Chapter 1

INTRODUCTION

Food is a necessity of life and must be consumed to sustain it. Scientifically, food may be defined as any substance that, when ingested, usually will supply nutrients such as carbohydrates, fats, proteins, vitamins, mineral elements and water that nourish the body. These furnish oxidative energy required to fuel body activities, provide materials for building and/or maintenance of body tissues and supply substances that act as regulators for body processes.

1.1 FOOD PROCESSING

Food processing involves any operation or operations that will alter the value of food. This may range from simple washing to the delicate and complicated processes of food preservation and developing new products. The main objectives are enhancement in shelf life, consumer convenience and preservation of nutrients. The food processing industry, therefore, is credited with all treatments received by food from its origin (land or sea) to the point in space and time when it is consumed. Thus, almost all foods are subject to processing of one type or another. Food processing is studied under the umbrella of Food Science and Technology.

1.2 FOOD SCIENCE

Food Science emerged as a discipline in the early 1950's as a result of accumulation of scientific information on food. It may be defined as a body of coherent and systematic knowledge that deals with understanding the nature and composition of food materials and their behaviour under various conditions to which they may be subjected. The study involves knowledge about the nature of food, i.e., its composition, behaviour when subjected to different conditions of processing, preservation and storage, the causes of spoilage and the principles underlying methods of processing and preservation. Moreover, Food Science may also be concerned with improving quality of the product so that it reaches the consumer in an attractive, safe and nutritious form.

1.3 FOOD SCIENCE AND TECHNOLOGY

In the present day context, the terms, Food Science and Food Technology are often used synonymously. These describe the whole set of changes through which a food passes from the time of harvesting to consumption. In other words, Food Science and Technology may be defined as the application of physics, chemistry, microbiology, engineering and nutrition to the handling, processing and storage of foods.

By definition, a food scientist or a food technologist is expected to be conversant with the problems connected with understanding the nature, handling, processing and storage of food. The subject is so vast and the problems so complex that it calls for a multidisciplinary approach. Usually a team of food scientists and technologists work together with experts in other disciplines to run a food processing industry. Therefore, a career in Food Science and Technology demands a broad educational background and the ability of the person to apply this knowledge whenever and wherever the need arise.

The food scientists and technologists are responsible for the safety, taste, appearance and nutrition of processed foods. They are expected to: -

a. select new and proper raw materials,
b. know the fundamental changes in composition and physical condition of food-stuffs that may occur during and subsequent to industrial processing,
c. develop new products, processes and equipment,
d. understand and control food manufacturing operations and
e. solve technical problems associated with food manufacturing, processing, storage and distribution.

Studies on food safety have triggered research into better detection methods for food-borne pathogens and toxins. Research on food toxicology, food allergies and sensitivities, emerging pathogens, hazards to special population groups are the priorities of food scientists of the day.

1.4 RELATIONSHIP WITH OTHER DISCIPLINES

Food Science and Technology involves application of the knowledge of some basic and applied sciences to the study, handling, processing, storage and distribution of foods. Primarily two distinct aspects in the field are recognized: -

a. The scientific aspects and
b. The technological aspects.

The study of Food Science is concerned with understanding the nature of food, and causes of spoilage, etc. These are closely related to physics, chemistry and biology in many respects. On the other hand, the technological areas of food preservation and processing require knowledge in different fields of engineering, processing, manufacturing, packaging and sanitation. Food Science and Technology is made up of several components that include food chemistry, biochemistry, food microbiology, sensory analysis, food engineering, packaging and sanitation.

1.4.1 Physics

Physics has contributed towards food handling and transportation equipment that are responsible for good quality of the raw material, Basic principles underlying heat exchange (cooling, heating), evaporation, etc., were revealed by physicists. The discovery of semi-conductors followed by transistors and chips has led to a revolution in the food industry. Furthermore, equipment used in food analysis has been developed by people with knowledge in physics. Determination of pH, relative humidity, permeability of gases and moisture in packaging materials and techniques for assessing the texture of both raw and processed foods have their origin in physics. The latest techniques used in food processing, including irradiation preservation and microwave heating, have been contributed by physicists.

1.4.2 Chemistry

The food molecules are complex, so also are the changes occurring in them. As such, the study of food chemistry is very complicated. Reactions occurring during spoilage and processing are of chemical or biochemical nature. The methods of food analysis, in most cases, are based on the characteristic properties of specific chemical groups like amino, carbonyl, carboxylic, phenolic and others. These methods have been evolved, in part, by the chemists.

Other changes observed in foods may be of biochemical nature. These include the ripening process and subsequent spoilage of fruits and vegetable as a result of enzyme activity. The study and analysis of enzymes and flavouring components involves aspects of biochemistry. The discovery of synthetic rubber has led to the development of the whole new field of polymer chemistry. This in turn has promoted the production of tailor-made, non-rigid, plastic packages that protect foods from oxidative rancidity and loss of moisture vapours. Knowledge of chemistry and biochemistry, thus, is of immense value to the food technologist.

1.4.3 Biology

A number of biological sciences are of significance in the study of Food Science and Technology. In the breeding of new varieties suitable for processing, the know-how of botany, plant breeding, genetics and plant physiology are necessary. Knowledge of plant pathology, entomology and parasitology is essential to grow healthy plants and animals. These are also required to keep the commodities safe from the attack of pests in the field and in storage chambers. Study of human physiology enables one to understand how the food will act inside the body. It is also useful in establishing processes that will inactivate or destroy antinutrient factors or fortify the foods.

Microbiology is an important biological science associated with Food Science and Technology. Microorganisms are the chief spoilage agents in foods. Therefore, their control is desirable if food industry is to thrive. A number of processing techniques have been developed to achieve this goal, e.g., pasteurization, sterilization, irradiation, etc. Moreover, activities of some microorganisms are usefully exploited in such processes as the production of leavened bread or alcoholic beverages by yeasts and the use of lactic acid bacteria in the production of dairy (yoghurt, cheese), meat (sausages) and vegetable products (pickles). Some organic acids, antibiotics, enzymes, vitamins, steroids, etc. are produced by the proper utilization of microorganisms.

1.4.4 Engineering

The conversion of raw agricultural commodities into finished products is an area where the role of engineering is prominent. Use of appropriate technology is essential to overcome short-term supply and long term-shortage. Several branches of engineering are indispensable in this regard. Chemical, biochemical, electrical, electronics and mechanical engineers have their role in developing processes and equipment for commercial plants. Almost all the advances in thermal processing have been the result of creative engineers. The applications of computer technology, microwave heating and other similar techniques have now become an integral part of the food industry.

Designing and maintenance of commercial food processing plants and equipment are jobs that engage the services of engineers. The study of problems related to heat and mass transfer of food materials, process flow for batch and continuous processes as well as plant and factory design are some areas in which engineering sciences are indispensable. Because of the added advantages of a sound engineering background to the food scientist, educational programmes in Food Technology heavily weighted with courses customarily found in a chemical engineering curriculum have emerged under the name of "Food Engineering".

1.4.5 Computer Science

Computers have influenced methodology of analytical and industrial instrumentation by facilitating industrial operations, including inventory, process and quality controls. It has enabled development of new tools with powerful capabilities for studying the physiochemical properties of materials particularly at microscopic, submicroscopic and molecular levels. In fact, modern instrumentation including spectroscopy, microscopy, calorimetry and rheological analysis is simply inconceivable without computer assistance.

Computers have also been used for data storage and retrieval, communications (including data transmission) and data analysis. They have also been used for molecular modeling, allowing much improved insights into molecular architecture and behaviour of molecules. While at present such modeling is difficult for complex systems such as foods, considerable progress has been made.

1.5 CAREER OPPORTUNITIES

The discipline of Food Science and Technology is being offered in Pakistan at Diploma level (DAE) in Faisalabad and Sahiwal. It is also being offered at Women Polytechnic in Karachi for female students. There are now over 25 universities awarding degrees at graduate and postgraduate levels. The prominent ones are University of Agriculture Faisalabad, GC University Faisalabad, PMAS Arid Agricultural University Rawalpindi, Sindh Agricultural University Tandojam, University of Karachi, Karachi, KPK Agricultural University Peshawar, Gomal University D.I. Khan, University of Poonch Rawalakot, University of Veterinary and Animal Sciences Lahore, International Karakoram University Gilgit, University of the Punjab Lahore and BZ University Multan. The graduates from these institutions are serving in every part of the country and abroad in industry, education or government organizations.

1.5.1 Career in Food Industry

Food processing is the largest industry in the world in terms of manpower employed, while it ranks second in Pakistan. In this industry food technologists are engaged in processing plants that convert raw food into products such as beverages, breakfast cereals, baked goods, dairy products, pickles, jams, snacks, meat products, confectionery and convenience foods. They are also involved in the food ingredient plants that process and manufacture salt, pepper, spices, flavours, colours, preservatives, antioxidants and others.

Food technologists work in quality assurance to secure that food in every stage of processing meets the government and consumer standards. They are busy in quality control of raw materials, ingredients, packaging materials, in-process testing, final batch release and ensuring the shelf life of processed products. They work in product development where there is no limit to the number of ways the food supply can be used. They prepare new products and standardize recipes. In the process development, they are responsible for innovations in processes. On the processing floor, the food technologists are busy in controlling men, machines and materials to guarantee production of safe and nourishing products within the budget.

A number of food technologists, after obtaining work experience, are diversifying their expertise by gaining an MBA degree. They work in managerial cadre in the food industry. Some also find jobs with suppliers of food processing equipment, ingredients and supplies as technical sales executives.

1.5.2 Career in Food Service Establishments

Large catering organizations, chain restaurants and airlines are demanding new, more convenient and a greater variety of foods. With the opening of multinational restaurants, the demand for food technologists has increased. Organizations such as KFC, McDonald, Pizza Hut, Dominos, Fat Burger, Burger King, OPTP, Bar B Q Tonight, Salt & Pepper, Subway and others are employing food technologists, especially in their quality assurance and product development sections.

The need of health institutions (hospitals) is formulation of healthful diets for the healthy and the sick with desired nutrients. This has given rise to the concept of designer foods. Food scientists and technologists can find openings in these establishments quite attractive, interesting and challenging.

1.5.3 Career in Teaching Institutions

Food Technologists opting for academic positions find jobs in over 30 academic institutions in the country. For this, a minimum of master's degree is required. However, for entry as Instructor in Polytechnics, DAE is sufficient. In the academic institutions, they are assigned various courses for teaching. In this capacity these food technologists keep themselves abreast with the latest developments in the discipline. The job description in the universities also includes conducting and supervising research.

1.5.4 Career in Research Institutes

There are numerous government research institutes in the country that employ food technologists as Scientific Officers or equivalent. Among these are PCSIR, Pakistan Atomic Energy Commission, Pakistan Agricultural Research Council, Provincial Agricultural Research Institutes and others. In these institutions the main thrust is to conduct basic and applied research in food chemistry, food microbiology, nutrition, food toxicology and product development. A postgraduate degree in Food Technology is preferred as the basic qualification.

1.5.5 Career in Other Organizations

Besides these, food professionals also enter the extension wing of the Provincial Agriculture Departments as Agricultural Officers. The recently established Punjab Food Authority has more than 1000 openings in different cities. Similar opportunities are being created in other provinces. In non-governmental organizations (NGOs), they are employed in social action programmes. Some have even meritoriously passed the civil service examinations and are now in the civil services. Some professionals have even set up their own food processing business and are running it successfully. Others are working independently as consultants guiding the food industry. Of course, many have found jobs overseas. They are employed in the Middle East, Europe, USA, Canada, Australia and in other parts of the world.

1.5.6 Potential Openings

In addition to the above, job opportunities are also available for food professionals in Export Promotion Bureau of Pakistan, Ministry of Agriculture and other similar organizations. For the production of halal foods, Pakistan has enacted "Pakistan Halal Authority Act 2016" that requires, among others, Food Technologists on panels of all halal certification bodies.

1.6 PROFESSIONAL SOCIETY

The Pakistan Society of Food Scientists and Technologists (PSFST) is the professional body of the food scientists and technologists in Pakistan. The Head Office of this Society is located in the National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad. The objectives of the Society are:

a. to promote the cause of Food Science and Technology and Nutrition;
b. to improve the professional competence of Food Scientists and Technologists;
c. to provide professional communications through technical publications, scientific meetings, seminars, symposia, lectures, workshops, etc. and
d. to encourage education and training at all levels in various fields of Food Science and Technology.

The Society is working to create strong linkages between the private (food and allied industries) and the public sectors (universities and research institutions). It holds annual Food Science Conferences and publishes Pakistan Journal of Food Sciences. The membership categories are Professional, Associate, Student, Emeritus, Honorary, Life and Corporate Members.

Prof. Dr. Muhammad Shafiq Chaudhry (Lahore) was the Founding President from 1990 to 1997. Prof. Dr. Muhammad Saeed (Peshawar) succeeded him for the next tenure (1998 – 99), while presently Dr. Faqir Muhammad Anjum (Faisalabad) is the President. Prof. Dr. Javaid Aziz Awan has been the Secretary of the Society for a decade (1990 – 99), while Prof Dr. Tahir Zahoor (Faisalabad) is currently holding this important office.

Chapter

6

MACRO FOOD CONSTITUENTS

Water, carbohydrates, lipids and proteins are usually present in large quantities in foods, while vitamins and inorganic materials are found in smaller amounts. Besides these nutritionally important components, foods also contain other constituents such as colours, flavours, organic acids and toxic substances.

