Cyclic TPN	Administration of TPN solution for 12 to 18 consecutive hours usually at night followed by a 6–12 hour period of no infusion.
Deamination	Removal of the amino (NH) group from an amino acid.
Deep vein thrombosis	The formation of a thrombus (clot) in a deep vein.
Degradation	The breakdown of one compound to another, containing a smaller number of atoms reduced to smaller and simpler form.
Dehydration	(i) Excessive loss of water (along with electrolytes) from body due to diarrhoea, vomiting, or other conditions, threatening the life, if not adequately replaced in time. (ii) Scientific term for drying, but tends to be used for factory dried materials as distinct from wind dried, in case of food.
Dementia	Deterioration or loss of intellectual faculties, reasoning power, memory, and will due to organic brain disease, characterized by confusion, disorientation, apathy and stupor of varying degrees.
Dermatitis	Inflammation of the surface of the skin.
Dhokla	A fermented steamed preparation made using chana-flour or rice flour, with spices and seasoning. Eaten as a snack.
Dialysis	Separation of small molecules from the larger in a solution by virtue of their different rates of diffusion through a semipermeable membrane. Membranes are natural—such as pig bladder, egg parchment, or artificial—such as cellulose derivatives. The solution is usually placed in a bag of the membrane and this is immersed in water. The small molecules diffuse out into the water, leaving the larger molecules inside the bag. This is a frequent method of separating proteins from solutions of salts.
Diastole/Diastolic pressure	The rhythmic period of relaxation and dilation of a chamber of the heart during which it fills with blood.
Diffusion	The movement of particles from an area of higher concentration to one of lower concentration resulting in even distribution all over.

Disease	Closing or shutting up of blood vessels.
Distension	A state of dilatation.
Diuresis	Increased secretion of urine.
Diverticulosis	The presence of many diverticula or pouch or saclike protrusions on the wall of the intestine or any hollow part of gut.
Dosa	A snack prepared from a fermented batter made from rice and <i>udad</i> dal.
Dumping syndrome	Disorder following food ingestion characterised by sweating and weakness, due to rapid emptying of stomach contents into the small intestine.
Duodenum	First portion of the small intestine, extending from the pylorus to the jejunum.
Dysbiosis	An imbalance in gut microflora that may produce effects.
Dyspepsia	Indigestion or upset stomach.
Dyspnoea	Difficulty or distress in breathing.
Eclampsia	The late stage of pregnancy-induced hypertension characterised by proteinuria and often grand mal seizures occurring near the time of labour.
Emaciation	Wasting of the body; excessive leanness.
Emphysema	An anatomic alteration of the lungs characterized by abnormal enlargement of the air spaces distal to the terminal respiratory bronchiole, accompanied by destructive changes of the alveolar walls; abnormal presence of air or gas in the body tissues.
Emulsion	A system of two immiscible liquids in which one is finely divided and held in suspension in another, e.g. milk, mayonnaise.
Endogenous	From within; originating in the cells or tissues of the body.
Enteral nutrition	Provision of nutrients to the gastro-intestinal tract through a tube or catheter when oral intake is inadequate.
Enteric	Pertaining to the intestine.
Esterification	The process of converting an alcohol or an acid to an ester, i.e. compound of acid and alcohol.
Extrinsic	Vitamin B-12; term used by Castle prior to identification of the nature of the compound.
Exudate	A fluid discharged from the tissues.
Faeces	Stools. The excretory product after digestion is complete.
Fatigue	Feeling of tiredness, exhausted easily.
Fibre, crude	Indigestible part of foods as defined in the UK Fertiliser and Feeding Stuffs Act of 1932. The residue left after successive extractions with petroleum ether, 1.25% sulphuric acid and 1.25% sodium hydroxide minus ash, carried out under closely specified separation procedures.
Fibre, dietary	In nutrition, collective term for the structural elements of plant tissues which are not digested (or only partly digested) by man, e.g. cellulose, hemicelluloses, lignin,

