THE REPUBLIC OF UGANDA

Ministry of Education and Sports

HOME-STUDY LEARNING

SENIOR 5

FOODS AND NUTRITION

August 2020

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE

UGANDA NATIONAL EXAMINATIONS BOARD

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This material has been developed as a home-study intervention for schools during the lockdown caused by the COVID-19 pandemic to support continuity of learning.

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FOREWORD

Following the outbreak of the COVID-19 pandemic, government of Uganda closed all schools and other educational institutions to minimize the spread of the coronavirus. This has affected more than 36,314 primary schools, 3129 secondary schools, 430,778 teachers and 12,777,390 learners.

The COVID-19 outbreak and subsequent closure of all has had drastically impacted on learning especially curriculum coverage, loss of interest in education and learner readiness in case schools open. This could result in massive rates of learner dropouts due to unwanted pregnancies and lack of school fees among others.

To mitigate the impact of the pandemic on the education system in Uganda, the Ministry of Education and Sports (MoES) constituted a Sector Response Taskforce (SRT) to strengthen the sector's preparedness and response measures. The SRT and National Curriculum Development Centre developed print home-study materials, radio and television scripts for some selected subjects for all learners from Pre-Primary to Advanced Level. The materials will enhance continued learning and learning for progression during this period of the lockdown, and will still be relevant when schools resume.

The materials focused on critical competences in all subjects in the curricula to enable the learners to achieve without the teachers' guidance. Therefore effort should be made for all learners to access and use these materials during the lockdown. Similarly, teachers are advised to get these materials in order to plan appropriately for further learning when schools resume, while parents/guardians need to ensure that their children access copies of these materials and use them appropriately.
I recognise the effort of National Curriculum Development Centre in responding to this emergency through appropriate guidance and the timely development of these home study materials. I recommend them for use by all learners during the lockdown.

Alex Kakooza
Permanent Secretary
Ministry of Education and Sports

ACKNOWLEDGEMENTS

National Curriculum Development Centre (NCDC) would like to express its appreciation to all those who worked tirelessly towards the production of home–study materials for Pre-Primary, Primary and Secondary Levels of Education during the COVID-19 lockdown in Uganda.

The Centre appreciates the contribution from all those who guided the development of these materials to make sure they are of quality; Development partners - SESIL, Save the Children and UNICEF; all the Panel members of the various subjects; sister institutions - UNEB and DES for their valuable contributions.

NCDC takes the responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for improvement. The comments and suggestions may be communicated to NCDC through P.O. Box 7002 Kampala or email admin@ncdc.go.ug or by visiting our website at http://ncdc.go.ug/node/13.

Grace K. Baguma
Director,
National Curriculum Development Centre

ABOUT THIS BOOKLET

Dear learner, you are welcome to this home-study package. This content focuses on critical competences in the syllabus.

The content is organised into lesson units. Each unit has lesson activities, summary notes and assessment activities. Some lessons have projects that you need to carry out at home during this period. You are free to use other reference materials to get more information for specific topics.

Seek guidance from people at home who are knowledgeable to clarify in case of a challenge. The knowledge you can acquire from this content can be supplemented with other learning options that may be offered on radio, television, newspaper learning programmes. More learning materials can also be accessed by visiting our website at www.ncdc.go.ug or ncdc-go-ug.digital/. You can access the website using an internet enabled computer or mobile phone.

We encourage you to present your work to your class teacher when schools resume so that your teacher is able to know what you learned during the time you have been away from school. This will form part of your assessment. Your teacher will also assess the assignments you will have done and do corrections where you might not have done it right.

The content has been developed with full awareness of the home learning environment without direct supervision of the teacher. The methods, examples and activities used in the materials have been carefully selected to facilitate continuity of learning.

You are therefore in charge of your own learning. You need to give yourself favourable time for learning. This material can as well be used beyond the home-study situation. Keep it for reference anytime.

Develop your learning timetable to ca ter for continuity of learning and other responsibilities given to you at home.

Enjoy learning

SENIOR FIVE
HOME STUDY MATERIAL
NUTRITION AND FOOD TECHNOLOGY

TOPIC: PROTEINS

Sub-topic: Chemical Structure of Proteins

Specific objectives

By the end of this topic you should be able to:

- Describe the structure of an amino acid
- Explain the condensation and hydrolysis reactions of proteins.
- Classify proteins.
- Discuss protein quality and its significance.
- Discuss the properties of proteins.
- Enumerate the functions of proteins in the body.
- State the sources of proteins.
- Discuss the factors that influence protein requirements.
- Describe the effects of deficiency of proteins in the body.
- Describe the effects of excessive intake of proteins in the body.

Requirements you will need:

- Time
- Note book
- Pen pencil
- Some protein foods as per lesson requirement.

Instructions/procedure

Find a suitable place and time to read this material. Attempt all the activities given. You are free to consult the internet, textbooks and discuss with your friends. Some activities may need more than 1 hour to complete them. Follow the instructions that you have been given carefully before doing each activity. You may need some extra time to practical work.

Glossary:

Hydrolysis- is any chemical reaction in which a molecule of water ruptures one or more chemical bonds.

Deamination- is the removal of an amino group from a protein molecule.

Denaturation- is a process in which proteins lose their shape and, their function because of changes in pH or temperature.

Macronutrients- are those nutrients that the body needs in large amounts.

Lesson 1: Proteins

By the end of this lesson you should be able to:

- *Describe the structure of an amino acid*
- *Explain the condensation and hydrolysis reactions of proteins.*

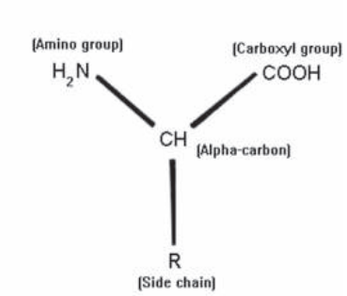
Introduction

Protein is a macronutrient that essential in building the body. Proteins play many important roles in the body. They do most of the work in cells and are required for the structure, function, and regulation of the body's tissues and organs.