6.1 WATER

Water is chemically composed of two molecules of hydrogen and one of oxygen. It has the chemical formula of H_2O. Water has a molecular weight of 18.01534, melting point at 1 atmosphere of 0.000°C and boiling point of 100.000°C. It exists in all the three forms, i.e., as gas, liquid, and solid. It is invariably present in liquid form in relatively large amounts in all foods except a few like common salt, sugar and vegetable cooking oils. Foods rich in water are fruits, vegetables, meat, milk and beverages such as tea, coffee, carbonated drinks and '*lassi*' (Table 6.1).

The water molecule dissociates to yield H^+ and OH^- ions: -

$$H_2O \longrightarrow H^+ + OH^-$$

Thus, it is both a proton donor and a proton acceptor, and hence is neutral. When an acid is added to water, it increases the proton donors (H^+) and makes the water acidic. The addition of an alkali increases the proton acceptors (OH^-) and makes the water alkaline.

Foods contain numerous substances including organic acids such as acetic, citric, oxalic, malic and tartaric in their water; hence have a pH below 7.0.

Table 6.1 Average water content in some selected foods (g/100g)

Food	Water	Food	Water
Almond	4.3	Ghee, buffalo	0.2
Apple	84.7	Halwa, suji	21.3
Banana	73.5	Honey	14.8
Beef	62.9	Mango, ripe	81.6
Bread	35.4	Milk, buffalo	82.6
Butter	16.5	Orange, sweet	87.8
Carrots	82.5	Peanut, roasted	4.5
Chapatti	30.9	Pistachio	4.2
Chicken meat	68.7	Potato	77.1
Chickpea, cooked	51.9	Soybean oil	0.0
Cucumber	95.1	Spinach پالک	92.7
Curd	90.1	Tomato	93.5
Eggs, boiled	74.3	Walnut	3.3
Fish, Shanghara	72.4	Wheat flour	12.7

Source: Hussain (2001)

6.1.1 Nature of Water in Food

Water exists in foods as free and as physically and chemically bound water. The free water, as found in tomato and orange juice, is available for chemical and biochemical reactions as well as for use by the microorganisms. This water can be frozen or removed from the food system. In physically bound water, the forces that are involved are of a physical nature. Such physical binding may predominate in the type of water binding seen in emulsions, gels, etc. Chemically bound water, involves chemical linkages of water molecules to various constituents such as carbohydrates and salts as water of hydration. Such bound water is very difficult to remove during drying and may not separate out during freezing.

The bound water provides reduced chemical and biochemical reactions as well as microbial activity depending upon its degree. In foods with 0 to 25% equivalent relative humidity (ERH), water is unfreezable and food is quite stable. The stability increases with lowering of water. Auto-oxidation occurs in such foods. In foods with 25 to 80% ERH, freezing point of tissues is reduced or is unfreezable, while foods are liable to deteriorative changes such as non-enzymatic browning, enzyme activity and hydrolytic and oxidative reactions. In foods with 80 to 99% ERH, there is a reduction in the freezing point of tissue. Growth of microorganisms, enzyme activity, oxidative and hydrolytic reactions and nonenzymatic browning take place in foods.

6.1.2 Nature of Food Dispersions

Water molecules have a dipole nature and dissolve salts because of attractions between the water dipoles and the ions that exceed the force of attraction between the oppositely charged ions of the salt. Non-ionic, but polar compounds are dissolved in water because of hydrogen bonding between water molecules and groups such as alcohols, aldehydes and ketones. Several components are found dispersed in water phase in the foods. Among these are carbohydrates, lipids, proteins, vitamins, mineral elements, organic acids and others. Food solutions are dispersions in which solid or semi-solid particles are evenly distributed in water. These dispersions may be colloidal (particle size from 1 nm to 0.5 μm) or coarse (above 0.5μm).

Colloidal solutions are made up of long chain macromolecules consisting of aggregated molecules of proteins, polysaccharides or lipids. Examples are solutions containing gums, pectic substances, proteins and lipids (e.g. jams, jellies, and milk). The macroparticles in coarse solutions can be crystals, semi-crystalline aggregates or amorphous flocks, e.g., ketchup.

Food gel is another type of dispersion that consists of a continuous phase of interconnected particles intermingled with a continuous water phase. The gels have various degrees of rigidity, elasticity and brittleness depending upon the gelling agent (e.g., pectin, carboxymethyl cellulose, cornstarch, gums). The properties of the gel depend upon type and concentration of the gelling agent, pH and temperature. Jams, jellies and marmalades are typical examples of food gels.

Emulsion is a dispersion in which two immiscible liquids are dispersed. This has two phases: dispersed phase (droplets of one liquid) and a continuous phase (the other liquid). This is usually unstable as the dispersed droplets float (e.g. of oil). Food emulsions normally consist of water and a plastic lipid such as oil, fat, wax, etc. Emulsifying agents increases the stability of the emulsions. Butter and margarine are water-in-oil emulsions, while milk, cream and mayonnaise are oil-in-water emulsions.

6.1.3 Role of Water in Foods

Water is essential for all chemical reactions that occur in a living organism. It is an important constituent and governs the rates of many chemical reactions. It provides a medium in which nutrients, enzymes and other chemical substances are dispersed. Water is a reactant in such reactions as hydrolysis. It also serves as a transport medium and carries nutrients to the cells and removes the wastes.

Water contributes greatly to the desirable native qualities of foods. The presence of water in the correct amount and form is necessary for acceptable quality of food. The percentage of water and the state in which it appears are important in determining the storage life of a food. Fresh fruits and vegetables are high in available moisture. These have a shorter shelf life than grains and dry seeds that contain much less water, mostly bound in the cells.

6.1.4 Water in Human Body

The human body consists of about 60 to 70% water. Most of it is taken in the form of drinking water and beverages (carbonated, non-carbonated, juices, tea, 'lassi'). A reasonable proportion of the body requirements are also met from other foods, while some is produced inside the body as a result of oxidation of carbohydrates, proteins and fats. The normal water requirements of man vary with age, type of activity and climatic conditions. A sedentary man in a temperate environment may only need about 2L per day, but a physical labourer in a tropical region demands much more to meet his body requirements.

6.2 CARBOHYDRATES

Carbohydrates are compounds that chemically contain carbon, hydrogen and oxygen — the latter two elements usually existing in the ratio of 2:1 as they do in a water molecule. Carbohydrates are formed in the green parts of plants from carbon dioxide of the atmosphere and water from the soil through the process of Photosynthesis: the sun's rays serve as the source of energy. In its simplest form, the photosynthetic process can be represented by the following equation: -

$$6CO_2 + 6H_2O \xrightarrow{\text{Photosynthesis}} C_6H_{12}O_6 + 6O_2$$

6.2.1 Classification of Carbohydrates

Carbohydrates are classified into two broad groups - simple and compound. Simple carbohydrates are those that cannot be hydrolysed into anything simpler, e.g. dioses, trioses, tetroses, pentoses, hexoses, heptoses, octoses, nonoses and decoses. Only some trioses, pentoses and hexoses occur in nature. Out of these the most significant are the hexoses that are also known as monosaccharides.

6.2.1.2 Simple carbohydrates and sugars

Monosaccharides are the simplest form of carbohydrates and cannot be hydrolyzed any further by acids or enzymes. Examples are glucose (dextrose), fructose (levulose) and galactose (Fig. 6.1). Two monosaccharides, glucose and fructose, are found in plants especially fruits. Galactose does not exist in nature in the free form, rather as part of the disaccharide lactose and is released only when lactose is hydrolyzed.

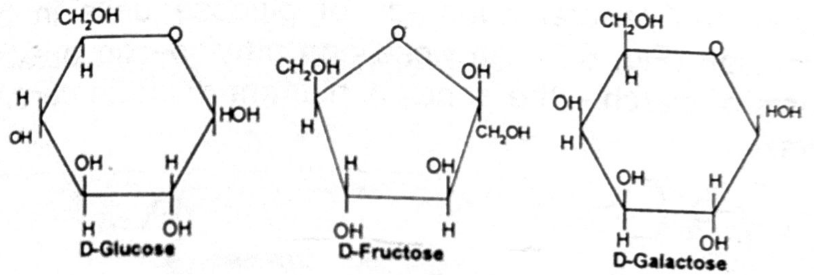


Fig 6.1 Monosaccharides

Disaccharides are formed when two monosaccharides condense together with the loss of a water molecule. Examples are sucrose (cane, beet or common household sugar), maltose (malt sugar) and lactose (milk sugar). When these disaccharides are hydrolyzed, they yield their respective component monosaccharides:

Glucose + Glucose $\longrightarrow$ Maltose + Water

Glucose + Fructose $\longrightarrow$ Sucrose + Water

Glucose + Galactose $\longrightarrow$ Lactose + Water

The monosaccharides and disaccharides are collectively referred to as sugars. These are, in general, white crystalline compounds, soluble in water and sweet tasting. On the basis of an assigned sweetness of 100 units to sucrose, fructose, glucose and galactose possess a sweetness score of 173, 74 and 32 units respectively. On the same scale the disaccharides lactose and maltose have a relative sweetness of 16 and 32 units respectively.

Sugars when heated intensely will turn brown (caramelize). This is an important property exploited in the manufacture of several products where caramel colour or flavour is necessary e.g., sweets, custards, ice cream and beverages.

6.2.1.2 Compound carbohydrates – Oligo- and poly-saccharides

Oligosaccharides are formed when about 3–7 monosaccharide molecules are condensed. Two common oligosaccharides found in legumes and associated with flatulence in man are the trisaccharide (raffinose) and the tetrasaccharide, starchyose.

Polysaccharides result when more monosaccharides than are found in oligosaccharides condense. The general formula for the polysaccharides is $(C_6H_{10}O_5)n$, where n represents the number of monosaccharide units linked together. The monosaccharides may join together to form straight or branched chain polymers, amylose and amylopectin, respectively. Amylose, the straight chain polymer (Fig. 6.2), contains between 70 to 350 glucose units per chain. Amylopectin has several hundreds of glucose units in branched chain formation (Fig. 6.2). Amylose and amylopectin are the major components of starch – the principal nutrient found in cereals, roots and tubers.

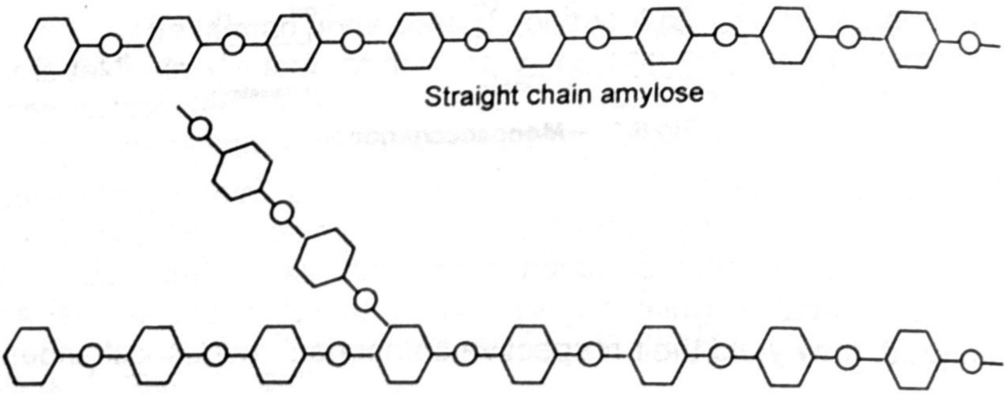


Fig. 6.2 Straight and branched chain fractions of starch

Starch is non-crystalline white powder, insoluble in cold water. It can be hydrolyzed into simpler molecules by either heating with an acid or a suitable enzyme. Corn syrup is produced by hydrolysis of cornstarch. In the production of beer, the enzymes contained in germinated barley (malt) are responsible for the conversion of starch into maltose – the disaccharide that is utilized by the brewery yeast. When starch is heated in water (moist heat) it produces a gel — an important property exploited in the thickening of gravies, soups, sauces, in the baking of bread and production of custards.

Other polysaccharides, apart from starch, include cellulose, glycogen, pectin, agar and alginate. Cellulose is the principal structural carbohydrate in plants. It is unaffected by the digestive enzymes of humans and other monogastric animals, where it serves as a form of fibre and provides bulk to the diet. Ruminants can digest cellulose through the activities of microorganisms in their rumens. Glycogen is the stored reserve carbohydrate in the animal body. In response to energy needs, the animal or human draws upon this source. Pectin is mainly found in fruits and some root vegetables. Under certain conditions it has superior gelling properties than starch and, hence, is used in the manufacture of such products as jams, jellies and marmalades. Agar and alginate, extracted from seaweeds, are also capable of forming gels and are used in many foods as gelling agents. Agar is especially used in the manufacture of culture media for microorganisms. Cellulose, pectin, agar and alginate have no nutritive value for human beings except as bulking agents.

6.2.2 Carbohydrates in Human Nutrition

In the human body digestible carbohydrates (sugars, starches) mainly serve as sources of energy. These are converted into monosaccharides in the digestive tract and when absorbed, yield about 16 kJ (3.75 kcal) of energy/g after oxidation. If carbohydrates in excess of body energy needs are consumed, part is stored as glycogen and the rest converted to fat for storage in adipose tissue.