	pectins and gums. They are of varying composition and have a range of physiochemical and physiological properties. It is the modern term for what was previously called roughage or bulk in food. Dietary fibre is different from crude fibre.
Fibrinogen	One of the proteins of the blood plasma which is responsible for the clotting of blood. Under the influence of thrombin it is converted to fibrin, which is deposited as a network of strands (threads, fibres) that trap the red cells and form the clot.
Fibroblast	Fibre-producing large stellate cell in which the nucleus is big, oval and pale staining. Fibroblasts are common in developing or repairing tissues where they are concerned in synthesis of fibrous protein, collagen.
Flatulence	Distension of stomach or intestine with gases.
Flavonoids	A subclass of phenol phytochemicals that are pigments and act as free radical scavengers.
Fluoridation	The process of adding fluorine.
Fontanelle	A membranous space between the cranial bones in foetal life and infancy.
Food fortification	Fortification involves the addition of nutrients to foods irrespective of whether or not the nutrients were originally present in the food.
Gastrin	A hormone produced by the mucosa of the stomach, which stimulates production of gastric secretions and motility.
Gastroenteritis	Inflammation of the mucosa of the stomach and in intestines.
Gelatinization	Swelling and increase in viscosity of the starch molecule due to absorption of water on heating. Each type of starch such as rice, maize, wheat, potato has its own gelatinization temperature. This varies between 60°C and 80°C. There are many substances, e.g. gelatin, pectin, algin, gums, etc. which also show, gelatinization.
Genistein	An isoflavone found in soya products.
Gestational diabetes	Diabetes that exists only during pregnancy.
Gingivitis	Inflammation of the gums (gingiva).
Glossitis	Inflammation of the tongue.
Gluconeogenesis	Formation of glucose from noncarbohydrate sources, namely, certain amino acids and the glycerol fraction of fats.
Glycogen	“Animal starch”—polysaccharide produced from glucose by the liver or the muscle.
Goitrogen	A substance that leads to goitre, a disorder of the thyroid gland.
Granulocytopenic	Condition characterised by an abnormal reduction of certain WBCs.

Haemagglutinin	Older name is haemagglutinins or phytoagglutinins; toxic substances found in many legumes which cause red blood cells to agglutinate <i>in vitro</i> . Raw or undercooked beans of some varieties of <i>Phaseolus vulgaris</i> cause vomiting and diarrhoea within two hours of consumption due to the high level of lectins, but they are rapidly destroyed by boiling.
Haematuria	Condition in which blood is present in the urine.
Haemochromatosis	A condition in which excessive iron absorption leads to skin pigmentation and deposits of haemosiderin in the liver and other organs.
Haemorrhage	Loss of blood from the vessels; bleeding.
Haemorrhoids	The blood vessels in the lower rectal or anal region.
Hallucinogen	A drug or substance that produces hallucinations.
Heartburn (Pyrosis)	A retrosternal burning related to reflux of acid fluid from the stomach into the oesophagus.
Heartburn	A burning sensation due to hyperacidity in the cardiac region over the pericordium or beneath the sternum, usually from the oesophagus.
Hemicellulose	A class of indigestible polysaccharides that form the cell wall of plants.
Hiatus hernia	A common disorder in which abnormal protrusion of stomach at oesophageal opening is seen.
Homoeopathy	A system of medicine expounded by Samuel Hahnemann, based on the simile phenomenon. Cure of disease is effected by minute doses of drugs which produce the same signs and symptoms in a healthy person as are present in the disease for which they are administered.
Homoeostasis	Internal state of balance maintained by the body's regulatory processes.
Homogenize	To make of uniform quality throughout, through pounding, beating and mixing.
Hormone	Substance produced by an organ (endocrine gland) to produce a specific effect on another organ.
Hydration	Absorption of, or combination with, water.
Hyperalimentation	Provision of unusually large amount of energy (usually intravenously).
Hyperaemia	Excess of blood in any part of the body.
Hyperbilirubinaemia	Excessive amount of bilirubin in the blood. A severe and prolonged physiological jaundice sometimes seen in a premature newborn.
Hyperemesis gravidarum	Prolonged and persistent vomiting during pregnancy.
Hyperkalaemia	An increased level of potassium in the blood.
Hyperlipoproteinaemia	Increased concentration of lipoproteins in the blood.