Proteins are made up of smaller units called amino acids, which are attached to one another in long chains. There are 20 different types of amino acids that can be combined to make a protein. The sequence of amino acids determines each protein's unique structure and its specific function.

Chemically, protein is composed of amino acids, which are organic compounds made of carbon, hydrogen, nitrogen, oxygen. Others contain sulphur and phosphorus. Protein is the only nutrient that provides nitrogen in the body which is essential in the manufacture of new body cells. Amino acids are the building blocks of proteins, and proteins are the building blocks of muscles.

Structure of an amino acid



An amino acid is composed of:

- Amino group (—NH_2),

-An acidic carboxyl group (—COOH), and

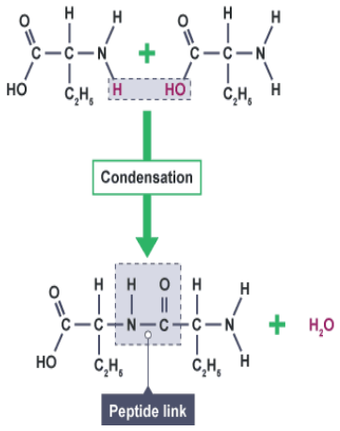
- An organic *R* group (or side chain) that is unique to each amino acid.

Each molecule contains a central carbon (C) atom, called the α-carbon, to which both an amino and a carboxyl group are attached. The remaining two bonds of the α-carbon atom are generally satisfied by a hydrogen (H) atom and the *R* group.

Condensation and hydrolysis reactions of proteins

Have you ever joined beads together to form a necklace? Amino acids can be joined together to form a protein chain. Like we use the 26 alphabetical letters to form different words, the amino acids can also be joined to form different types of protein.

Proteins are formed in a condensation reaction. When two amino acid molecules join together, a water molecule is removed. A new bond is formed in protein molecules where amino acids have joined (-CONH) is called an amide link or a peptide link. In the same way tripeptides, tetrapeptides, and other polypeptides are formed. If the structure formed is long enough, it is called a protein.



Formation of a peptide

Classification of amino acids

1. **Essential amino acids**

Eight amino acids cannot be synthesized in the body of an adult. They must be provided in the diet in order for protein synthesis to occur.

These essential amino acids are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine. In children histidine and arginine will be required together with the above eight.

2. **Non-essential amino acids (ten)**

These amino acids can be synthesized in the body. They are not acquired diet. glutamine, tyrosine, cysteine, glycine, proline, serine, ornithine, alanine, asparagine, and aspartate.

3. **Neutral Amino acids** contain one amino group and one carboxyl group with no additional group with a straight hydrocarbon side chain e.g. glycine, alanine, Valine, Leucine, Methionine, Isoleucine, Norleucine, Serine, Cystine, and Cysteine. The side chain may have a ringed structure e.g. tryptophan, tyrosine and phenylalanine.

4. **Basic Amino acids** contain one carboxyl group with an additional basic group on the side chain group e.g. ornithine, lysine, tyrosine and histidine.

5. **Acidic Amino acids** contain one amino group and an additional carboxyl group on the side chain group for example aspartic acid and glutamic acid.

Summary:
In this lesson we have learnt that amino acids are organic compounds made of carbon, hydrogen, nitrogen, oxygen and sometimes with sulphur and phosphorus. Two amino acids join together with a peptide bond giving off a water molecule and forming a polypeptide.

Amino acids according to the biological value, acidicity or basic state of the amino acids

Lesson 2: Classification of proteins

Specific objective:

By the end of this lesson you should be able to classify proteins

Proteins are mainly classified according to the following forms;

1. *Biological value*
2. *Molecular structure*
3. *Derived proteins*
4. *Tissue proteins*

Biological Value (BV)

This refers to the degree or measure of how nourishing a protein is. How much of the protein or nitrogen is available for growth and repair of the body. It can also be used to denote the percentage of absorbed nitrogen retained in the body in form of tissue manufacture or body protein.

Biological value is of 2 forms;

1. **High biological value / Complete / First class proteins;**

   These are the proteins that contain all the essential amino acids in sufficient amounts to meet the body's needs. Most of their nitrogen is available for growth and repair. They are obtained from animal proteins like meat (beef, mutton, pork, and game), fish, eggs, milk and milk products (cheese, butter, yoghurt) and soya beans.

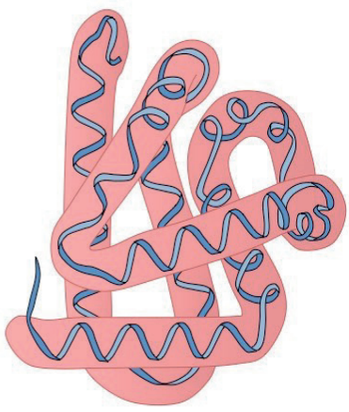
2. **Low biological value / Incomplete / Second class proteins;**

   These are deficient or lack one or more of the essential amino acids required by the body. They are obtained from plant food sources like; Legumes like peas, beans, and nuts, Whole grain cereals like maize, rice, wheat, pulses and gelatine.

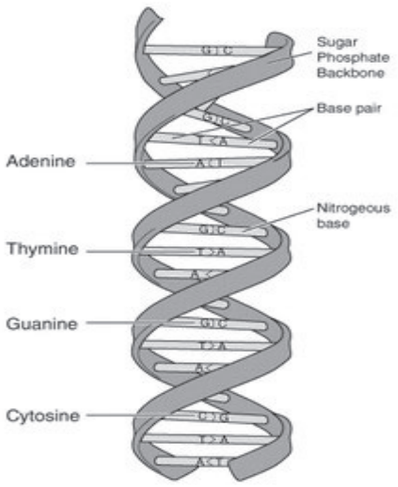
Molecular Structure

This is due to the specific linkages and chain structure or arrangement of the protein molecules. There also other bonds like: hydrogen bonds, ionic bonds, and van der Waals attractions involved in the protein structures. These are grouped into 2 major classes that is simple proteins and complex proteins

Fibrous Protein



Globular Protein



Helix structure

1. **Simple Proteins**

These are proteins made up of only amino acids and their derivatives. They are of 2 forms;

a) Globular proteins

These have polypeptide chains which are rounded and folded with cross links to form spherical molecules.