The major sources of carbohydrates in the diet are cereals such as wheat, rice, corn and their products (bread, biscuits, cakes), and roots and tubers (potatoes and sweet potatoes). Fruits and vegetables also supply appreciable quantities of carbohydrates, especially sugars and dietary fibre (Table 6.2).

Table 6.2 Carbohydrate contents of some selected foods

Food	Carbohydrates g/100g	Fibre g/100g
Almond	20.2	1.7
Apple	13.6	0.8
Banana	25.2	0.5
Butter	1.1	0.0
Carrots	9.0	0.8
Cauliflower	5.1	0.8
Chapatti	56.6	0.8
Chicken meat	0.0	0.0
Chickpea, cooked	29.6	3.4
Corn flour	70.0	2.0
Cucumber	3.2	0.3

Food	Carbohydrates g/100g	Fibre g/100g
Curd	3.2	0.0
Eggs, raw	0.9	0.0
Fish, Shanghara	1.8	0.0
Ghee, buffalo	0.0	0.0
Goat meat	0.0	0.0
Guava, whole	15.0	5.3
Gur	90.1	0.0
Honey	86.5	0.1
Mango, ripe	14.4	0.6
Milk, buffalo	4.9	0.0
Orange, sweet	8.6	2.3
Peanut	23.4	2.7
Potato	20.2	0.4
Rice, polished	79.3	0.4
Soybean oil	0.0	0.0
Spinach	4.1	0.8
Sugar, white	99.5	0.0
Tomato	3.9	0.6
Wheat flour	72.6	1.3

Source: Hussain (2001)

6.3 LIPIDS

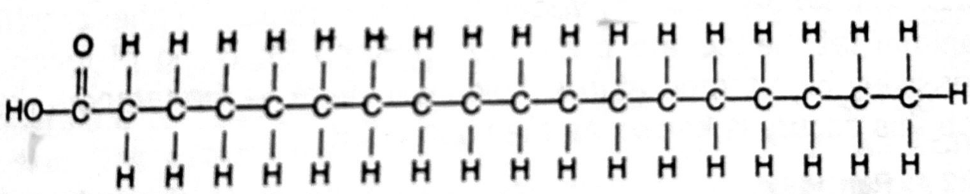
Lipids are a group of compounds soluble in organic solvents (chloroform, ether, carbon tetrachloride, petrol), but insoluble in water. Included in this group are waxes, free fatty acids, carotenoids, steroids, fats and oils, as well as some other substances. Chemically, lipids consist of carbon and hydrogen, while they also have oxygen in their structure. Fats and oils, the common constituents of foods, make up a sizeable percentage of food lipids.

6.3.1 Fats and Oils

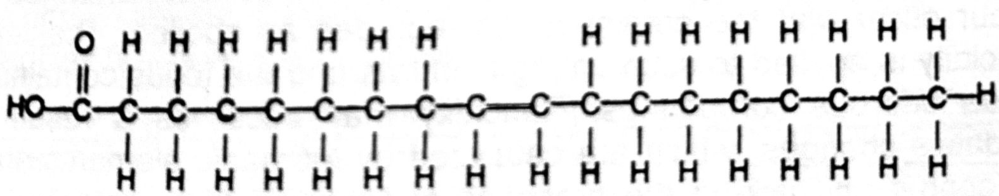
Fats are esters of saturated or unsaturated fatty acids with glycerol. ~~Some common saturated and unsaturated fatty acids are listed in Table 6.3~~. ~~Chemical structure of representative fatty acids is shown in Fig. 6.3~~. When one molecule of a fatty acid combines with one molecule of glycerol, the resultant compound is called a monoglyceride. When two fatty acid molecules combine with one molecule of glycerol, diglyceride is formed, while three molecules of

Table 6.3 Some saturated and unsaturated fatty acids found in foods

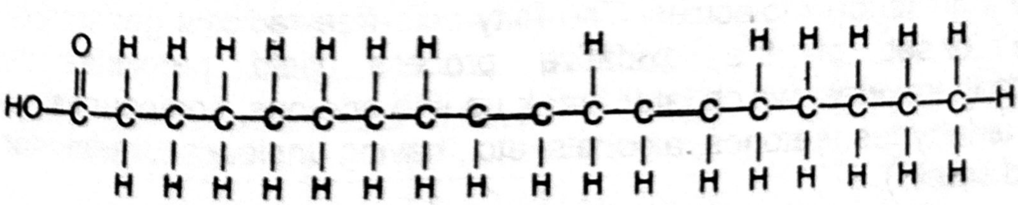
Fatty acid	Chemical formula	Typical source
	Saturated fatty acids	
Butyric	$CH_3(CH_2)_2\,COOH$	Butter fat
Caproic	$CH_3\,(CH_2)_4\,COOH$	Butter fat
Caprylic	$CH_3\,(CH_2)_6\,COOH$	Coconut oil
Capric	$CH_3\,(CH_2)_8\,COOH$	Palm oil
Stearic	$CH_3\,(CH_2)_{16}\,COOH$	Animal and vegetable fat
Arachidic	$CH_3\,(CH_2)_{18}\,COOH$	Ground nut oil
	Unsaturated fatty acids	
Palmitoleic	$CH_3(CH_2)_5CH{=}CH(CH_2)_7\,COOH$	Palm oil
Oleic	$CH_3(CH_2)_7CH{=}CH(CH_2)_7\,COOH$	Olive oil
Linoleic	$CH_3(CH_2)_4CH{=}CHCH_2\,CH{=}CH(CH_2)_7\,COOH$	Linseed
Arachidonic	$CH_3(CH_2)_3\,(CH{=}CHCH_2)_4(CH_2)_3\,COOH$	Animal lecithin



A saturated fatty acid – Stearic acid



A monounsaturated fatty acid – Oleic acid



A polyunsaturated fatty acid – Linoleic acid

Fig 6.3 Chemical structure of saturated and unsaturated fatty acids

fatty acids reacting with one of glycerol give rise to a triglyceride. Fats and oils are principally mixtures of triglycerides.

6.3.1.1 Properties of fats and oils

Fats are normally solid at ambient temperature owing to the presence of more saturated fatty acids in which the carbon atoms of the hydrocarbon chain are saturated with hydrogen. The oils, on the other hand, are liquid at ambient temperature since they contain more unsaturated fatty acids in which the hydrocarbon chain lacks a few atoms resulting in the formation of one or more double bonds.

Fats and oils can be made to mix with water in the presence of emulsifiers. The product formed when two immiscible solvent states are made miscible in the presence of an emulsifier is known as an emulsion. Whole milk is good example of a natural fat-in-water emulsion, while butter is a representative example of water-in-fat emulsion.

Fats and oils will react with alkalis to form soaps. Oils are fats liquid at room temperature having their melting point below room temperature. However, most fats melt between 30 and 40°C; being partly hydrocarbons, the fats and oils smoke when heated to above 200°C. The smoke point of vegetable oils is usually higher than that of animal fat, hence are preferred for deep fat frying of foods. At excessively high temperatures, lipids will ignite — the temperature at which this occurs is known as the flash point.

6.3.1.2 Rancidity

When fats and oils are stored for long periods, changes in odour occur and the commodity is regarded as spoiled. The term rancidity is applied to such changes in fats and the foods containing these odorous compounds. Rancidity may occur as a result of oxidative changes, which are catalyzed by inorganic elements such as copper and iron in the presence of light and high temperature. Oxygen, which is important in this reaction initiates reaction across the triglyceride molecules. The fatty acid free radicals generated at the onset of the oxidative process yield peroxides and hydroperoxides, which later break up into odorous, compounds such as aldehydes, ketones, alcohols, etc., having unpleasant rancid taste and smell.

The second type of rancidity, known as hydrolytic rancidity, occurs as a result of lipase hydrolysis of oils and fats. This enzyme breaks down the fatty acid-glycerol ester bonds in the presence of water, yielding the basic components, glycerol and fatty acid:

Lipases occur naturally in fats and oils but may additionally come from microbial sources. Effort is usually made to destroy these enzymes during oil processing. Like most other enzymes, lipases are denatured by heat. When fats and oils are stored in airtight containers in a dark, cool place, deterioration by oxidation is minimized. Addition of antioxidants such as tocopherols also helps retain the natural characteristics of the fats.

6.3.1.3 Applications of fats and oils

cooking

Fats and oils are commonly employed for culinary purposes in making stews, salads, frying and baking cakes, biscuits and other bakery products. These are primarily obtained from animal sources (tallow, butter) or plant materials (cotton seed, ground nut, soybean, corn, canola, and sunflower). Margarine is manufactured from refined hydrogenated vegetable oils and emulsified by votator process.

6.3.1.4 Nutritional significance of fats and oils

In the human body, fats and oils provide more than twice as much energy as the carbohydrates on equal weight basis. One gram of fat or oil will yield 38 kJ (9 kcal) of energy when oxidized in the body. The excess fat consumed by the individual is stored in the body and serves as energy reserve in times of need. The stored fat, especially in adipose tissues, helps to maintain constant body temperature by providing an insulating layer between the body and the skin. The same fat around the delicate organs such as kidneys protects them from physical injury. In addition, fats and oils are good sources of the essential fatty acids and vitamins A, D, E, and K that are necessary and cannot be synthesized by the human body. Table 6.4 gives fat content of some selected foods.

Table 6.4 Fat content of some selected foods (g/100g)

Food	Fat	Food	Fat
Almond	55.0	Ghee, buffalo	99.5
Apple	0.3	Goat meat	11.2
Banana	0.4	Halwa, suji	13.3
Beef	18.6	Honey	0.2
Bitter gourd	0.2	Jalebi	9.8
Bread	1.3	Lentil, cooked	1.4
Butter	80.6	Mango, ripe	0.3
Carrots	0.2	Milk, cow	3.9
Cauliflower	0.2	Peanut, roasted	44.1

Food	Fat	Food	Fat
Chapatti	1.2	Pistachio	55.7
Chicken meat	17.6	Potato	0.2
Chickpea, cooked	3.8	Rice	0.9
Corn flakes	0.4	Soybean oil	99.9
Curd	3.1	Sugar, white	0.0
Eggs, hen, raw	11.2	Tomato	0.2
Fish, Shanghara	3.4	Wheat flour	1.2

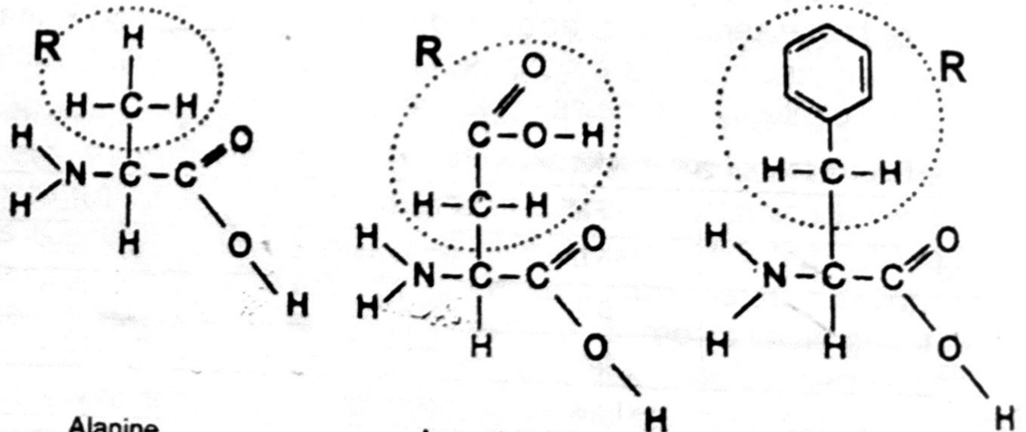
Source: Hussain (2001)

6.4 PROTEINS

Proteins are complex nitrogenous compounds of very high molecular weight. It has been estimated that about 2000 different proteins exist in nature. Proteins are classified on the basis of their reaction to heat (coagulable and non-coagulable) or on their solubility in water and salt solutions (e.g., globulin, albumin). All proteins are composed of amino acids linked together chemically to give the specific structure and characteristic properties.

6.4.1 Amino Acids

Amino acids are the basic building blocks of all proteins existing in nature. There are 20 naturally occurring amino acids that are found in different combinations in various proteins. The structural formulae of some amino acids are shown in Fig. 6.4.



Alanine Aspartic acid Phenylalanine

(where R represents the variable group specific to each amino acid).

Fig 6.4 Structural formulae of some amino acids

Each amino acid thus has an amine ($-NH_2$) and an acidic group ($-COOH$). Hence, they may be alkaline, acidic or amphoteric in reaction. The number and type of functional groups and the side chain structure form the basis for classifying amino acids into neutral, acidic, basic, aliphatic or aromatic types.

Nutritionally all amino acids are broadly classified into two groups — essential and non-essential. The essential amino acids cannot be synthesized by the human body or are synthesized in amounts insufficient to meet the body needs. Therefore, these must be included in the diet. The essential amino acids are: -

histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine,

The common sources of these amino acids are animal products (meat, milk, eggs, and fish) and plant foods such as cereals, legumes and leafy vegetables.

The non-essential amino acids can be synthesized from other amino acids in the human body and are not essential in the diet. These are: -

alanine, arginine, asparagine, aspartic acid, cystein, cystine, glutamic acid, glycine, proline, serine and tyrosine.