Hyperparathyroidism	State produced by an increased functioning of the parathyroid glands.
Hypertension	Increase in blood pressure above normal.
Hyperventilation	Abnormally rapid, deep breathing.
Hypoglycaemia	A lower than normal level of glucose in the blood.
Hyposmia	Diminished sense of smell.
Idli	A mixture of rice and black gram fermented and steamed before eating.
Immunocompetence	Ability to resist infection, disease.
Infant mortality	Infant deaths in the first year of life.
Infiltration	A process by which cells, fluid or other substances pass into tissue spaces or into cells.
Infarction	The formation of an area of dead tissue resulting from obstruction of blood vessels supplying the part, e.g. Myocardial (Heart).
Inflammation	The reaction of the tissues to injury, characterized clinically by heat, swelling, redness and pain.
Insensible perspiration	Perspiration that evaporates before it can be felt as a fluid on the skin.
Insidious	Pertaining to the progress of a disease with few, if any, symptoms to indicate its seriousness.
Insulin shock	Sudden severe lowering of blood glucose level with coma as a result of over dosage of insulin in diabetics or in the treatment of psychoses.
Interesterification	Fats are mixtures of triglycerides with various fatty acids and glycerol. By dry heat at 45 to -90°C there is an exchange of the fatty acids between the glycerol molecules—interesterification—with a consequent change in physical properties of the fat, e.g. lard is not a good creaming fat until it has been so treated.
Intermediate moisture foods (IMF)	Contain 15–49% moisture.
Intoxication	Intoxication is a condition that follows the administration of a psychoactive substance and results in disturbances in the level of consciousness, cognition, perception, judgement, and which affects behaviour, or other psychophysiological functions and responses.
Intracranial pressure	Pressure within the cranium.
Intractable	Not easily managed.
Intrinsic factor	Mucoprotein in gastric juice which facilitates absorption of vitamin B ₁₂ , deficient in patients with pernicious anaemia.
Irradiation	Exposure to radiation—generally used to sterilize various foods, as the radiations kill microorganisms.
Ischaemic heart disease	A local deficiency of blood to heart muscles, chiefly from narrowing of the arteries.

Isoflavones	A subclass of phenol phytochemicals, found in beans and other legumes (especially, soyabean) that may have cancer-preventing properties, especially against hormone-driven cancers.
Isomerisation	The chemical process by which a compound is transformed into any of its isomeric forms, i.e., forms with the same chemical composition but with different structure or configuration and, hence, generally with different physical and chemical properties.
Jaggery	A traditional non-centrifugal cane sugar consumed in Asia. It is a concentrated product of date, cane juice, or palm sap without separation of the molasses and crystals, and can vary from golden brown to dark brown in colour.
Jambhul	Jambhul. Small purple fruit.
Jaundice	Condition characterized by elevated bilirubin level of the blood and deposit of bile pigments in skin and mucous membranes.
Jejunum	Middle portion of the small intestine; extends from duodenum to ileum.
Joule	Unit of energy in the metric system; 1 calorie equals 4.184 joules; represented by J.
Jowar	Indian name for sorghum (<i>Sorghum vulgare</i>) (great millet. Kaffir corn, guinea corn).
Karanji	A deep-fried wheat preparation with a filling of coconut, jaggery, sugar, etc, enclosed in wheat-flour coat.
Karela	Bitter gourd.
Keratomalacia	Dryness and ulceration of the cornea resulting from vitamin A deficiency.
Kernicterus	Bilirubin pigmentation of gray matter of the central nervous system, especially basal ganglions, accompanied by degeneration of nerve cells.
Ketone	Any compound containing a ketone-CO grouping; ketone bodies include acetone, beta-hydroxybutyric acid and aceto-acetic acid.
Ketone bodies	Compounds formed during fatty acid oxidation, e.g. Acetoacetic acid, acetone, beta hydroxy butyric acid.
Ketosis	Condition resulting from incomplete oxidation of fatty acids and the consequent accumulation of ketone bodies in blood.
Khari biscuit	A salty biscuit prepared from the dough of refined wheat flour rolled out in layers.
Kheer	Porridge; a sweet, milk preparation using rice, semolina, vermicelli, etc.
Khichadi	A preparation made by cooking a mixture of rice and pulse with seasoning, spices, etc.