They are all soluble in water and easily denatured. Examples include; Albumin, Globulin, Insulin and all enzymes.

2. **Fibrous protein**

These have peptide chains which are coiled and twisted to form zigzag and spring like coils. They are elastic, insoluble in water, have less internal bonding and need prolonged cooking to become edible. Fibrous proteins are found in the protective and supportive tissues like skin, hair, tendons and muscles. Examples include; Gluten found in wheat flour, Elastin found in tendons and arteries, Collagen in connective tissue of muscles, Myosin in muscles

3. Complex or Conjugated proteins

These are simple proteins which are chemically combined with a non-protein or prosthetic group. They are named after the chemical group that is attached. Examples include;

- **a)** Nucleoproteins; contain nucleic acids e.g. DNA and RNA present in the cell nuclei, thymonucleic acid found in the thymus gland
- **b)** Phospho-proteins; contain phosphate group or phosphoric acid e.g. casein in milk
- **c)** Lipoproteins;with triglyceride or other lipid / fat material like lecithin
- **d)** Chromo proteins; contain a pigmented or chromatographic group e.g. haemoglobin, chlorophyll, Metallo-proteins with metal or mineral groups attached e.g. haeme or haemoglobin (iron), ceruloplasmin (copper), chlorophyll (magnesium)
- **e)** Glycoprotein or Muco-protein; contain a carbohydrate group e.g. mucin found in the secretions from the mucous membrane

4. Derived proteins

Derived proteins are produced by the action of acids, alkalis or enzymes leading to change in their primary structure. These are of two forms;

1. Primary derived proteins are produced from physical reactions that involve denaturation and coagulation. They are insoluble in all reagents.

2. Secondary derived proteins are produced from hydrolysis of proteins by chemical agents and enzymes. They are soluble in water for example proteases, peptones, peptides.

5. Tissue proteins

Proteins may also be classified according to the different roles they play in the body structures and metabolism. These include;

1. Structural proteins like collagen
2. Contractile proteins like myosin, actin
3. Antibodies like white blood cells
4. Blood proteins such as fibrinogen, albumin, thromboplastin
5. Hormones like thyroxine, insulin and other regulators
6. All enzymes in digestion and cell metabolism

Activity:

- Can you find out the different bonds involved in the protein structures? Explain how they are used in classification of proteins. Write them down in your note book.
-

Summary:
In this lesson you have learnt to classify proteins. These are classified according to:

- Biological value
- Molecular structure
- Derived proteins
- Tissue proteins

Lesson 3: Protein quality and its significance

Specific objective

By the end of this lesson you should be able to explain protein measurement and its significance.

Protein quality is an index used to measure how nourishing a protein is. This is how much of the protein will be available to the body for protein synthesis. Protein with all essential amino acids is a high quality protein usually animal source. The plant sources are low quality proteins, they are lacking in one or more amino acids

Measurement of protein quality

Dietary protein quality is determined using the indices or ratios of protein quality

Indices of protein quality are the ratios used to measure or determine the essential amino acid content of protein foods or how much of the protein is available to the body during protein synthesis. These include;

1. Biological Value (BV); this is the percentage of the absorbed nitrogen retained in the body under normal conditions

$$BV = \frac{\text{Quantity of } N_2 \text{ absorbed by the body}}{\text{Quantity of } N_2 \text{ in dietary protein}} \times 100$$

2. Net Protein Utilization (NPU); this is the product of the biological value of a protein food and the degree of food protein digestibility. The value is less for indigestible protein foods like the cereals.
3. Protein Efficiency Ratio (PER); this is the change in body weight gain relative to the protein intake.
4.

It shows how much of the ingested protein has been used for body growth and repair.

$$\text{P.E.R.} = \frac{\text{Weight gained in grams}}{\text{Dietary protein in grams}} \times 100$$

4.Chemical or Amino Acid Score; it's the ratio between the content of the limiting amino acid in a test protein food to the content of the same amino acid in a reference protein food like eggs.

$$\text{Aminoacid Score} = \frac{\text{\% of Limiting Aminoacid in test protein}}{\text{\% of Limiting Aminoacid in reference proteins}}$$

Limiting amino acid is one that denies the ability of a protein to take part in protein synthesis.

Significance of protein quality

The absorbed amino acids have 2 possible fates in the body. They may be incorporated directly into the body tissue in anabolism or degraded in the component parts through catabolism.

Anabolism (tissue building)

Tissue building takes place in the process known as protein synthesis.

Protein synthesis refers to the assembling of proteins from amino acids in the cell cytoplasm.

Activity:

Find out why you need to eat proteins with a high biological value.

Summary:
In this lesson you have discovered protein quality and its significance. Protein quality is an index used to measure how nourishing a protein is. It is measured using: biological value, net protein utilization, chemical or amino acid score, protein efficiency ratio.

Lesson 4: Functions of protein

Specific objective:

In this this lesson you should be able to:

- Enumerate the functions of proteins in the body.
- State the sources of proteins.