6.4.2 Formation of Proteins

In the formation of proteins, the amino group of one amino acid reacts with the acid group of another, liberating a molecule of water and forming the peptide link (Fig 6.5).

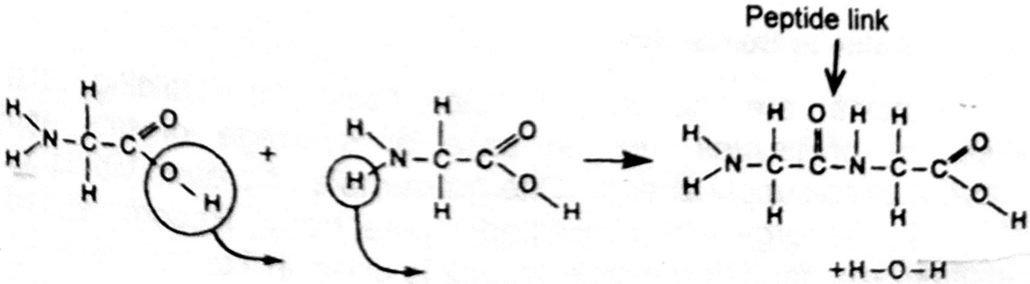


Fig. 6.5 Formation of a peptide

When only two amino acids link together through a peptide bond, the resultant product is called a dipeptide, when three are linked a tripeptide is formed and when several amino acids join together, a polypeptide is produced. Proteins contain a few hundred such peptide bonds — or in other words, a few hundred amino acids (out of the 20 naturally occurring) bond together to form a protein.

The characteristics of the proteins depend upon the number and types of amino acids present in them.

6.4.3 Applications of Proteins

Proteins serve prominent functional roles in foods. These are added to foods for a variety of reasons: solubility, foaming, emulsification, gelling ability and nutritional quality. These allow modifying flow properties, emulsifying, forming gels and foams, or binding water and fat. Proteins have applications in meat products, baked goods, dairy products, confectionery and beverages. A variety of dietetic, hospital and vegetarian food as well as infant formulae are produced with protein ingredients.

Highly soluble proteins are employed where emulsification, whipping and film formation are important. Less soluble proteins are desirable in applications with high protein levels and with limited emulsification or where protein–protein interactions are needed. In ice cream and whipped toppings, food foams are produced with proteins. Proteins are also used as emulsifiers in salad dressings and sausages. In the production of gelatin, yoghurt and bread dough, their gelling ability is used.

Proteins are modified by heat that makes food more palatable. It also makes proteins form gels or set structures (e.g. in yoghurt, sausages, bread). Heat denatures proteins and may be used to improve water-binding ability and emulsification. Proteins are hydrolyzed with acids, alkalis or enzymes to yield peptides and eventually amino acids. Acid hydrolysis produces hydrolyzed vegetable proteins that have meaty flavour profile. Alkali treatments are employed in the production of gelatin.

6.4.4 Proteins in Human Body

Proteins are needed in the body for building and maintenance of tissues, and in case of shortage of fats and carbohydrates to supply energy. One gram mole of protein yields 17 kJ (4 kcal) of energy when oxidized in the body. Recommended intake of proteins for different age groups is given in Table 6.3.

Some proteins such as enzymes, hormones and antibodies have special roles in living organisms. Enzymes are biological catalysts without which the control and execution of most body functions would be impossible. Similarly, hormones are essential to regulate the functions of different organs in the body. Antibodies are also proteins in nature and help fight against infections.

Table 6.3 Recommended daily intake of proteins

Group	Age	g/kg of body weight
Infants	0 – 6 months	2.2
	6 – 12 months	2.0
Children	1 – 3 years	1.8
	4 – 6 years	1.5
	7 – 10 years	1.2
Adolescents	11 – 14 years	1.0
	15 – 18 years	0.9
Adults	19 + years	0.8

Children need more protein on a body weight basis than adults because they are growing and building body tissues. Deficiency of protein in the diet can result in a disease known as kwashiorkor, a condition characterized by depigmentation of the hair and oedema.

Proteins of good quality for tissue building and repair are found in lean meat, poultry, fish, seafood, eggs, milk and cheese. Next best are dry beans, pulses and nuts (groundnuts, almonds, walnuts, etc.). Cereals and their products also provide some proteins, which are of lower quality than animal proteins. Vegetables and fruits are generally poor in protein content (Table 6.4).

Table 6.4 Protein content of some selected foods (g/100g)

Food	Protein	Food	Protein
Almond	17.0	Goat meat	18.1
Beef	16.6	Guava, whole	1.0
Bread	8.3	Mango, ripe	0.8
Butter	0.9	Peanut, roasted	24.6
Carrots	0.9	Milk, buffalo	4.1
Cauliflower	2.2	Pistachio	21.5
Chapatti	8.8	Potato	1.8
Chicken meat	20.1	Rice	6.7
Chickpea, cooked	12.4	Soybean oil	0.0
Eggs raw	11.8	Sugar, white	0.0
Fish, Shanghara	21.2	Tomato	1.3
Ghee, buffalo	0.2	Wheat, flour	10.9

Source: Hussain (2001)

Chapter 1

INTRODUCTION

HISTORY

Egyptian records describe that art of confectionery over 3000 years ago. Excavations of Herculaneum, buried under volcanic dust in A.D. 79, revealed a confectioner's workshop. The sweets of those ancient times were often based on honey, but sugar cane juices, boiled to concentrate, were also used in China and India.

The cultivations of sugar cane increased during the middle Ages. Sugar refining was developed in Persia in the seventh century, and the growing of cane spread through southern Europe to the West Indies and, eventually, to most tropical and subtropical parts of the world. Sugar is also obtained from beet, and production from this source was accelerated in Europe by the Napoleonic Wars and by World Wars I and II.

At the same time, a search for alternative sweeteners led to the development of products from corn and other starches. These now constitute an integral part of confectionery formulations and their production is a major industry.

RAW MATERIALS

1. Physical and Chemical Properties

The properties of the raw materials determine the nature of the confection, its quality, and its shelf life. These include the solubility of sugars and the viscosity of their solutions, the melting points and stability of fats, and gelatinization by colloidal materials such as starch and pectin. The reaction of milk products with sugars during cooking processes is an important factor (Maillard reaction). Microbiological activity arising from ingredients used or from external sources must be controlled to avoid spoilage.

2. Sweetening Ingredients

Sugar. Sugar is the main sweetening substance used in confectionery; chemically, it is pure sucrose. Sugar may be of cane or beet origin, and the modern commercial product has such a high degree of purity (>99.9%) that its origin cannot be recognized. In addition, partially refined sugars play a useful part in the flavoring of confectionery. These are variously described as brown sugar, Demerara, molasses, and golden syrup. All are derived from cane sugar because the equivalent products derived from beet have unsatisfactory flavors (→Sugar).

Invert Sugar. Invert sugar, a product of cane or beet sugar, is made by hydrolysis with acid or enzyme. Sucrose is a disaccharide which, when hydrolyzed, is split into the isomeric monosaccharides dextrose and fructose:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \longrightarrow \underset{\text{Dextrose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

The reaction occurs to some extent upon prolonged boiling of a solution of sugar, but it is greatly accelerated by the presence of an acid or an acid salt such as cream of tartar (Potassium hydrogen tartrate). The enzyme invertase is also used to bring about inversion and is employed to soften the texture of fondant cream centers. Commercial invert sugar, a solution of dextrose and fructose of about 77% concentration, is sometimes called artificial honey because its composition is similar to that of the natural product.

Corn Syrup, Glucose Syrup, and Liquid Glucose. Corn syrup is the name given in the United States to the product obtained by the hydrolysis of starch. Because different starches, e.g., potato, are used in other countries, glucose syrup seems to be a more appropriate and general name.

In 1811 the Russian chemist G.S.C. KIRCHHOFF discovered that a sweet substance could be made from starch by treatment with acid. Since then, many syrups of different viscosity, sweetness, and saccharide content, have been produced. Originally glucose syrup was made entirely by acid hydrolysis under pressure, but now the process has been extended to a combination of acid and enzyme treatment. This has resulted in considerable variation in the proportions of dextrose, maltose, and the higher saccharides, known as oligosaccharides. A more recent development has been the isomerization of the dextrose to fructose by further enzyme treatment (-Glucose and Glucose-containing Syrups).

Other Sugars. Dextrose is the ultimate conversion product of starch. The commercial forms are the monohydrate $C_6H_{12}O_6.H_2O$ and the anhydrous form. Dextrose has unusual crystallization properties and is less sweet than sucrose. These properties are useful in some confections.

Lactose is the natural sugar of mammalian milk and is an ingredient of confectionery in which mild products are used, e.g., caramels. Lactose is available-commercially and has very low sweetness and solubility.

Function of Sugars in Confectionery. The main reasons for the use of sugars in confectionery are (1) their ability to preserve food, (2) their contribution to body, flavor, and texture, and (3) their ability to enhance the flavor of other ingredients. However, in the technology of confectionery, the combination of these sugars is the important factor. The presence of glucose syrup, for example, will retard sucrose crystallization, increase viscosity, and provide a syrup concentration that resists microbiological action.

3. Other Raw Materials

Although the sugars described are the primary raw material, other ingredients play an important part in the formulation of the variety of confections available today.

Milk. Milk in its various forms is used in the manufacture of caramel, fudge, and toffee. Liquid mild is rarely used because of its high water content (87.5%), and concentrated or dried milk is the accepted ingredient (→ Milk and Milk Products).

Concentrated milk and sweetened condensed milk are considered best by most confectioners because they are readily dispersed in the preparation process. Milk powders are not easily reconstituted, and incomplete reconstitution will result in a rough texture. Condensed sweetened milk has about 40% added sugar; both this and milk powder may be produced in the nonfat form in which the original milk fat has been removed. In caramel formulation, milk fat may be replaced by another vegetable fat for reasons of economy. Nonfat milk ingredients are sometimes used in other high-moisture confections where there is some danger of partial decomposition of the milk fat.

Fat. Vegetable fats are used in may recipes and are usually refined and hardened natural oils (→ Fats and Fatty Oils). The one exception is cocoa butter, the natural fat of the cacao bean. The processing of fats is a specialized industry, and unrefined oils are unsatisfactory because of their poor stability and low melting point. Vegetable fats are produced mainly from palm kernel, coconut palm, soybean, peanut, and cottonseed oils, and their melting points are increased either by physical separation (stearines) or by hydrogenation. Palm kernel oil and coconut oil contain high proportions of short-chain fatty acids, e.g., lauric acid, and are called lauric fats. The remaining oils are then known as non-lauric and contain a larger proportion of long-chain fatty acids.

The origin of the fat has a considerable influence on texture, and the hardened lauric fats generally have a sharp fracture whereas the non-lauric have a more plastic consistency. Lauric fats are also susceptible to hydrolytic rancidity, which will cause objectionable soapy flavors resulting from the liberation of lauric acid.

In confectionery formulations, particularly those with high moisture, great care must be taken in the selection of other raw materials. Cocoa powder, milk powder, egg albumen, flour, and some spices, for example, must have a low microbiological count and be free from fat-splitting enzymes, e.g., lipase.

Minor Ingredients. Many other ingredients are used in compounding the very large number of confections. Gelatinizing and aerating agents are materials such as gelatin, agar, pectin, and egg albumen, used for making jellies and whipped or aerated products. Starches and modified starches are used as stabilizers and also in the preparation of a class of jellies. Soy flour may be regarded as a nutritional filler. Preserved fruit, jams, and dried fruit are often included in confectionery for their flavor, texture, and appearance. Nuts may be added in a comminuted form, as in marzipan, or in chopped pieces. In the latter case, the confection must be one of low moisture, such as hard caramel, toffee, or nougat. In higher moisture material, nuts lose their crispness because of the differences in water activity between the nuts and the matrix. Emulsifiers are needed to stabilize the fat despersion when fats are included in syrup-based formulations. The main emulsifiers are vegetable lecithin and glyceryl monostearate.

The appearance and flavor of a food are of major importance. Many flavors are used : some are natural, such as the essential citrus oils; others, such as vanillin, are synthetic. Selection and blending of flavors constitute an art, and no food, however well prepared, will be liked if the flavor is wrong. The color of food plays a significant part in its acceptability, but the colorant used must conform to legal standards approved internationally or locally. Certain natural colors, such as those extracted from vegetables, have universal approval, but in most countries, the list of synthetic colors allowed is relatively short.

Properties and Microbiology of Confectionery

Solubility and Syrup Concentration. The solubility of substances in water varies considerably and generally increases with temperature. Some materials are capable of forming supersaturated solutions; i.e., more substance is present in solution that would normally be present in a fully saturated solution at the same temperature. A supersaturated solution is formed by first heating the solid and solvent (sugar and water) until a concentrated solution is obtained. If this solution is then cooled without agitation and no solid is precipitated, a supersaturated solution is formed. Such solutions are unstable, and agitation will lead to precipitation.

The structure or texture of many confections is related to the solubility of the sugars and their ability to form supersaturated solutions. Crystallization may occur from some of these solutions upon agitations. This crystallization can be controlled, by addition of other sugars and regulation of viscosity, to give many different types of products. Fondants and fudge, which will be described later, are typical examples.