Kilocalorie	The unit of heat used in nutrition; the amount of heat required to raise temperature of 1000 g water through 1°C (from 15.5 to 16°C).
<i>Knol-khol</i>	A vegetable of <i>Brassica oleracea</i> var caulorapa.
Kokam	The dried rind of the fruit mangosteen.
Kwashiorkor	A form of malnutrition that is characterised by nutritional oedema with dyspigmentation of skin and hair. Serum albumin is more than 3.0 g/dl.
Labile	Chemically unstable.
Lamination	Arrangement in plates or layers.
Lard	Best quality fat surrounding stomach and kidneys of pig, also from sheep and cattle.
Lassitude	A state of exhaustion or weakness; debility.
Laxative	Substance that accelerates the passage of food through the intestine. If it alters peristaltic activity, it is termed a purgative; other types stimulate or depress the muscular activity of the gut. Epsom salts function similarly through osmotic pressure. Castor oil is hydrolyzed by lipase to liberate ricinoleic acid which irritates the intestinal mucosa. Drugs such as aloes, senna, cascara, rhubarb and phenolphthalein irritate the intestine.
Legume	Seeds of the Leguminosae, including peas, beans and pulses. There is no difference between the terms 'peas' and 'beans' apart from common usage; the term 'pulses' or grain legumes refers to the dried seed, as distinct from the immature seed eaten with the pod, and according to the classification used by the Food and Agriculture Organization, excludes oilseeds, soya beans and groundnuts (although the last two are members of Leguminosae).
Lenticular	Pertaining to or resembling a lens.
Lesion	The alteration, structural or functional, due to the disease; commonly limited to morphological alterations.
Leucocyte	White blood cells, normally 5000–9000 per cubic millimetres; includes polymorphonuclear neutrophils, lymphocytes, monocytes, polymorphonuclear eosinophils and polymorphonuclear basophils. A 'white cell count' determines the total; a 'differential cell count' estimates the numbers of each type. Fever, haemorrhage, violent exercise cause an increase—leucocytosis; starvation and debilitating conditions cause a decrease—leucopenia.
<i>Lichi</i>	The fruit of <i>Nephelium litchi</i> .
Lignins	Woody part of plants; a noncarbohydrate component of dietary fibre.
Limiting amino acid	That essential amino acid present in the protein in question in least amount (relative to the dietary needs). The ratio between the amount of the limiting amino acid

Lipaemia	and the requirements serves as a chemical estimation of the nutritive value of the protein. Most cereal proteins are limited by lysine, and most animal and vegetable proteins by the sulphur amino acids (methionine plus cystine).
Lipoprotein	The presence of a fine emulsion of fatty substance in the blood.
Lipotropic	A conjugated protein that incorporates lipids to facilitate transportation of the lipids in an aqueous medium.
Lithiasis	Substances that are connected with the movement of fat, e.g. choline, methionine, lipocacic (pancreatic extract) are lipotropic substances, They prevent fatty infiltration of the liver.
Lymph	The formation of calculi of any kind.
Lymphocyte	The colourless, odourless, slightly alkaline fluid intermediate between the blood and the tissues; the medium in which oxygen and nutrients are conveyed from the blood directly to the tissues, and waste products back to the blood. Eventually, added to venous blood, chemically it is similar to blood plasma; contains salts, serum albumin and globulins, fibrinogen, prothrombin and leucocytes (lymphocytes). It circulates through special lymphatic system.
Maida	A cell formed primarily in lymphatic tissue in many parts of the body, as lymph nodes, spleen and tonsils, morphological blood, and usually classified according to size.
Maillard reaction	Refined 'wheat flour'.
	Two processes (reactions) in foods can produce a brown colour. One is the enzymatic oxidation of phenolic substances, e.g. the cut surface of an apple. The other is a reaction between proteins or amino acids and sugars, and is variously known as the Maillard reaction, the browning reaction and nonenzymic browning. It takes place on heating or on prolonged storage and is one of the deteriorative processes that take place in stored foods, It is accompanied by a loss in nutritive value, since the part of the protein that reacts with the sugar is the free amino part of the lysine. This complex is not digested and there is thus a reduction in the biologically available lysine.
Mannitol	A sugar alcohol found in fruits. It is poorly digested and yields about half as much calories as glucose.
Marasmus	A form of malnutrition that is characterised by nutritional atrophy, severe, chronic calorie deficiency, and severe malnutrition. Serum albumin is more than 3.0 g/dl.
Masala	A mixture of several spices roasted and ground together for use in cooking.