1. Proteins supply material essential for the growth, building, repair, maintenance and continuous replacement of cellular tissue throughout life. This makes proteins particularly important in the diet of babies, children, expectant and nursing mothers.
2. Proteins provide amino acids for the synthesis of nitrogen containing substances like hormones and enzymes required for regulation of body processes. They are found in all body cells and regulate metabolism.
3. Proteins also act as a secondary source of energy to the body. This occurs when the main energy producing nutrients (carbohydrates and lipids) aren't enough to provide the required energy. This leads to the deamination of proteins to provide energy. Deamination involves the removal of the amino group ($-NH_2$) from an aminoacid with the help of amino dehydrogenase enzyme. The amino group is then converted to the less toxic ammonia in the liver and later excreted as urea. The remaining carboxyl group (-COOH) is converted to glucose which is metabolized via the Acetyl CoA in the Krebs' cycle to form energy. This yields a total of 4 kcal per gram of protein.
4. Blood or plasma proteins are essential for the regulation body water / osmotic balance in both the extracellular and intracellular fluid compartments through the process of osmosis. The plasma proteins have a high molecular weight which prevents them from diffusing through the cell membrane. They thus form colloidal solutions and thereby maintain fluid / water balance of the compartment. If the plasma protein level decreases as in protein deficiency, excess fluids accumulate in tissue leading to a condition known as oedema.
5. Blood proteins help to maintain the normal pH of blood (7.4). They neutralize or pick up hydrogen ions produced from cell reactions and release them when required. This avoids a shift in the pH for cellular reaction. This is made possible due to the amphoteric nature of protein molecules.
6. Proteins are essential in the manufacture of antibodies like white blood cells which destroy infectious organisms hence fight diseases. This improves body immunity.
7. Proteins are the major component of the solid matter of muscles and other body organs like the matrix of bones and teeth, skin, nails, hair, blood serum and all cells.

Activity

Can you identify the different sources of protein in your diet? Find out the type of protein they contain. Write them down in your notebook.

Summary:

In this lesson you can enumerate the functions of proteins in the body and state the sources of proteins. Proteins:

- supply material essential for the growth, and repair of body tissues.
- Provide materials for manufacture of substances like hormones and enzymes, antibodies and hemoglobin which have other uses in the body.
- Provide energy if enough carbohydrates and fats are eaten in the diet.
- Part of the body structure.

Lesson 5 Properties of proteins

Specific objective

The learner should be able to discuss the properties of proteins.

Requirements you will need:

- Time
- Note book
- Pen pencil
- Some protein foods like eggs, meat, milk

In this lesson you may require some ingredients to carry out a practical. This will help you discover some properties of proteins.

Properties of protein

These include;

1. Most proteins are insoluble in cold water, salty solutions and alcohols except globulin, albumin and fish protein but the solubility is increased by the application of heat e.g. converting of the insoluble collagen to soluble gelatine by use of moist heat. This makes meat soft and tender.
2. Proteins when mixed with water don't form true solutions but form colloidal dispersions / colloids /solutes. This is because of the complex high molecular weight. This is important in the regulation of water balance in body cells (colloidal osmotic pressure) and colloidal food systems like milk, butter and ice cream

3. Proteins are denatured / destroyed by a slight change in pH, rise in temperature and vigorous physical actions like beating, shaking.

Denaturation is the unwinding or untwisting and destruction of protein molecules. Denaturation of proteins is caused by the following agents;

a) Excessive heating or high temperature which leads to loss of the water binding power. The proteins will form tough solids which are difficult to digest.

b) Chemicals like acids, alkalis and alcohols. Alkalis or salts like sodium chloride, ammonium sulphate and lead acetate form insoluble compounds and precipitate out the proteins present. Acids lower the pH far from the isoelectric point which alters the solubility thus forming insoluble solids.

c) Vigorous physical actions like beating, whipping, shaking, agitation and whisking lead to the unwinding and untwisting of protein compounds. This destroys the protein properties.

d) Catalytic metals like lead, mercury, copper.

Denaturation is mainly employed in food preparation to avoid excessive heat application and use of chemicals that can lead to protein destruction and loss. This is an irreversible change in protein structure, properties and biological activity.

4. Proteins are hydrolyzed to produce polypeptides and eventually constituent amino acids in the presence of water, acids and enzymes. This is important during digestion, absorption and metabolism of proteins.

5. When protein molecules are heated in the presence of enzymes, they shrink, clump together and form a solid mass. Most protein foods are very delicate and set very quickly when heat is applied. These changes are very important during protein cookery.

- Heating to 60ºc causes proteins to shrink and turn into a solid mass. This is known as coagulation e.g. in the formation of the skin on boiled milk.
- Heating of proteins to 100ºc and above leads to the untwisting and unwinding of protein molecules and their destruction. This is known as denaturation and it's an irreversible reaction.
- The proteins will then become tough and indigestible.
- Some proteins change colour such as meat changing from reddish brown to grey/brown, white to cream/brown.
- Overcooking causes proteins to burn or blacken in colour.

6. Proteins especially fibrous proteins have the ability to stretch and contract providing an elastic property. This is important in the elastic nature of muscle proteins like myosin, actin and elastin. It also enables the wheat protein gluten to stretch during baking (yeast cookery).

7. On application of dry heat to foods that have both protein and carbohydrates, they produce brown compounds and change in flavour. This is known as Maillard browning or non-enzymatic browning.

This refers to the browning reaction in which the amino group of the proteins reacts with aldehyde / carboxyl group of sugars producing brown compounds and change in

flavour. The property is used in the browning of cereals, top crust or layer of bread, toasting of bread, roasting of nuts and flavouring of meat extracts and biscuits.

8. Protein molecules contain free amino and carboxyl groups at the ends of the polypeptide chain. They therefore carry both positive and negatives to form zwitterions. They are thus amphoteric in nature and act as buffers. This is important in acid-base balance in body fluids.

Activity:
Prepare and cook some protein dishes like poaching of eggs, beef stew, egg custard sauce. What do you observe? Write down your observation in your notebook.

Summary
In the practical activities, you have looked at properties of protein.

Proteins are affected by whipping, heat, addition of acid, alcohol and alkalis.
These cause denaturation and the changes are irreversible

Lesson 6 Factors that influence protein requirements.

Specific objective

By the end of this lesson you should be able to discuss the factors that influence protein requirements.

Protein requirement may be influenced by the nitrogen balance of the body.