Sugar itself, or in combination with glucose syrup in water, can be concentrated to such a high viscosity by boiling that, on cooling, a stable glasslike product is obtained. This is, in effect, a highly supersaturated solution, containing about 98% solids and 2% water, which is the basis of boiled sweet (hard candy) production. No change will occur in this product over long periods of time if it is stored under dry conditions at ambient temperature. The presence of glucose syrup in the formulation improves stability.

The solubility of various sugars and mixtures of sugars plays another important role. The maximum solubility of sucrose, for example, is 67% at 20^{0}C, and this solution is susceptible to microbiological decomposition by yeasts and molds. If the total sugar concentration is increased by combination with other sugars such as glucose syrup or invert sugar, much higher solubilities are ensured. This is illustrated in Table 1.

High solubilities retard or prevent fermentation due to relatively higher osmotic pressure. Modern technology now recognizes that a minimum concentration of soluble solids and, consequently, a lower water activity in the syrup phase of a confection is necessary to curtail any microbial activity. The syrup phase is the liquid portion which contains some of the sucrose, all of the residual moisture, and all of the non-crystallizable carbohydrates. It may also contain a hydrated colloid, such as the milk protein used in fudge.

By mixing various types of sugars together, the total soluble solids of the solution can be raised to a level that is microbially stable, without crystallization taking place. Syrup phase concentration in a fondant or paste, such as marzipan, can be determined by forced filtration of a sample in a laboratory press and measurement of the refractive index of the syrup obtained.

were included in the formulation. Many ingredients such as cocoa power, milk powder, and egg albumen are now guaranteed by their suppliers to be lipase free.

Methods for the detection of lipolytic activity are described in publications that also indicate the significance of microbiology in the confectionery industry.

TYPES OF CONFECTIONERY

Some indication of the different types of confectionery has been given in the previous section. The solubility and crystallization properties of sucrose and its combination with other sugars are largely responsible for the physical differences in confectionery products. The major ingredients of all confectionery are sugars. In combination with fats, milk, gelatinizing agents, and minor substances such as emulsifiers and flavors, an extensive variety of confections is possible. The principal types are hard candies, fondants, caramels, jellies, and nougats. These are discussed in detail in the following section.

Boiled Sweets and Hard Candy. Hard candies and boiled sweets consist of a solution of sucrose and glucose syrup (the typical ratio is 3:2) boiled down to a concentration of about 98% solids. The hot syrup is cooled to a plastic state at which stage it is flavored, colored, and formed into shapes. The final confections are in a glassy, single-phase, amorphous state, and will remain so under conditions of dry and cool storage. The high viscosity of the supersaturated liquid prevents the sucrose from recrystallizing.

Pulled Candy. If, during the plastic condition, hard candy is subjected to a process of stretching and folding, air is incorporated and some crystallization is initiated, but forming is still possible. The degree of crystallization depends on the sucrose content, the ratio of sucrose to invert sugar, the temperature, and the period of pulling. If, subsequently, the formed pieces are subjected to humid heat, crystallization will be completed and a short candy known as Scotch rock or after-dinner mints is obtained. Structurally, these are similar to fondants but with a much lower moisture content.

Fondant. Fondant is a partly crystallized sugar-glucose syrup prepared by mechanical beating and cooling of syrup under controlled conditions.

The syrup is prepared by using a ratio of sugar to glucose syrup of 3:1-10:1 dissolved in water and then cooked to a concentration of about 88% solids. This is cooled to a supersaturated solution and then beaten during further cooling. The fondant so produced is a stiff paste, which is composed of two phases: a dry phase consisting of minute sugar crystals suspended in the wet phase of sugar, noncrystallizable carbohydrates, and water. The ratio of dry to liquid phase depends on the initial ratio of sugar to glucose syrup and moisture content. Because the moisture is in the wet phase only, the water activity of these confections is relatively high. Some air is also occluded during the beating stage.

The recrystallization of sucrose is the basis of many types of confections, especially fondant. The main factors affecting the growth and formation of crystals of pure substances are the degree of supersaturation, the amount of agitation, the temperature of the solution, the nature and concentration of impurities (glucose syrup, colloids, etc.), and the shape and presence of existing crystal surfaces (seeds). Crystal growth is a two-step process. First, there is a mass transfer of sucrose molecules to the surface of the crystal then these molecules aggregate at the surface of the crystal.

Caramels and Toffee. Caramels are relatively low-cooked (113-117^{0}C) confections (typical sugar to glucose syrup ratio of 1:1) that retain their shape at room temperature because of the presence of hydrated milk protein (casein). Their sticky nature is rendered palatable by the presence of an emulsified fat which is also stabilized by the milk protein. Not only does the presence of hydrated milk protein prevent recrystallization of the sucrose because of its extreme viscosity, but the colloidal solution also presents realignment of the sucrose molecules.

The syrup-milk mixture is cooked to varying degrees to give hard caramels (ca. 5% moisture) or soft caramels (ca. 7-11% moisture). Additional fat may be added, depending on the amount of fat contributed by the milk ingredient. The typical flavor and color of caramels is a result of the Maillard reaction between the milk protein and the reducing sugars during the cooking process. Caramels are emulsions that are single phase with respect to the carbohydrate constituents; i.e., all of the sugars are in solution. For this reason, the water activity of caramels is relatively low. High-boiled (121-130^{0}C) caramels with less milk are called toffees.

Because caramels and fudges are emulsions, factors affecting the formation and stabilization of emulsions should be considered. Among these are the amount and type of agitation, the viscosity of the mass, the fat content, and the type and amount of emulsifying agents used (lecithin, milk proteins, etc.). Emulsions can be broken down by mechanical action, chemicals, and heat.

Fudge. If crystallization in caramels is initiated either by agitation or by seeding with the addition of powdered sugar or fondant, a short textured (i.e., one that breaks apart easily) paste is obtained. This fudge is like a fondant and has a dry phase (crystallizable sugars) and a wet phase (noncrystallizable carbohydrates, moisture, and some solubilized milk protein). Like fondants, fudge has relatively high water activity. Unlike caramels, the oil component of fudges is concentrated in the wet phase, and for this reason the emulsified phase of a fudge tends to be unstable. Fudge textures may vary greatly according to the proportion and size of sugar crystals formed, the dispersion of milk solids, and the fat content.

Nougats and Marshmallows. Nougats and marshmallows are confectionery foams containing thousands of finely divided air cells dispersed throughout the syrup matrix. These air cells are stabilized by the viscosity of the cooled carbohydrate matrix and the aerating agent. In turn, the cold flow of the syrup matrix is slowed by the air cells. During the incorporation of air, the volume of the syrup increases about 250%. The density decreases from about 1.4 to 0.7 for nougats or 0.4 for marshmallows. Varying densities can be found, depending on product type. Because of its increased surface area, the normally sticky syrup dissolves quickly in the mouth.

Factors affecting the formation and stabilization of foams are the type and concentration of aerating agent, the amount and type of agitation, the temperature of the syrup, the chemical and physical factors that affect aerating agents, the amount of residual moisture, the type of carbohydrates used, and the amount of air incorporated.

Nougats and marshmallows can be made in grained (controlled crystallization) or ungrained forms and, consequently, may have their carbohydrate constituents in a single phase (un-grained) or in two phases (grained). Nongrained nougats have a typical sugar to glucose syrup ratio of 2:3 and a residual moisture content of about 5% . They usually contain a small amount of fat to aid lubrication. Grained nougats have higher sugar and moisture content, with consequently lower density and higher water activity. For this reason, they are usually covered with chocolate to prevent drying out. They also contain emulsified fat in their wet phase for lubrication purposes. As with fudges, a seeding material is added during the processing of nougats to accelerate the crystallization process.

The foams of marshmallows are always stabilized and usually formed by a colloid, such as gelatin, that has setting characteristics. Marshmallows have a higher moisture content and feel softer in the mouth than nougats, with the characteristic rubbery – elastic texture of gelatin. The typical sugar to glucose syrup ratio of nongrained marshmallows is 3:2 and of grained 2:1. Both types have relatively high water activities, even though their residual moisture contents are about 16% and 5%, respectively, and they must be protected from drying out.

Jellies and Gums. Jellies and gums are single phase, low-boiled (105-108°C), high-moisture (20-25%) confections whose syrupy mass would be quite flowable but for the presence of some colloidal setting agent. The ratio of sugar to corn syrup is about 1:1. The recrystallization of sucrose is inhibited by the presence of hydrated colloid and the concomitant increase in viscosity.

Five main types of gelling agents are used in confectionery gels: starch in the United States; high-methoxyl and low–methoxyl pectins in Europe; and gelatin and agar-agar universally.

Each type forms its own characteristic gel. Starch forms cloudy gels with a chewy, stringy texture. High-methoxyl pectin produces clear gels with a tender short texture. Low-methoxyl pectin acts like a cross between starch and high-methoxyl pectin. Agar gels like pectin, but the gel is slightly more insoluble. Gelatin forms semi-clear gels that are rubbery and elastic.

Although the mechanism of gelling is vastly different for each type, the formation of all gels comes about by loss of heat or by chemical bonding. The hydrated colloidal molecules organize and bond together at various sites to form long-chain polymers in which the carbohydrate syrup matrix is entrained and held mainly by hydrogen bonding and capillary attraction between the chains.

The gel strength depends on the concentration of colloid, the total solids of the solution, the competition from other sources for water of hydration, chemical bonding, and changes in pH. Because of their high moisture content, jellies have relatively high water activity and tend to dry out. Gums are dried (less than 15% moisture) versions of starch jellies or gum arabic gelatin jellies.

Nut Pastes. The prime example of a nut paste is marzipan. Strictly speaking, marzipan is almond paste, but in some countries marzipan my contain other nuts or substitutes. Partly ground almonds are incorporated in a sugar-glucose or sugar-invert syrup by simple mixing and beating. Other pastes contain coconut or apricot kernels (persipan). The nut ingredients must be sterilized in the processing to destroy natural yeasts and enzymes.

Marzipan or "raw marzipan" usually consists of about two-thirds almonds and one-third sugar (invert, corn syrup, and sucrose). Defect free blanched almonds are kibbled to produce nibs. The nibs, both sweet and bitter (approximately 1% of total nut weight should be bitter), are blended and then mixed thoroughly with granulated sugar. At the mixing stage, it may be necessary to add water if previously dried almonds are being used (due to moisture loss in the drying process). The mixture is passed through

The addition of gelling agents such as agar can profoundly change the viscosity and texture of the syrup phase even more, but these are rarely used in fondants and crèmes.

Crystal size of the sugar

The size of the sugar crystals is very important to both the texture and the rheological properties of fondant.

The human palate can detect particles above 12-15 μm in size, and anything below this tastes 'smooth'. In making fondant, crystal sizes below 15 μm are usually desired to give a smooth texture in the confection. However, often much coarser particle sizes are used to give a rougher 'sharper' texture which can be appropriate, for instance, in 'after-dinner' mints to help 'cleanse' the palate. In coarse fudge, such as tableted fudge, larger sugar crystals can be very desirable and complementary to the extreme sweetness of this high-sugar confection.

Sugar crystal size also affects the rheological properties of fondant. Because small crystals have a greater surface area than larger crystals for the same weight of sugar, the syrup in which the sugar crystals are dispersed has to 'wet' a larger surface area. Generally, the smaller the crystal size the more viscous the fondant. This will affect depositing properties to some extent, although syrup composition and moisture content have a much greater effect.

These same variables affect the properties of the other confections, but are more complicated as other things are added. So that with cremes the addition of egg albumen and air considerably changes the texture and mouthfeel of the confection. Similarly, milk protein and fat in fudge have a profound effect on taste and properties.

Basic steps in making the confections

The book is not designed to describe in detail manufacturing methods and plant, but to concentrate on principles of making confectionery. The basic steps or unit operations in making each of these confections are as follows:

Fondant

Fondant is made by:

(1) ***Dissolving.*** The sugar is dissolved in water and then the other materials such as corn syrup or invert sugar are mixed in. This produces a syrup of approximately 25% water and 75% dissolved solids.

(2) ***Boiling.*** The syrup is then boiled to a controlled temperature to give a material with a known moisture content. Under atmospheric boiling

PA607

a normal fondant syrup will boil at 240°F (115°C), for a moisture content of 12.5%. However, this will depend on syrup composition to some extent and on atmospheric pressure. The higher the atmospheric pressure, the higher the boiling point for a given moisture content.

(3) ***Cooling.*** The supersaturated syrup is then cooled to a controlled temperature before crystallization of the syrup is induced. For fine (< 15 μm) crystals the syrup is cooled to 110–115°F (43–46°C) before mixing, and for coarser crystals temperatures of 170–190°F (77–88°C) can be used.

Normally the syrup is not mixed when being cooled, particularly on older fondant-making plant. With modern plant, control of mixing speed or 'shear rate' and cooling rate is used efficiently to crystallize the syrup to the required particle size distribution.

(4) ***Mixing/crystallizing.*** The next basic step is crystallizing by mixing or 'beating'. This induces the sugar to crystallize from the syrup, leaving the syrup saturated with sugar crystals dispersed through it.

The finished fondant is then ready for use in crème or for subsequent processing. Often it is stored in lidded pans in a store at 100^{0}F to allow it to 'mature' before use. During storage small unstable crystals of sugar redissolve and then crystallize again on the large crystals, so that generally crystal sizes increase during this period. If no moisture is lost during storage, the fondant becomes more fluid as sugar crystal surface area becomes less. However, often moisture is lost and the stored fondant becomes thicker and more difficult to handle, as a dry 'crust' is formed. On modern continuous equipment this is avoided, as the fondant passes from making straight through to use.