Mayonnaise	Oil-in-water emulsion made from vegetable oil, vinegar, salt, spices, emulsified with egg yolk and thickened.
Menarche	Onset of menses in the female.
Metabolite	Any substance that results from physiological and biochemical changes within the organism.
Metastasis	Growth of malignant tissue that spreads to surrounding tissues.
Methi	Leaves or seeds of fenugreek.
Micelle	A complex of free fatty acids, monoglycerides and bile salts that allows for the absorption of lipid products into the intestinal mucosal cell.
Milliequivalent	Concentration of a substance per litre of solution; obtained by dividing the milligrams per litre by the equivalent weight of that substance.
	Most bacteria cannot grow at a_w below 0.9, yeasts below 0.85 and moulds below 0.7. The dehydrated foods have a_w lower than 0.6 and hence are resistant to microbial infestation.
Moth bean	A legume of <i>Phaseolus aconitifolius</i> , jacq. Also known as Dew Gram, Aconite bean.
Motility	Ability to move spontaneously.
Mucositis	Inflammation of the mouth membranes.
Mutagen	Substance able to produce genetic damage or change by affecting chromosomes of spermatozoa or ova.
Mycotoxin	Toxins produced by fungi (moulds) especially <i>Aspergillus flavus</i> under tropical conditions and <i>penicillium</i> and <i>fusarium</i> species under temperate conditions. The problem is created by the storage of food under damp conditions which favour the growth of the moulds. They include aflatoxin (on nuts and cereals); ochra-toxin (on meat products and pulses), patulin (on fruit products), zearalenone and sterigmatocystin.
Myocardium	The heart muscle. The muscles of heart.
Nankhatai	A baked preparation made with refined wheat flour or semolina, sugar and shortening.
Neonatal period	The first 28 days of life.
Neuritic	Pertaining to inflammation of nerve.
Niacin Equivalent	The total niacin available from the diet, including pre-formed niacin plus that derived from the metabolism of tryptophan; 60 mg tryptophan = 1 mg niacin.
NSAIDS	Non-steroidal anti-inflammatory drugs, e.g. Aspirin, Indomethacin.
Nucleic acid	Complex organic genetic material containing four bases—adenine, guanine, cytosine and thymine—attached to ribose and phosphate; e.g. RNA and DNA.
Nucleoprotein	Conjugated protein found in the nuclei of cells; yields a protein fraction and nucleic acid.