Nitrogen balance

Nitrogen balance refers to the metabolic equilibrium or balance between the nitrogen intake in dietary protein foods and the output of nitrogen in compounds like urea and feaces. It can also refer to the equilibrium between the amount of nitrogen absorbed from protein foods for protein synthesis and the amount of nitrogen supplied to the body i.e.

$$N_2 \text{ Intake} = N_2 \text{ Absorbed}$$

This balance is adaptive to the body protein needs and is affected by the following factors;

- The degree of digestibility and absorption of a given protein food
- Body calorie/energy level which affects protein synthesis
- Nature of the diet
- Timing of meals; spacing between meals lowers the competition for active sites which increases action of enzymes. This increases digestibility of food and promotes a positive nitrogen balance.
- Clinical factors like fever, diseases and other infections, medication, traumatic injury and post-surgical conditions.

This leads to 2 forms of nitrogen balance i.e.

1. Positive nitrogen balance

   This is a state when the rate of synthesis of protein or intake of nitrogen exceeds its breakdown or output. It occurs when new body tissues are added that is growth throughout childhood, pregnancy, muscular development in athletes, and during recovery from infections, injury or stress.

2. Negative nitrogen balance

   This occurs when the rate of excretion of nitrogen is greater than the intake. There is a high rate of catabolism and it leads to loss of nitrogen or protein. It mainly occurs during the following circumstances;

   - Inadequate dietary supply of quality protein to meet the body's synthetic needs
   - Inadequate calorie/energy intake as in starvation
   - Malabsorption diseases like diarrhoea, indigestion will lead to excretion of undigested protein in feaces
   - Severe injury, burns, surgery, high fever and other infections
   - Excessive loss of blood (haemorrhage)
   - Excessive production of thyroxine or adrenocortical hormones without increasing dietary intake

Protein turnover

This refers to the rate of breakdown of body protein/tissues and the re-synthesis of new tissues. The rate varies in different tissues due to the level of activity. It is highest in the intestinal mucosa, liver, pancreas, kidney and plasma. It is lower in the muscles, brain and skin tissues. Turnover is slowest in structural tissues like collagen and bones.

Tissue protein is continuously breaking down into constituent amino acids even when the intake of dietary protein and other nutrients is adequate. Therefore, for tissue maintenance, a constant supply of essential amino acids is important. However, protein turnover is influenced by conditions like age, type of diet, body infections, injury, stress and rate of activity.

Activity

Identify the people whose protein requirements are high and explain why?

Summary: In this lesson you have learnt to identify

Protein requirement may be influenced by the nitrogen balance of the body. This may be: negative, positive, or at equilibrium.

Protein turnover is influenced by age, type of diet, body infections, injury, stress and rate of activity.

Lesson 7: Effects of deficiency and excessive intake of proteins in the body

Specific objectives

By the end of this lesson you should be able to:

- Describe the effects of deficiency of proteins in the body.
- Describe the effects of excessive intake of proteins in the body.

Protein deficiency

Protein deficiency is mainly caused by the following;

1. **Primary deficiency**

   This is due to insufficient dietary supply of proteins to the body. The cells will thus lack the amino acids for their synthetic activities. It leads to the following effects;

   - Retarded growth in infants
   - Diarrhoea which leads to loss of body fluids
   - Dehydration
   - Keratinization of membranes
   - Malfunctioning of various body organs like the liver and gastro-intestinal tract due to hormone deficiency.

2. **Secondary deficiency**

   This develops due to different pathological or physiological conditions in the body like liver damage, kidney failure, intestinal problems, infections which lead to indigestion and bleeding. The following effects are shown;

   - Loss of proteins due to kidney failure
   - Loss of proteins from the body through haemorrhage and wounds
   - Tissue damage due to injuries, fractures and surgical operations
   - Utilization of proteins as a source of energy in absence of lipids and carbohydrates
   - Tissue or muscle wasting and degeneration of the body
   - Increased susceptibility to infections and diseases due to lack of antibodies
   - Delayed wound healing
   - Severe cases of deficiency can lead to kwashiorkor and other protein energy malnutrition (PEM) diseases

Kwashiorkor is a protein deficiency disease which affects infants especially after weaning. It has the following signs and symptoms;

- Retarded or stunted growth
- Muscle wasting or loss of weight
- Diarrhoea and body dehydration
- Poor skeletal and mental development
- General body oedema (swelling of the face, feet and abdomen)

- Distended abdomen (pot belly)
- Poor resistance to infections
- Coarse, light, brown and sparse hair
- Loss of appetite

Skin lesions and scaly skin patches

Excess protein intake

Excess proteins in the body may result into obesity and its related complications. Excess proteins are not stored in the body but are deaminated to form glucose and ammonia. Glucose is used for energy production and if it's not needs it is stored as glycogen in form of fats (adipose tissue). Ammonia is excreted by the kidney with other nitrogenous products.

Summary:

In this lesson you have learnt to describe the effects of deficiency and excessive intake of proteins in the body

Insufficient and excessive intake of proteins in the body will lead to malnutrition of kwashiorkor and obesity respectively.

References

1. Foods and nutrition by Madden
2. Nutrition in perspective by
3. Food and nutrition by Anita Tull
4. Internet

TOPIC: CARBOHYDRATES

Specific objectives:

- Define carbohydrates
- Identify the chemical elements that make up carbohydrates
- Describe the formation of the carbohydrate molecule
- Classify carbohydrates
- Discuss the physical and chemical properties of carbohydrates
- Enumerate the functions of carbohydrates in the body
- Identify the sources of carbohydrates
- State the RDA of carbohydrates for different age groups and categories of people
- Describe the effects of deficiency of carbohydrates
- Describe the effects of excessive intake of carbohydrates

Lesson 1: Chemical elements, formation and classification of carbohydrates:

Specific objectives:

By the end of this lesson, you will be able to:

- Define carbohydrates
- Identify the chemical elements that make up carbohydrates
- Describe the formation of the carbohydrate molecule
- Classify carbohydrates

Requirements

You will need:

- Time
- Note book
- Pen pencil
- Ingredients for carbohydrate identification

Instructions/Procedures

This self-study material has been developed for you to use at home. It has some activities that you are expected to do. Read through carefully and attempt all of them. Keep good record of all completed work because you will need them when school reopens. You are expected to do some practical cookery, please request for ingredients from your parents. Remember to be economical with ingredients.