A diagram showing these operations is shown in Figure 1.

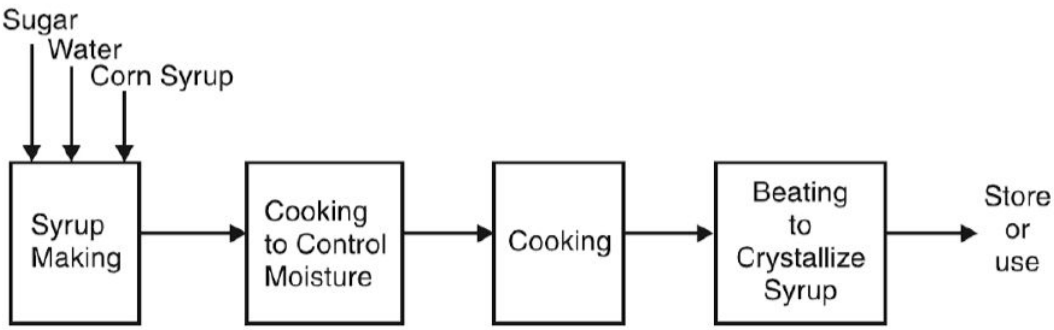


Fig. 1. Unit operations in fondant making.

Crème making

Crème making involves bringing together the three basic materials which make up the finished product, fondant, frappe and thinning (or 'Bob' syrup).

Household syrup is a mixture of candy syrup, sugar syrup or molasses mixed with glucose syrup. By the addition of glucose syrup the end product becomes less sweet and less aromatic. Stored cold, this is more viscous in consistency. Rules are laid down concerning the sucrose content, because household syrup has not been completely produced from cane or beet sugar. This has to be a minimum of 30 per cent.

Kitchen syrup, like household syrup, is a mixture of candy syrup, sugar syrup or molasses mixed with glucose syrup. The sucrose content has to be between 15 and 30 percent.

Syrup can not only be produced from cane and beet sugar but also from other plans. For example, maple syrup is produced from the drained and boiled-down juice of the maple tree (also called Acer), which grows in Canada and North America. This syrup is very aromatic and very sweet. Maple syrup is also obtainable mixed with glucose syrup.

CONFECTIONERY, LIQUORICE AND WINE GUMS

Confectionery

Confectionery can be divided according to ingredients and method of production.

— **Hard confectionery,** also called acid drops, consist of sugar and glucose syrup, which are dissolved in water and boiled down to a final moisture content of 2 per cent. Then flavour and colour are added and the warm mass is poured into moulds and cooled.

— **Soft confectionery,** such as fondant and marzipan are products based on sugar, glucose syrup, cream, milk and / or butter.

— **Peppermint** is produced from a mixture consisting of sugars, a gelling aid, starch and peppermint oil. The mixture can be rolled into a layer from which tablets are cut (hard peppermint). The mixture is also shape into granules of which tablets are pressed (soft or digestive peppermint).

— **Dragees,** or sugar-coated products, are finished with a layer of sugar, which contributes towards the taste, and beautifies the exterior, adding for instance gloss and colour or protection against the absorption of moisture.

Liquorice

Liquorice is produced from sugar, glucose syrup, gums, water, extract from the liquorice root, anmonium chloride, and colour and flavour compounds. The ingredients are dissolved in water and boiled. Then the mass can be pressed into liquorice (soft kinds of liquorice, such as shoe laces and liquorice allsorts) or poured (hard kinds of liquorice). Hard liquorice contains more gum and less sugar than the soft kind. For soft liquorice a combination of starch and gelatine is chosen as a thickener and more sugar is added than to hard liquorice. Liquorice is often glossed with oil.

Wine gums and soft gums

These products are produced from sugar, glucose syrup, gums, flavours and colours. Instead of gum, gelatine is often used, perhaps in combination with starch.

SWEETENERS

Among sweeteners are numbered products which because of their sweetening ability are used instead of sugar, syrup or honey. There are several reasons for replacing sugar or sugar-containing products.

— Sugar can be detrimental to certain users, for instance diabetics.

— Some sweeteners supply little or no energy.

— In the foodstuff industry the processing of sweeteners offers technological advantages over the use of sugar.

— Some sweeteners are less harmful to the teeth than sugar.

Sweeteners are processed on a large scale in industry, for sale to individuals for adding to their own drinks (tea and coffee), and for use in chewing gum, drinks and jams.

Sweeteners can be grouped on the basis of common characteristics. A much-used division is the separation into energy-supplying sweeteners and non-nutritive sweeteners, which supply little or no energy. One of the most complex characteristics of sweetness concerns the sweetness. This is expressed as relative sweetness in comparison to a 10 percent sucrose solution. In Table 1, the relative sweetness, the energy value, the cariogenicity, the laxative effect and the maximum permitted dosage per day (Acceptable Daily Intake – ADI) of several sweeteners are mentioned.

The energy-supplying sweeteners

To these belong the saccharides and the polyalcohols.

Saccharides

The saccharides, also called the starch sweeteners, are produced by the hydrolysis of polysaccharides of potatoes, sweetcorn or cereals using acids and / or enzymes. During this process, starch is changed into glucose via dextrin and maltose. If the conversion is total, i.e. all the links of the starch chain are broken, glucose only results (high DE glucose syrup). If there is incomplete hydrolysis, mixtures of the above-mentioned compounds develop (lower DE glucose syrups).

Saccharides are mainly used in the food industry to replace the more expensive crystal sugar or because of technological characteristics. Used are: glucose, fructose, invert sugar, maltose and dextrin-maltose.

Glucose or grape sugar is for sale as dextrose and glucose syrup.

TABLE 1 – SUMMARY OF SOME CHARACTERISTICS OF SWEETENERS

Sweetener	Energy Value (kj/g)	Sweetness compared to sucrose	Cariogenicity	Laxative Effect (use per day)	Acceptable Daily Intake (ADI) (mg/kg body weight
Dextrose	17	0.7	+	-	-
Glucose syrup	17	0.5	+	-	-
Fructose	17	1.1-1.4	+	-	-
Invert sugar	17	0.9	+	-	-
Maltose	17	0.5	+	-	-
Dextrin-maltose	17	0.2-0.5	+	-	-
Aspartame	17	100-400	-	-	0-40
Sorbitol	13-16	0.5	-	+(30-50 g)	-
Xylitol	13-16	1	-	+(50-70 g)	-
Mannitol	8-11	0.7	?	+(10-20 g)	-
Saccharin	-	200-700	-	-	0-2.5
Cyclamate	-	20-30	-	-	0.11
Lactitol	8	0.3-0.4	-	+(40 g)	-

Dextrose is pure glucose in crystal form. This is mainly processed into sweets and cubes of grape sugar.

Glucose syrup (white or confectioner's syrup) contains besides glucose also maltose and 20 percent water. Glucose syrup in solid form is called masse (cubes). Some noticeable characteristics of glucose are as follows :

- — Strong brown colouring during heating. This effect is desirable in bread and some baker's wares, for instance to obtain a brown crust.
- — Slowing down the crystallization of sucrose, because glucose syrup forms a thin protective layer around the seed crystal. This property is used in jams, ice-cream and sweets.
- — Greater fermentation ability, which is wanted in the baking and brewing industry. Single sugars ferment completely and leave no residue.
- — Greater depression of freezing point, through which the freezing and melting behaviour of ice-cream can be adjusted as required.

Fructose or fruit sugar occurs naturally in small quantities in honey and figs. With the help of enzymes, fructose is produced from glucose. Less fructose can be used to achieve the same sweetness as sucrose, because the sweetening power of fructose is higher than that of sucrose.

Invert sugar is a mixture of glucose and fructose, in which the mono-saccharides can react separately. Each of glucose and fructose in invert sugar has its own melting point and crystallization point. This is in contrast to sucrose, also consisting of glucose and fructose, which behaves as one compound. So sucrose has only one melting point and one crystallization point. Invert sugar is obtained from starch. Invert sugar is also found in honey, which under the influence of enzymes from the bees' stomachs is formed from nectar (sucrose). Invert sugar absorbs moisture quickly. It is used in the production of chocolate with a fondant filling to keep the whole pliable.

Maltose or malt sugar consists of two molecules of glucose. It is mainly used in the production of bread and beer.

Dextrin-maltose is a mixture of dextrin and maltose. It is processed into food for babies and sports people. Some characteristics of the sweetener are a less sweet taste, good solubility in liquids, and reduced fermentation activity in the stomach and intestines.

Polyalcohols

The **polyalcohols** occur naturally in several kinds of fruit and vegetables. However, for use in industry some are specially produced. They are sorbitol, xylitol and mannitol.

Sorbitol is produced from glucose. In contrast to sucrose, is it not completely absorbed in the human body. The largest part is again excreted. If more than 40 g per day is used, diarrhoea can oocur, because sorbitol

PA87

absorbs moisture in the intestines. The part of the sorbitol which is digested is absorbed by the blood slowly. As a result of this, the blood sugar content does not suddenly increase. Sorbitol is processed as a sweetener into products for diabetics (including chocolate, lemonade, biscuits and jam). It is also used in industry to improve the consistency of products.

Xylitol is produced from hemicellulose, from straw and birch wood. because the absorption of xylitol is slow, with too great a use diarrhoea also occurs. Xylitol is used in sugar-free chewing gum, among other things.

Mannitol is produced from glucose. Mannitol is not used as a sweetener because it causes even faster diarrhoea complaints. However it is used as a thickener and moisture stabilizer.

Non-nutritive sweeteners

This group includes saccharin, cyclamate, aspartame and lactitol.

Saccharin is made artificially from toluene (a coal-tar product). Saccharin is bound to calcium or sodium. Saccharin has, compared with sucrose, a very high sweetening power. It can stand up to cooking and baking. The disadvantages are poor solubility and a bitter after-taste. In very high dosage and prolonged use careinogenic abnormalities have been noted in animal experiments. For these reasons, a maximum permitted dose per day has been set for human consumption.

Saccharin is processed into tablets powder and liquid and is used in beverages.

Cyclamate or cyclohexylsulphamate are also artificially produced. Cyclamates are seen as ideal sweeteners, because they dissolve well in water are stable with acids and bases, can stand cooking or baking and have no after-taste.

Cyclamates are prohibited in some countries, because of their carcinogenic characteristics. In the Netherlands the use of cyclamates is limited to diabetic products.

Aspartame is a low-calorific, artifical sweetener, consisting of two peptides (aspartyl and phenylalaline). On heating above 150^0C the compound decomposes and the sweet taste disappears. This renders the sweetener unsuitable for the production of pastry in the home. In industry it can be used, if worked at high temperatures for a short time, directly followed by quick cooling. Under these circumstances no decomposition takes place. Aspartame is not stable in an acid environment.

Lactitol is obtained from milk sugar (lactose) by reduction of the glucose part of the disaccharide. Lactitol is only partly absorbed into the blood stream, and is broken down in the intestines by the intestinal flora. A consumption of more than 40 g per day can lead to intestinal interference.

Lactitol can stand acids and high temperatures (about 145^{0}C). The sweetener is used in slimming aids, products for diabetics (in ice-cream and pastry) and in sugar-free sweets, liquorice and chewing gum.

QUALITY DETERIORATION, SPOILAGE AND STORAGE

Sugar, syrup and confectionery scarcely spoil because of their high sugar content.

Sugar will clump together if stored in a moist place; especially icing sugar and caster sugar.

Syrup can start to ferment in warm moist surroundings. Syrup which is stored too cool and too long eventually crystallizes.

Confectionery can start to run (become sticky) under the influence of moisture.

In unopened packaging the above-mentioned products can be stored for years. In opened packaging, stored cool and dry they can be kept for a maximum of one year.

Sweeteners have an unlimited storage quality.