Nucleotide	A hydrolytic product of nucleic acid; contains a purine or pyrimidine base and a sugar phosphate.
Nutrient	Chemical substance in foods which nourishes, e.g. amino acid, fat, calcium.
Nutrigenomics	Nutrigenetics is concerned primarily with the interaction between an individual's genes and that individual's diet; when applied to the human genome generally, the field is known as nutrigenomics (or nutritional genomics).
Nyctalopia	Night blindness.
Occlusive vascular disease	Closing or shutting up of blood vessels.
Oedema	Presence of abnormal amounts of fluids in intercellular space, resulting in swelling.
Oliguria	Scanty secretion of urine.
Omega-3 fatty acids	Fatty acids with the first double bond located at the third carbon from the methyl end, e.g. Eicosapentaenoic acid found in marine organisms. Alpha linolenic acid has 18 carbons and 3 double bonds and is also of the omega-3 type.
Opiate	A preparation of opium. Any narcotic or soporific.
Osmosis	Passage of a solvent from the lower to the higher concentration when two solutions are separated by a semi-permeable membrane. It continues till equilibrium is reached.
Osmotic Pressure	The pressure that causes water or any other solvent to undergo osmosis.
Osteomalacia	A condition characterized by impaired mineralization caused by vitamin C and calcium deficiency.
Osteopenia	Very little bone mass at any stage of the life cycle; a specific definition that is based on bone densitometry.
Osteoporosis	Loss of bone tissue to the point that the specific skeletal site is unable to sustain ordinary strains; a specific definition that is based on bone densitometry.
Oxidative stress	The balance between the formation of toxic, free radical oxidation products and the biochemical reduction reactions that convert these compounds to benign end products.
Parenteral nutrition	Provision of nutrients directly into the blood stream intravenously.
Paresthesias	Abnormal sensation such as numbness, burning, pricking.
Parwar	Vegetable of the plant <i>Trichosanthes dioica</i> .
Pectin	A polysaccharide found in many fruits like apple and guava, having gelling properties.
Pedha	A sweetmeat made by evaporating milk, mixed with sugar.
Pentosan	Complex carbohydrates widely distributed in plants, e.g. fruit, wood, corncobs, oat hulls. Not digested in the body

Perosteal	but broken down by acid to yield the 5-carbon sugars or pentoses.
Peristalsis	Pertaining to or involving the periosteum (outer covering of bone).
Petechiae	The wave-like movement by which the contents in the alimentary canal are moved forward.
pH	Small, pin-point bleedings in the skin; one of the symptoms of scurvy.
Phosphorylate	Negative logarithm of hydrogen ion concentration, which expresses the acidity or alkalinity of a substance.
Photophobia	To introduce a phosphate grouping into an organic compound, e.g. glucose monophosphate produced by the action of enzyme phosphorylase.
Pica	Abnormal intolerance of, or sensitivity to, light.
Placenta	Compulsive ingestion of unsuitable substances having little or no nutritional value, e.g. starch, dirt or clay (amylophagia, geophagia).
Plaque	A vascular structure on the wall of the uterus developed specially for providing nourishment to the growing foetus.
Plasma	Any patch or flat area; atherosclerotic plaque is a deposit of lipid material in the blood vessel.
Plasticizers	Fluid portion of the blood without blood cells before clotting has taken place.
Platelets	A substance incorporated in an organic formulation or substance to maintain it in a flexible or plastic condition, preventing or retarding cracking or development of brittleness.
Pneumatic separation	Spindle-like white blood cells present in the blood and essential for clotting of blood. Also called thrombocyte.
Poach	Separation by means of air or gas pressure.
Polymeric	To cook an egg in boiling water or milk.
Polyp	Term referring to protein and carbohydrate molecules which appear intact or as an isolate.
Polyphagia	A smooth spherical or oval mass projecting from a membranous surface; may be broad-based or pedunculated.
Porphyrin	Excessive eating.
Postprandial	A pigmented compound containing four pyrrole nuclei joined in a ring structure; combines with iron in haemoglobin.
Post-menopausal	After a meal.
Premature (preterm)	Loss of bone mineral density involving mainly the trabecular bone tissue. Fractures of the distal radius and crush fractures of the lumbar vertebrae are common.
	Refers to an infant born before 37 weeks gestation.