Introduction

Carbohydrates are large group of organic compounds occurring in foods and living tissues including sugars, starch, and cellulose. They consist of the elements Carbon (C), Hydrogen (H) and Oxygen (O) in the ratio of 1: 2: 1.

They have the general or basic formula; $C_nH_{2n}O_n$ or $C_n(H_2O)_n$

They contain hydrogen and oxygen in the same ratio as water (2:1).

Carbohydrates are formed by green plants from carbon dioxide and water during the process of photosynthesis. Animals are unable to synthesis carbohydrates but most plants can manufacture them. Photosynthesis is the process by which chlorophyll containing plants are able to manufacture carbohydrates from CO_2 in the air and water from the soil. Sunlight is used as energy and it is trapped by chlorophyll pigment.

General equation of Photosynthesis:

$$6\,CO_2\,(g) + 2\,H_2O\,(l) \xrightarrow[\text{Sunlight (uv rays)}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6\,O_2\,(g) + 6\,H_2O\,(l)$$

Enzymes Glucose

Oxygen and water are given off during the process as the by-products.

At first a very simple carbohydrate (glucose) is formed but as the process continues the single molecules (monosaccharide) are linked together to form larger molecules (disaccharides) and eventually polysaccharides. These are stored as starch or cellulose in various parts of the plants like the roots, pods, seeds, fruits, stems or leaves.

Carbohydrate classification:

Carbohydrates are classified according to the number of single sugar units in the structure. These are Monosaccharides, Disaccharides, Oligosaccharides and Polysaccharides.

1. **Monosaccharides ($C_6H_{12}O_6$)**

   Monosaccharides are the simplest form of carbohydrates which cannot be hydrolyzed any further by enzymatic action. They have the basic carbohydrate structure and are made up 3 - 7 carbon atoms i.e. trioses (3 carbons), tetroses (4 carbons), pentoses (5 carbons), hexoses (6 carbons) and heptoses (7 carbons).

   The most important monosaccharides in human nutrition are hexoses which include glucose, fructose and galactose. They all have a sweet taste; dissolve in water; diffusible; form crystals and not affected by heat.

(i) **Glucose** (Dextrose / Grape / Corn Sugar)

Glucose is the simplest hexose sugar found in sweet ripe fruits like grapes, sweet vegetables, maize, roots and onions. Glucose is a white, moderately sweet crystal obtained from the hydrolysis of starch.

Glucose is a strong reducing sugar or agent capable of dissolving blue Benedicts / Fehling's solution. It reduces copper from the cupric (Cu) state that is blue to cuprous (Cu^{2+}) state which is colourless. This test is also used for detecting glucose level in urine.

Glucose is the form in which sugar circulates in the blood stream to provide the major energy or fuel source to the body. This sugar or glucose concentration is maintained at 90 mg / dl of blood by insulin hormone. Insufficient level of insulin hormone in blood can lead to diabetes.

Glucose is commercially available in crystalline or powder form, tablets, syrup or colourless liquid. It is often used in confectionary, jam making and brewing industries.

(ii) **Fructose** (Laevulose or Fruit Sugar)

Fructose is the sweetest of all the hexose or simple sugars and doesn't crystallize easily. It mainly occurs in sweet fruits, honey and sweet vegetables. It can also be got from the hydrolysis of sucrose.

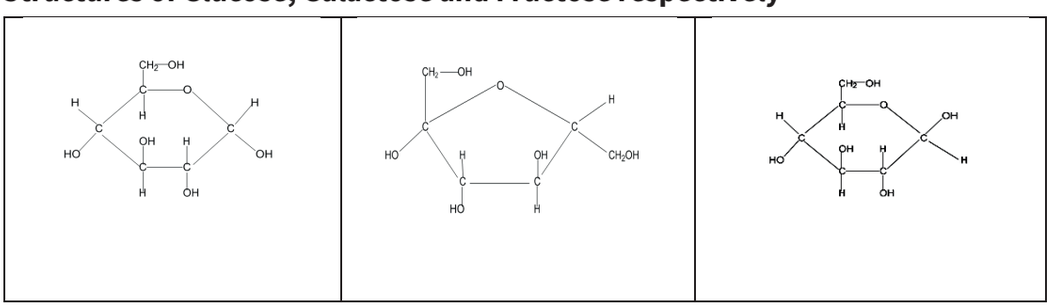
Fructose provides an acceptable nutritive sweetener for use in carbohydrate and calorie modified diets.

(iii) Galactose

Galactose results from the hydrolysis of lactose and is changed to glucose in the liver for energy production.

The reaction is reversible and during lactation, glucose may be reconverted to galactose for use in breast milk production.

Structures of Glucose, Galactose and Fructose respectively



2. Disaccharides ($C_{12}H_{22}O_{11}$)

Disaccharides are also known as **double sugars** because they are composed of 2 monosaccharide units linked together with the help of a glycosidic bond.

Glycosidic bonds are the characteristic linkage or joining structures between sugar units which occur in a condensation reaction with loss of a water molecule.

Disaccharides are all white solids, water soluble, diffusable, crystalline and vary in sweetness. They are split to simple sugars by acids or enzymes. The 3 main disaccharides include Sucrose (from glucose and fructose), Lactose (from glucose and galactose) and Maltose (from 2 glucose molecules)

(i) **Sucrose** (Table Sugar)

This is mainly found in sugarcane, beetroots, sorghum cane, brown sugar, syrup and all the sweet fruits and root vegetables. It is formed from 1 molecule of glucose and 1 molecule of fructose. It can be hydrolyzed by enzymes and acids.