Name	Sources	Sweetness	Permicible Limit
Sorbitol	Derived from glucose through hydrogenation Found in fruits like berries.	60 % as sweet as sugar	No established limit generally regarded as safe.
Manitol	Derived from fermentation of sugar.	50-60% of relative sweetness of sugar	No established limit generally regarded as safe.
Saccharin	Made in laboratory by oxidizing the chemical o-toluene sulfonamide or Phthalic anhydride.	300- 400 times sweeter than sugar	5mg/kg of body weight
Neotame	Derived from a dipeptide घ is structurally related to Aspartame	7000-13000 times sweeter than sucrose	0.3 mg/kg & 2 mg/kg of body weight in US & EU.
Alitame	Formed from amino acid, such as aspartic acid ει alanine	Relative sweetness is about 2000	40-300 mg/kg
Cyclamate	Synthesized in Lab by the reaction of cyclohexamine + Sulphuric acid	30-50 times sweeter than sucrose	In EU the acceptable daily an intake is 0-7 mg/kg of body weight
Aspartame	Sugar free gelatin i.e sugar free Jell Sugar free gum i.e Tri-dent gum	200 times sweeter than sugar	50 mg/kg of body weight
Sucralose	created through chemical Reaction that involves chlorination of sucrose.	400 – 800 times sweeter than sucrose	5mg/kg of body weight

CLARIFICATION OF SOME TERMS USED

1.	*(i)* Chlorophyll	: Green colouring matter present in the leaves of plants.
	(ii) Photosynthesis	: Process by which energy of sunlight is used by plants for converting $C0_2$ from atmosphere and H_2O into sugars.
	(iii) Maturity	: State of full development, ready for use
3.	*(i)* Bagasse	: Residue of sugarcane after extracting juice from it.
	(ii) Cane preparation	: Process of cutting sugarcane to fine pieces.
	(iii) Fibre	: Thread like slender parts of sugar cane, insoluble in water.
4.	*(i)* Clarification	: Treatment of cane juice for removal of suspended and dissolved impurities.
	(ii) Clarifier	: Equipment for settling treated cane juice, for decantation of clear juice and removal of settled portion, termed as mud.
	(iii) Filtercake	: The insoluble material from treated juice retained on screen or cloth of filter.
	(iv) Clarified juice or Clear juice	: The juice obtained after separation of precipitated impurities.
5.	*(i)* Multiple effect evaporator	: A set of bodies in which cane juice is concentrated with maximum use of vapours generated by boiling of juice.
	(ii) Vapour cell or pre-evaporator	: A boiling vessel in which juice is boiled under pressure, the vapour thus generated being used for heating or boiling in process of manufacture, while the concentrated juice is led to multiple effect evaporator.
	(iii) Exhaust steam	: Steam from primemover after generation of power.
	(iv) Live steam	: Steam from boilers either at the boiler pressure employed for power generation or at reduced pressure for use in process.
	(v) Syrup	: Concentrated clear juice from evaporator.
	(vi) Brix	: Dissolved solids in sugar bearing liquid.
	(vii) Condensate	: Hot water obtained on condensation of vapour or steam used for heating or boiling.
	(viii) Calandria	: Part of a boiling vessel fitted with tubes or coils in which juices or syrups or thick liquors are heated by steam or vapour.
	(ix) Scale	: (a) Deposit mostly consisting of inorganic salts on the inside of tubes in boilers or heating and evaporator vessels or pans.

(b) Coating of thin film of material outside the tubes of juice heaters, evaporator vessels or pans.

(x) Vacuum	:	State of reduced atmospheric pressure in a vessel.
(xi) Condenser	:	Apparatus in which vapours are condensed by cooling with water.
6. *(i)* Seed	:	Mass of fine sugar suspended in syrupy liquid boiled in vacuum pans with sugarbearing liquids.
(ii) Massecuite	:	Mass of sugar crystals surrounded by sugar containing liquor, obtained in vacuum pans.
(iii) Molasses	:	Mother liquor separated from sugar crystals contained in massecuite.
(iv) Heavy Molasses	:	Mother liquor obtained by centrifugal separation of sugar crystals from massecuite with little or no use of water.
(v) Light molasses	:	Mother liquor obtained during centrifugal operation with application of water, after separation of heavy molasses from massecuite.
(vi) Pan	:	Apparatus in which syrup or molasses are boiled so as to obtain sugar crystals of the desired size.
(vii) Molasses conditioning	:	Dilution of molasses from different massecuite to about 70° Bx followed by heating to 70°C.
(viii) Final molasses	:	Mother liquor obtained from the last stage of boiling from which sugar can no longer be recovered economically in the process of Sugar manufacture.
7. Crystalliser	:	Apparatus in which the massecuite from pan is discharged, equipped with stirring mechanism.
8. *(i)* Centrifugal	:	Machine for separation of sugar crystals from mother liquor by rotary motion and centrifugal force.
(ii) Superheated water	:	Water heated under pressure above its boiling point.
(iii) Spinning or purging	:	Separation of Sugar crystals in centrifugal machines,
(iv) Pug mill	:	Vessel, provided with stirrer, on top of centrifugal machines receiving massecuite or magma, which feeds the centrifugal machine.
(v) Grass hopper	:	Sugar conveyor with shaking motion.
(vi) Grader	:	Apparatus with set of screens subjected to vibrations for classifying final sugar into different size grains.

1. BIOCIDE

A chemical substance that kills living cells. Its purpose is to to destroy microorganisms, pests, etc.

2. AFFINATION

Mingling of raw sugar with warm saturated sugar syrup.

Its purpose is to removes the molasses coating from the raw sugar crystals.

3. CLARIFICATION

Removal of impurities from sugarcane juice during the manufacture of sugar.

4. CARBONATION

It is a type of clarification, in which sugarcane juice is treated with carbon dioxide and lime (CaO).

5. BROWN SUGAR

Soft sugar whose crystals are covered by a film of refined dark syrup.

6. PHOTOSYNTHESIS

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms.

7. PYRAN

Pyran or oxine is a six membered heterocyclic, non-aromatic ring, consisting of five carbon atoms and one oxygen atom and containing two double bonds.

8. FURAN

A colorless volatile liquid with a planar unsaturated five-membered ring its molecule.

9. SULPHITATION

Purification of juice employing sulpher dioxide and lime is termed as sulphitation.

10. IMBIBITION

It is a special type of diffusion when water is absorbed by solid-state colloids causing an enormous increase in volume, or in diffusion certain minimum volume of juice has to be maintained, thus necessitating imbibition.

11. SACCHARIFICATION

The process of breaking a complex carbohydrate into monosaccharide compounds.

12. DEXTRO-ROTATION

It refers to clock-wise or right-handed rotation.

13. LEVO-ROTATION

It refers to counter clock-wise of left-handed rotation.

14. ACONITIC ACID

It is an organic acid. It is an intermediate in the tricarboxylic acid cycle produced by dehydration of citric acid. Formula $C6H6O6$

15. PLANE-POLARIZED LIGHT

It is a light wave in which all photons have the same polarization i.e the waves oscillate in only one direction.

16. SUGAR

Sugar is generally carbohydrates being formed by carbon hydrogen and oxygen.

Sugar is the generic name for sweet-tasting, soluble carbohydrates, many of which are used in food. Simple sugars, also called monosaccharaides, include glucose, fructose, and galactose.

17. MASSECCUITE

Mass of sugar crystals surrounded by sugar containing liquor obtained in vacuum pans

18. MOLASSES

Mother liquor separated from sugar crystals contained in masseccuite.

19. BAGASSE

Residue of sugarcane after extracting juice from it.

20. RAW SUGAR

Unrefined or raw sugar is made from the juice of the sugarcane plant. ... Raw sugar has a brown color because of the presence of molasses, a by-product of refining sugarcane that contains a number of essential minerals and vitamins

21. REFINED SUGAR

Refined sugar comes from sugar cane or sugar beets, which are processed to extract the sugar. It is typically found as sucrose, which is the combination of glucose and fructose. We use white and brown sugars to sweeten cakes and cookies, coffee, cereal and even fruit.

22. SWEETENER

Sweetener are the substance used to sweeten food or drink which have the ability to used instead of sugar ,syrup or honey due to many reasons

23. RELATIVE SWEETNESS

Is the ratio of concentration of substances? Sweetness is a basic taste most commonly perceived when eating foods rich in sugars. Sweet…sucrose in solution has a sweetness perception rating of 1 & other substances are rated relative to this.

24. ANION

An anion is an atom or a molecule which is negatively charged, i.e has more no. of electrons than protons.

25. CATION

A cation is an atom or molecule which is positively charged has more no. of protons than electrons.

26. BEVERAGE

Beverage means something you can drink. Any portable liquid especially one other than water, as tea, coffee, beer or milk.

27. SURFACTANTS

Surfactants are compounds that lower the surface tension (or interfacial tension) between two liquids, between a gas & liquid, or between a liquid & a solid. Surfactants may act as detergents, wetting agents, emulsifiers, foaming agents, & dispersants.

28. GLYCEMIC INDEX

The relative ability of a carbohydrate food to increase the level of glucose in the blood is a relative ranking of carbohydrate in foods according to how they affect blood glucose levels.

29. OBESITY

Obesity is a medical condition that occurs when a person carries excess weight or body fat that might affect their health. Obesity means abnormal or excessive body fat.

30. POST HARVEST

Post-harvest handling is a stage of crop production immediately following harvest, including cooling, cleaning, sorting & packing. The instant a crop is removed from the ground or separated from its parent plant, it begins to deteriorate.

31. LIME-

White caustic alkaline substance consisting of calcium oxide which is obtained by heating limestone.

32. DECANT-

Gradually pour (wine, port, or another liquid) from one container in to another, typically order to separate out sediment.

33. FILTER CAKE-

A deposit of insoluble material left on a filter.

34. VACUUM-

A space entirely devoid of matter.

35. GLYCOGEN-

Substance deposited in bodily tissue as a store of carbohydrates. It is polysaccharides which forms glucose on hydrolysis.

36. PRESERVATIVE-

A substance used to preserve food stuffs, wood or other materials against decay.

37. CONFECTIONARY-

It is art of making confections which are food items that are rich in sugar and carbohydrates.

38. REDUCING SUGAR

A reducing sugar is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group. All monosaccharaides are reducing sugars, along with some disaccharides, oligosaccharides, and polysaccharides.

39. NON REDUCING SUGAR

Non-reducing sugars do not have an OH group attached to the anomic carbon so they cannot reduce other compounds. All monosaccharaides such as glucose are reducing sugars.

40. SACCHARIDES

An organic compound containing a sugar or sugars. Any of a series of sweet-tasting, crystalline carbohydrates, especially a simple sugar (a monosaccharide) or a chain of two or more simple sugars (a disaccharide, oligosaccharide, or polysaccharide). Glucose, lactose, and cellulose.

41. INVERTASE

An enzyme produced by yeast which catalyzes the hydrolysis of sucrose, forming invert sugar.

42. DEXTROSE

Dextrose is a pure glucose in crystal form. This is mainly processed into sweets and cubes of grape sugar.

43. DEXTRAN

A carbohydrate gum formed by the fermentation of sugars and consisting of polymers of glucose.

44. SUCROSE

Sucrose is the disaccharide consisting of the monosaccharide "glucose and fructose"

It is commonly referred to as "sugar", "white sugar" or "granulated

Sugar".

45. FRUCTOSE

Fructose is the monosaccharide that combines with glucose to form

Disaccharide sucrose, its is known as fruit sugar since it contain in many

fruits. Fructose is 1.2_1.8 times as sweet as sucrose.

46. GLUCOSE

Glucose is the monosaccharide that combines with the fructose

To form sucrose, with glactose to form lactose, and with another

glucose to form disaccharide maltose.

47. DEXTRIN

Dextrin are group of low molecular weight carbohydrates produced by the hydrolysis of starch or glycogen .Dextrin are mixture of polymer of glucose units linked by a (1__4)or a(1_6) glycoside bonds.

48. ALDEHYDE

An organic compound contain in a functional group with the structure CHO formed by oxidation of alcohols .Typical aldehyde includes methanol (Formaldehyde) and Ethanol (Acetaldehyde).

49. KETONES

An organic compound containing a carbonyl group=C=O bonded to two hydrocarbon groups, made by oxidizing secondary alcohols. The simplest such compound is acetone.

50. COLLOID

A colloid is a substance microscopically dispersed evenly throughout another substance. The dispersed phase particles have diameter between about 5 and 200nm.

51. EXTRACTION

In food processing, extraction is defined as the transfer of one or more components of a biological feed from its source material into a fluid phase, followed by separation of the fluid phase and recovery of the component from the fluid.

52. BULK SWEETENERS

Bulk sweeteners, including sugars, are also known as nutritive sweeteners, have a technical role in the food as well as sweetening it. They contribute to the bulk, the texture and the viscosity of foods.

53. INTENSE SWEETENERS

These intense sweeteners are food additives used to impart a sweet taste to foods. Containing little or no calories, intense sweeteners are used in the food industry as an alternative to sugars in some products.

54. STALE

Stale food is no longer fresh or good to eat. Their daily diet consisted of a lump of stale bread, a bowl of Rice and stale water.

55. EXTRANEOUS MATTER

Extraneous matter is defined in the sugar industry as plant material, other than sugar cane stalks, rich in Sucrose, in association with mineral matter consisting soil particles and stones. The extraneous matter reduces the levels of sucrose and interferes with the sugarcane factory processing.

56. NUTRITIVE & NON-NUTRITIVE SWEETENER

Nutritive and nonnutritive sweeteners enhance the flavor and/or texture of food. Nutritive sweeteners provide the body with calories and also known as bulk sweetener, while nonnutritive sweeteners are Very low in calories or contain no calories at all also known as intense sweeteners. They can both be added to food and beverages.

57. IMBIBITION

Imbibition is a special type of diffusion when water is absorbed by solids-colloids causing an enormous increase in volume.

58. GUM BASE

Gum base is the non-nutritive, non-digestible, water-insoluble masticatory delivery system used to carry sweeteners, flavors, and any other substances in chewing gum and bubble gum. It provides all the basic textural and masticatory properties of gum

59. GUM

Gum is a sticky substance that oozes out of a tree or another plant, and chewing gum is the stuff you blow bubbles with or stick under your desk.

60. PRIMARY JUICE

The undiluted juice

61. SECONDARY JUICE

the diluted juice that joins primary juice to form mixed juice

62. BAGACILLO

Bagacillo refers to one of juice impurities

63. JELLY

It is a fruit-flavored dessert made by warming and then cooling a liquid containing gelatin or a similar setting agent in a mould or dish so that it sets into a semi-solid, somewhat elastic mass.

64. GEL

Gel is a type of dispersion that consists of continuous phase of interconnected particles intermingled with a continuous water phase.