Prostaglandins	One of the several physiologically potent compounds, of ubiquitous occurrence, that have a unique structure containing 20 carbon atoms and are formed from essential fatty acids, and with activities affecting the nervous system, circulation, female reproductive organs and metabolism.
Proteolytic	Affecting the hydrolysis of protein.
Prothrombin	Factor in blood plasma for blood clotting; precursor of thrombin.
Proximate analysis	Nearly complete analysis comprising protein, fat and mineral and by subtracting these from the total, calculating 'carbohydrate by difference'. The last value may be corrected for crude fibre.
Pruritus	Itching, an uncomfortable sensation due to irritation of a peripheral sensory nerve; a symptom rather than a disease.
Puree	Pulp of a vegetable or fruit such as tomato or mango.
Purine	Compounds containing the structure—double ring with 5-carbon atoms and four nitrogen atoms. They occur in nucleic acids. Caffeine and theobromine are purines. When taken in the diet, purines are excreted as uric acid. Sweetbread (pancreas) is rich in purines, followed by sardines and anchovies, then meat and fish, with little in vegetable, none in fruits and cereals.
Pyridine	Complex of nicotinamide with adenine, two molecules of ribose and two molecules of phosphate; also known as coenzyme I, Diphosphopyridine Nucleotide (DPN) cozymase and as Euler's yeast coenzyme. Essential part of the mechanism of oxidation in the tissues.
Pyrimidine	Compounds containing the structure-ring compound with four carbon atoms and two nitrogen atoms. They occur in nucleic acids.
Rabdi	A sweetmeat prepared by evaporating milk for a long time until it becomes thick, and contains sugar and condiments like saffron, cardamom, etc.
Ragi	A millet of the plant <i>Eleusine coracana</i> ; it appears like red mustard seeds.
Rajma	Dry French bean; legume of the plant <i>Phaseolus vulgaris</i> .
Rancid	Term that describes rank taste or smell that results from oxidative decomposition of fatty acids.
Rawa	Semolina, made from wheat; varies from coarse to very fine varieties.
Reconstitution	(1) To make into original state or volume or composition. (2) Continuous repair of progressive destruction of tissues.
Redgram dal	Pulse of ' <i>Cajanus cajan</i> ', also known as <i>arhar dal</i> , <i>tur dal</i> , <i>tuver dal</i> or pigeon pea.

Regurgitation	The backward flow of food; casting up of undigested food.
Resorption	A loss of substance from the tissue, e.g. loss of mineral salts from bone.
Retinopathy	Degenerative disease of the retina.
Retrogradation	When starch is heated with water for gelatinization and then allowed to stand, the association and rearrangement of amylopectin in swelled starch particles proceed to gradually harden the particles. This process is called the retrogradation of starch.
Sensible perspiration	Visible drops or beads of sweat.
Serum	The fluid portion of the blood that separates from the blood cells after clotting.
Sesame	<i>Sesamum indicum</i> —tropical and sub-tropical plant, also known as til. Seeds are small and, in most varieties, white; used whole in sweetmeats and to decorate cakes and bread and for the extraction of oil.
Sherbet	Arabic name for water-ice (sugar, water and flavouring), also known by French name, <i>sorbet</i> , and the Italian name, <i>granits</i> . Used to be served between courses during a meal to refresh the palate.
Shrikhand	A sweetmeat prepared using curds from which whey has been drained off. Also contains sugar, flavours and sometimes contain saffron, cardamom, permitted colours and in some types even fruit pulp.
Sloughing	Casting off of a mass of necrotic tissue.
Spasm	A sudden muscular contraction.
Specific Dynamic Action (SDA)	Thermic effect of food (abbreviated as TEF), also known as specific dynamic action (SDA) of a food or dietary induced thermogenesis (DIT), is the amount of energy expenditure above the resting metabolic rate due to the cost of processing food for use and storage. Simply, it's the energy used in digestion, absorption and distribution of nutrients.
Spleen	The largest lymphoidal vascular organ located immediately below the diaphragm on the left side; where the red blood cells are absorbed when their life is over.
Stasis	Retardation or cessation of the flow of blood in the vessels; congestion.
Steroid	A group of compounds similar in structure to cholesterol; includes bile acids, sterols, sex hormones. Glucocorticoids (cortisone), mineralocorticoids (aldosterone), etc.
Stomatitis	Inflammation of the mouth
Suji	Product obtained from wheat. May vary from coarse to very fine; Semolina.
Syndrome	A set of symptoms occurring together.