65. CANDY

crystallized sugar formed by boiling down sugar syrup

66. MARSHMALLOW

Marshmallow is a sugar based confection consists of sugar, water and gelatin whipped to a spongy consistency, molded into small cylindrical pieces, and coated with corn starch.

67. CLEAR-LIQUID STAGE (160°C, SUGAR CONCENTRATION 100%)

At this temperature all the water has boiled away. The remaining sugar is liquid Andy light amber in color.

68. BROWN-LIQUID STAGE (170°C, SUGAR CONCENTRATION 100%)

Now the liquefied sugar turns brown in color due to carmelization. The sugar is beginning to break down and form many complex compounds that contribute to a richer flavor. Caramelized sugar is used for dessert decorations and can also be used to give a candy coating to nuts.

69. BURNT-SUGAR STAGE (177°C, SUGAR CONCENTRATION 100%)

Above about 350° F, the sugar begins to burn and develops a bitter, burnt taste.

70. MILLINGMILLING

is the process of machining using rotary cutters to remove material by advancing a cutter into a workpiece.

71. SANITATION

Sanitation refers to public health conditions related to clean drinking water and adequate treatment and disposal of human excreta and sewage, or exert a controlling effect on any harmful organism.

72. CAPITAL

Capital is a term for financial assets, such as funds held in deposit accounts, as well as for the physical factors of production; that is, manufacturing equipment.

73. THREAD STAGE

Thread Stage is a cooking term meaning that a sugar syrup being heated has reached 106 – 112 C (223 – 234 F.) It is a test of how hot a sugar syrup is, and of how much water is left in it. At this point of heating, the sugar concentration in the syrup is 80%.

74. SOFT BALL STAGE

Soft Ball Stage for Candy Making using Cold Water Test. 235 F to 240 F (118 C to 120 C) A small amount of syrup dropped into cold water forms a soft, flexible ball, but flattens like a pancake after a few moments in your hand.

75. FIRM-BALL STAGE

Firm-ball Stage is a cooking term meaning that a sugar syrup being heated has reached 118 – 121 C (245 – 250 F.) It is a test of how hot a sugar syrup is, and of how much water is left in it. ... You test by drizzling a small amount of the sugar syrup from a spoon into a cup of cold water.

76. TOFFY

Candy of brittle but tender texture made by boiling butter and sugar together

77. CUSH-CUSH

a dish made from fried or boiled cornmeal or crumbled corn bread , typically served sweetened with syrup or in milk

78. STARCH

A white orderless , tasteless , granular or powdery complex carbohydrate that is chief storage form of carbohydrates in plants .

79. BUBBLE-GUM

A type of gum that you chew and that can be blown into large bubbles.

80. GELATIN

A clear substance that is made by boiling animal bones or tissues & used for making jelly .

81. POL

This represents to the percentage of sugar in sugarcane.

82. CHEWING-GUM

A sweetened and flavoured soft material that is chewed but not swallowed.

83. CRUSHER

the device that is used to reduce size of material to the extent where it can be further processed

84. SOFT CANDY

It is a candy made by caramelizing sugar or molasses (creating inverted sugar) along with butter, and occasionally flour. The mixture is heated until its temperature reaches the hard crack stage of 149 to 154 °C.

85. FERMENTATION

The fermentation process takes up to 7 days, and produces several flavor precursors and chocolate taste. Yeasts produce ethanol, lactic acid bacteria produce lactic acid, and acetic acid bacteria produce acetic acid.

86. HARD CONFECTIONERY

also called acid drops consist of sugar and glucose syrup which are dissolve in water and boiled down to a final moisture content of 2 percent. Then flavour and colour are added and the warm mass is poured in to moulds and cooled.

87. SOFT CONFECTIONERY

Such as fondant and marzipan are products based on sugar, glucose syrup, cream, milk and / butter

88. NIBS

These are agglomerates of granulated sugar crystals, made by dampening the sugar the thoroughly drying and breaking up the resulting hard mass. The product is sieved to various sizes.

89. LIQUOR

Liquor is an alcoholic drink produced by the distillation of grains, fruit, vegetables that have already gone through alcoholic fermentation. The distillation process purifies the liquid and removes diluting components like water for purpose of increasing its proportion of alcoholic contents.

90. COCOA SOLIDS

Cocoa solids are the Constituents of cocoa beans including cocoa butter and a group of lipids that remain solid at room temperature. Cocoa solids are key ingredients of chocolate, chocolate syrup, chocolate confection.Cocoa solid contain both cocoa liquor and cocoa mass.

91. WATER ACTIVITY

defined as the ratio of the vapor pressure of water in food to the vapor pressure of pure water at the same temperature

92. FUDGE

Fudge is a soft brown sweet that is made from butter, cream, and sugar.

Fudge is a rich, chocolate candy made with plenty of sugar, cream, and butter. Fudge is usually cut into squares and eaten in small quantities.

93. CORN SYRUP

a syrup containing dextrins, maltose, and dextrose that is obtained by partial hydrolysis of cornstarch.

94. CONDENSED MILK

whole milk reduced by evaporation to a thick consistency, with sugar added.

a thick, sweetened milk made by evaporating part of the water from cow's milk and adding sugar

95. SKIMMED MILK

Skimmed milk is milk from which the cream has been removed.

96. LECITHIN

any of a group of phospholipids, occurring in animal and plant tissues and egg yolk, composed of units of choline, phosphoric acid, fatty acids, and glycerol. a commercial form of this substance, obtained chiefly from soybeans, corn, and egg yolk, used in foods, cosmetics, and inks.

97. FONDANT

a thick paste made of sugar and water and often flavoured or colored, used in the making of sweets and the icing and decoration of cakes.

98. HARD CANDY

a candy made of sugar and corn syrup boiled without crystallizing

Hard candy is a type of candy made to dissolve slowly in the mouth.

99. BOILING POINT

The temperature at which a liquid boils and turns to vapour .

Water vapor condenses onto a surface when the temperature of the surface is at or below the dew point temperature.

100. THE DEW POINT

is defined as "the temperature at which dew begins to form." ... Condensation occurring during a cleaning process in a refrigerated room of a meat-processing facility.

101. EQUILIBRIUM RELATIVE HUMIDITY,

a function of water activity when the pressure of water vapours and air pressure become equal in close system.

102. BRIX

Dissolved solids in sugar bearing liquid.

103. OSMOSIS

A process by which molecules of a solvent tend to pass through a semipermeable membrane from a less concentrated solution into a more concentrated one.

104. DIFFUSION

Diffusion is net movement of anything from a region of higher concentration to a region of lower concentration.

105. CONTINUOS DIFFUSION

Is low power consuming and expected to gave high extraction performance .

106. BATCH DIFFUSION

Is high power consuming and extraction need very high pressure .

107. RIND

The tough outer skin of certain fruit, especially citrus fruit.

108. NODE

A node is a point along a standing wave where the wave has minimum amplitude.

109. EMULSION

A fine dispersion of minute droplets of one liquid in another in which it is not soluble or miscible

110. CASTER SUGAR

finely granulated white or pale golden sugar.

111. CARBONATION

Carbonation is the chemical reaction of carbon dioxide to give carbonates, bicarbonates, and carbonic acid.

112. ICING SUGAR

Powdered sugar, also called confectioners' sugar or icing sugar, is a finely ground sugar produced by milling granulated sugar into a powdered state. It usually contains a small amount of anti-caking agent to prevent clumping and improve flow.

113. ANTI-CAKING AGENT

An anticaking agent is an additive placed in powdered or granulated materials, such as table salt or confectionaries to prevent the formation of lumps and for easing packaging, transport, flowability, and consumption. Caking mechanisms depend on the nature of the material.

114. LIQUID SUGAR

Liquid sugar is the sugar you consume in liquid form, such as from beverages like sugar-sweetened soda.

115. INTERNODE

a part of a plant stem between two of the nodes from which leaves emerge.

116. LIXIVIATION

Lixiviation is the process of separating soluble from insoluble substances by dissolving the former in water or some other solvent.

117. PRESS WATER

A machine or apparatus used to extract water from a substance.

118. PERCOLATION

the process of a liquid moving slowly through a substance that has very small holes in it

DEWATERING

Dewatering is the removal of water from solid material or soil by wet classification, centrifugation, filtration, or similar solid-liquid separation processes

119. MACERATION

a process in winemaking in which the crushed grape skins are left in the juice until they have imparted the desired color or the proper amount of tannins and aroma.

120. RANCIDITY.

Rancidity generally is the complete or incomplete oxidation or hydrolysis of fats and oils when exposed to air, light, or moisture or by bacterial action, resulting in unpleasant taste and odor. Specifically, it is the hydrolysis or autoxidation of fats into short-chain aldehydes and ketones, which are objectionable in taste and odor.When these processes occur in food, undesirable odors and flavors can result.

121. HYGROSCOPIC.

A hygroscopic substance is able to absorb or adsorb water from its surroundings.

122. BUFFER.

a buffer is an aqueous solution of either a weak acid and its conjugate base or a weak base and its conjugate acid. A buffer may also be called a pH buffer, hydrogen ion buffer, or buffer solution.

123. POLARIMETRY.

Polarimetry is the measurement and interpretation of the polarization of transverse waves, most notably electromagnetic waves, such as radio or light waves. Typically polarimetry is done on electromagnetic waves that have traveled through or have been reflected, refracted or diffracted by some material in order to characterize that object.

124. SYRUP

Syrup is thick viscous liquid consisting the solution of sugar in water.

125. TREACLE

Treacle is any uncrystallised syrup made during the refining of sugar.

126. DENSIMETER

Process to measure the density of various liquid by densimeter.

127. SPECIFIC GRAVITY

Specific gravity is a ratio of a density of a substance to the density of a reference substance.

128. BAUMÉ

Baumé is pair of hydrometer scale which is used to measure the density of various liquid.

129. REFRACTIVE INDEX

Refractive index is define as the ratio of speed of light in vacuum and phase velocity of light in medium.

130. NUTRITION

The process of taking in food and using it for growth metabolism.Nutrional stages are ingestion, digestion, absorption, transport, assimilation and excretion.

131. COCOA BUTTER

A fatty substance obtained from cocoa beans, used in the manufacture of confectionery and cosmetics.

132. CONCHING

A conche is a surface scraping mixer and agitator that evenly distributes cocoa butter within chocolate and may act as a "polisher" of the particles.

133. TEMPERING

Tempering is done to for production of desired sized crystals. The fats in cocoa butter can crystallize in six different forms (Polymorphous Crystallization).

134. BLOOMING

It is a whitish coating that can appear on the surface of chocolate. It is safe to eat, but may have an unappetizing appearance and surface texture.

135. FAT BLOOM

Fat bloom is caused by storage temperature fluctuating or exceeding 24°C. Rub the surface of the chocolate lightly, and if the bloom disappears, it is fat bloom.

136. SUGAR BLOOM

Sugar bloom is caused by moisture. Condensation on to the surface of the chocolate or moisture in the chocolate coating causes the sugar to absorb the moisture and dissolve.

137. INVERT SUGAR

Sucrose, which is a disaccharides, can be broken down into a mixture of two monosaccharides, known as dextrose (Glucose) & laevulose (Fructose), which is known as invert sugar. Main purpose of invert sugar is to prevent from crystallization.

138. HARD-BALL STAGE

is a cooking term meaning that a sugar syrup being heated has reached 121 – 130 C . It is a test of how hot a sugar syrup is, and of how much water is left in it.

If the stage has been reached, the syrup will form a firm ball (clump).

139. HARD-CRACK STAGE

Hard-Crack Stage is a cooking term meaning that a sugar syrup being heated has reached 149 – 154 C.

It is a test of how hot a sugar syrup is, and of how much water is left in it. At this point of heating, the sugar concentration in the syrup is 99%.

140. SOFT CRACK STAGE

Soft-crack stage refers to a specific temperature range when cooking sugar syrups. Soft-crack stage occurs at 270 to 290 F. At this stage, the sugar concentration of the syrup is 95 percent, which determines how pliable or brittle the candy will be.

141. MAILLARD REACTION

A nonenzymatic reaction between sugars and proteins that occurs upon heating and that produces browning of some foods (as meat and bread)

142. ENZYMATIC BROWNING

Enzymatic browning is one of the most important reactions that occur in fruits and vegetables, usually resulting in negative effects on color, taste, flavor, and nutritional value.

143. NON ENZYMARIC BROWNING

Nonenzymatic browning, is a process that produces the brown pigmentation in foods, without activity of enzymes. The two main forms of non-enzymatic browning are caramelization and the Maillard reaction

144. CARAMELIZATION

is a non-enzymatic reaction that occurs when carbohydrates or sugars in food are heated. It is the process of removal of water from a sugar followed by isomerization and polymerisation steps.

145. PH

is a measure of hydrogen ion concentration, a measure of the acidity or alkalinity of a solution.

146. MICROCRYSTALLIN SUGAR

Microcrystalline cellulose (MCC) is a term for refined wood pulp and is used as a texturizer, an anti-caking agent, a fat substitute, an emulsifier, an extender, and a bulking agent in food production.[1] The most common form is used in vitamin supplements or tablets.

147. WATER ACTIVITY

the ratio of the vapor pressure of water in food to the vapor pressure of pure water at the same temperature.

148. COUNTER CURRENT EXTRACTION

A method of multiple liquid-liquid extractions is countercurrent extraction, which permits the separation of substances with different distribution coefficients (ratios).