Syndrome X	A cluster of metabolic disorders, including NIDDM, hypertension, and dyslipidemia, that is characterised by insulin resistance.
Synthesis	Process of building up a compound.
Symbiotic	A more or less intimate association (co-existence), or union between organism of different species. The organisms are mutually benefited and sometimes so dependent on each other that life apart is impossible.
Systemic	Pertaining to the body as a whole.
Systole	The contraction phase of the cardiac cycle.
Tachycardia	Rapid beating of the heart.
Tandoor	An oven used for baking. Heat source used may be coal, kerosene or LPG.
Teratogen	Any agent (infectious, environmental or nutritional) that causes a malformation in the foetus.
Terpenes	The largest class of phytochemicals, found in a wide variety of plants.
Thalassemia	Anaemia secondary to defective synthesis of the globin part of the haemoglobin.
Thepla	A typical preparation made by using a mixture of flours and fenugreek leaves, referred to as <i>methi thepla</i> .
Thrombus	An aggregation of blood factors, mainly platelets and fibrin which, if small, can contribute to growth of plaque; if large, it can obstruct a blood vessel resulting in angina, myocardial infarction, or sudden death.
Toxin	A poisonous substance elaborated by certain organisms, e.g. bacterial toxins.
Toxoemia	A disorder of pregnancy characterized by hypertension, oedema, albuminuria.
Tranquillizer	Any agent that produces a calming or sedative effect without inducing sleep.
Transamination	Transfer of an amino group to another molecule, e.g. transfer to a keto acid, thus forming another amino acid.
Transferrin	Globulin that binds and transports iron from the gut wall to the tissue cells.
Transfusion	The introduction into a blood vessel of blood, saline solution or other liquid.
Tropical sprue	A syndrome of unknown aetiology that causes diarrhoea and malabsorption; does not respond to gliadin-free diet therapy.
Ulceration pregnancy	The process of formation of an ulcer, an open sore on a surface.
Ulcerative colitis	Ulcer of the colon, an idiopathic inflammatory disease involving primarily the mucosa and submucosa of the colon. It is peculiar to man and not contagious; manifested clinically by abdominal pain, diarrhoea and rectal bleeding.

Unsaturated	Characterizing an organic compound with double or triple bonds.
Upma	Preparation made from roasted semolina, seasoned, having soft consistency and eaten as a snack.
Uraemia	Presence of urinary constituents in the blood resulting from deficient secretion of urine.
Urea	Chief excretory nitrogenous constituent of the urine; formed by the liver as a breakdown product of waste proteins.
Ureter	Either of the long, narrow tubes conveying the urine from the pelvis of each kidney to the urinary bladder.
Urethra	The canal through which the urine is discharged, extending from the neck of the urinary bladder to the external urethral orifice.
Urticaria	Hives or nettle rash. A skin condition characterized by the appearance of intensely itching wheals or welts with elevated, usually white centres and a surrounding area of erythema. They appear in crops, widely distributed over the body surface, tend to disappear in a day or two, and usually are unattended by constitutional symptoms.
Usal	Preparation made from legumes like green gram (<i>moong</i>), mothbeans (<i>matki</i>) and cowpeas (<i>chowli</i>).
Vaal	Field bean; pulse of the plant <i>Dolichos lablab</i> .
Vanaspati	Purified, hydrogenated, vegetable oil, used in place of oil and <i>ghee</i> ; may be fortified with vitamins A and D.
Varan	Simple seasoned or unseasoned <i>dal</i> liquid preparation.
Varicose veins	Veins that have become abnormally dilated and tortuous, because of interference with venous drainage or weakness of their walls.
Vasodilation	Dilation of the blood vessels; the reverse is vasoconstriction.
Villi	The numerous finger-like projections that cover the mucosal surface of the small intestine.
Virus	A vast group of minute structures, in the range of 250 to 10 millimicrons, composed of a sheath of protein encasing a core of nucleic acids, capable of infecting almost all members of the animal and plant kingdom, including bacteria (bacteriophage), characterized by a total dependence on living cells for reproduction and lacking independent metabolism.
Water activity(a_w)	Ratio between vapour pressure of water in the food and that of pure water at the same temperature.
Xanthine	Derivative of purines, caffeine, theobromine, theophylline.
Xanthoma	Cholesterol deposits (from low density lipoproteins) seen on tendons and elbows.

Xerophthalmia	Dry, infected eye condition caused by the lack of vitamin A.
Xylose	Pentose, sugar found in plant tissues.
Yeast	Unicellular organism grouped with fungi, useful in the process of fermentation and brewing.
Yoghurt	Curd, sour and sweetened; may also contain fruit pulp.

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