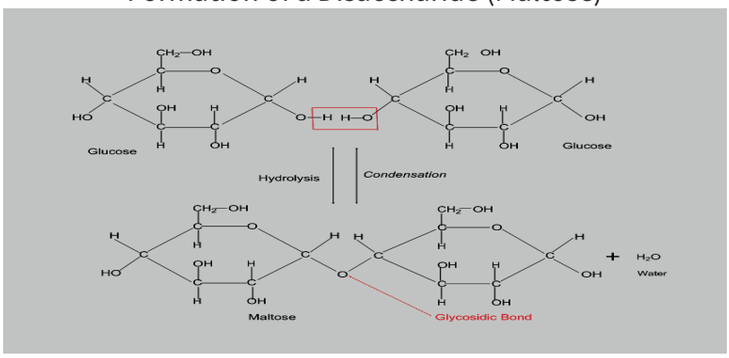
(ii) **Lactose** (Milk Sugar)

Lactose is the sugar found in milk and is the least sweet of all the disaccharides. It is formed from 1 molecule of glucose and 1 molecule of galactose.

(iii) **Maltose** (Malt Sugar)

It is made up of 2 glucose units and occurs in malt products of starch hydrolysis, germinating seeds and cereal grains and starchy material on action of diastase and maltase enzyme. It can also be hydrolyzed by boiling starch with dilute acids. Maltose has α (1, 4) glycosidic bonds.

Formation of a Disaccharide (Maltose)



3. Oligosaccharides

These are complex carbohydrates made up of small portions ranging from 3 to 10 single units. They are irregular in form and when digested yield few constituent monosaccharide units. Naturally occurring oligosaccharides include starchyose (a tetra-saccharide made of glucose), raffinose (a tri-saccharide of glucose, fructose and galactose).

They are usually found in legumes and cannot be digested but provide food for bacteria flora to thrive in the intestinal tract producing gas that can bring abdominal discomfort, pain and embarrassment.

Commercially prepared oligosaccharides are used in special infant formulas, on people with gastrointestinal problems and sports drinks since they are easily digested.

4. Polysaccharides [$(C_6H_{10}O_5)_n$]

These are complex carbohydrates composed of many or several single sugar units bonded by glycosidic bonds at each connection. They contain long chains and branched formations with relatively high molecular weight.

Unlike sugars, they are amorphous (non-crystalline), tasteless and generally insoluble.

Examples of polysaccharides include starch, cellulose, glycogen, pectin, dextrin, hemicellulose and gums.

(i) Starch

Starch is the storage form of carbohydrates in plants and thus it's the most significant source of energy in human nutrition. It will yield glucose on complete hydrolysis and consists of long chains of glucose often branched or linked by glycosidic bonds.

Starch is of 2 forms i.e. Amylose and Amylopectin

- Amylose only makes up 20 -30% of the starch portion of starch is made up of long coiled chains of glucose units with α (1,4) glycosidic bonds and less branching. It is responsible for maintaining the normal blood sugar level and forms the outer coating of starch cells which makes them insoluble in cold water but more soluble in hot water than amylopectin without swelling but does not form a gel. With iodine, it stains blue.
- Amylopectin is the large portion of starch made of branching chains with 1,4 and 1,6 linkages at specific points along the chains. Less soluble in water, but soluble in hot water with swelling. It has gel-like properties responsible for the thickening of starch mixtures. Turns yellow or orange with iodine.

(ii) Glycogen (Animal Starch)

This is the form in which animals store carbohydrates. Animals convert glucose into glycogen which is stored in the liver and muscle tissue as a temporary energy reserve. Glycogen helps to maintain the normal blood sugar level when fasting. It also provides fuel for muscle action especially during athletic activity. It also prevents body fatigue, tissue protein breakdown, ketoacidosis and energy loss. Glycogen is more highly branched than starch, more soluble and rapidly hydrolyzed to glucose for energy production.

(iii) Cellulose

Cellulose forms the chief cell structure of plants, skins of fruits, coverings of seeds and bran layer of cereals. It is made up of long straight chains of about 5000 glucose units linked by β-glycosidic bonds. These cannot be broken down by human digestive enzymes. This renders them indigestible but they are a source of bulk in the diet which stimulates peristaltic movement of gut muscles to remove wastes and thus prevent constipation.

(iv) Dextrin

These are polysaccharide compounds formed as intermediate products in starch breakdown due to action of heat, acids and enzymes. The large starch molecules nearest to the heat or acids are broken into simpler but still fairly large brown compounds known as dextrins e.g. the crusty brown top on bread toast.

(v) Pectin

These are indigestible carbohydrates found in ripe fruits and some vegetables. They lack nutritional significance but have the ability to absorb water and form gels. This is used in making of fruit jellies and setting of jam.

Activities:

- Identify monosaccharide, disaccharide, oligosaccharide and polysaccharide from the carbohydrate foods that you use to prepare meals at home.
- Try and look out for videos from internet if possible to help you understand further the classification of carbohydrates.

Summary;
In this lesson you have learnt that;

Carbohydrates are classified according to the number of single sugar units in the structure. These are Monosaccharides, Disaccharides, Oligosaccharides and Polysaccharides. You have also learnt the definition of carbohydrates, elements that make up carbohydrates and chemical structure.

Lesson 2: Properties, functions and sources of carbohydrates:

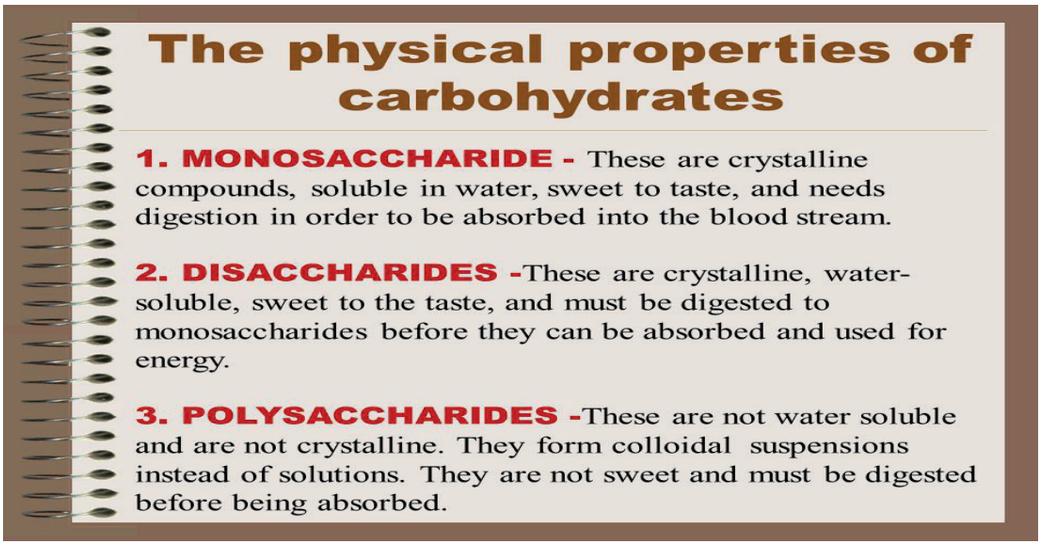
Specific objectives:

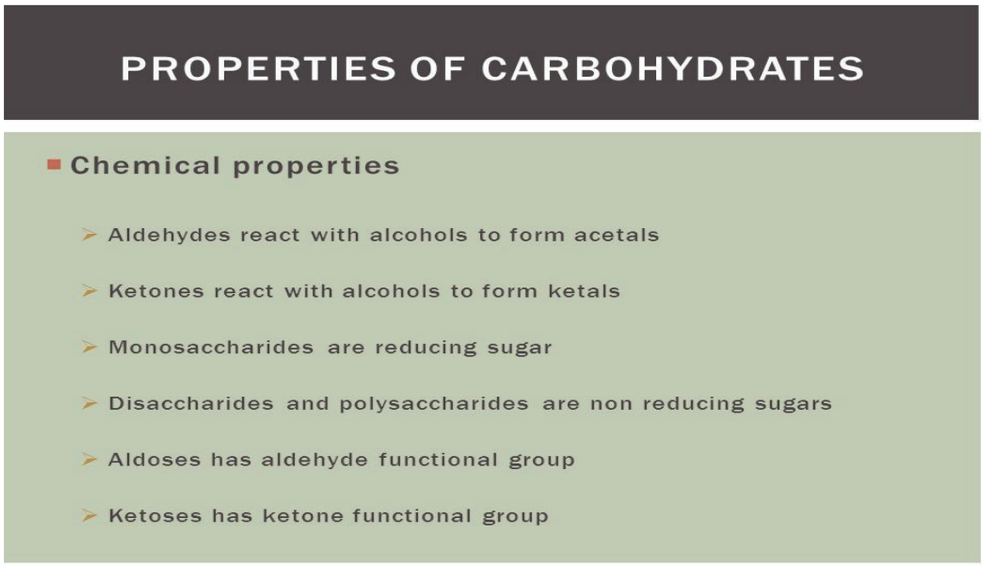
By the end of this lesson, you will be able to:

- Discuss the physical and chemical properties of carbohydrates
- Enumerate the functions of carbohydrates in the body
- Identify the sources of carbohydrates

Requirements you will need:

- Text books
- Internet
- Note book
- Pen
- Pencil





Biological Functions of Carbohydrates

1. The primary function of dietary carbohydrates is to provide fuel (energy and heat) for the body. When oxidized they release 4 kcal/g of energy. This takes place in the cells in the presence of oxygen. This energy is used for the proper functioning of the body muscles and maintenance of body temperature

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

2. Excess carbohydrates in the bloodstream are converted into body fat which is stored under the skin as adipose tissue. This forms the layer which helps in insulating the skin against heat loss but too much can lead to obesity. The layer of fat also surrounds and protects body organs like the heart, pancreas and kidneys against physical shock and damages.
3. Complex carbohydrates like cellulose, pectin and hemicellulose are useful in stimulating the peristaltic movement of the gastro-intestinal tract. They absorb water to give bulk to the intestinal contents, give a wide surface area for absorbing nutrients and eases removal of wastes. This enables easy digestion and thus prevents constipation and other intestinal disorders.
4. Carbohydrates are highly satisfying due to the presence of indigestible carbohydrates like cellulose which are bulky and give a feeling of satisfaction.
5. Dietary carbohydrates have a protein sparing effect hence they help to regulate protein metabolism. The body will use carbohydrates preferably as the source of energy when they are sufficiently supplied in the diet but a low carbohydrate intake will lead to use of the proteins stored in the tissues for energy production. This is so because body energy needs take priority over other functions. Therefore, sufficient amounts of carbohydrates will prevent channeling of too much protein for energy production and thus spare them to be used for their primary role of tissue building.
6. A constant amount of glucose is necessary for the proper functioning of the brain and the central nervous system (CNS). The brain has no storage for glucose but depends on the minute to minute supply of glucose from the blood. Insufficient supply of glucose may lead to fainting, shock and irreversible brain damage.

7. Glucose is converted to glycogen which acts as an emergency energy reserve for the body. This helps to maintain the normal blood glucose at 90-100 mg/dl. This is controlled by insulin, glucagon and epinephrine hormones.
8. Glycogen is also an important source of contractile energy for the cardiac muscles. Low glycogen stores due to low carbohydrate intake may cause cardiac symptoms like angina.
9. Carbohydrates are required for the normal metabolism of fats. When carbohydrates are severely restricted e.g. during fasting, starvation or uncontrolled diabetes, excess fats will be metabolized faster so as to provide energy. This will lead to accumulation of incompletely oxidized products (intermediates) like ketones and acids which cannot be metabolized. This can lead to keto-acidosis which causes cell damage. Therefore, a sufficient supply of dietary carbohydrates prevents the formation of ketone bodies
10. Carbohydrates combine with proteins to form glyco-proteins which help in the form of the cell membrane.
11. Oxidation of carbohydrate leads to the production of heat energy. This provides warmth to the body.
12. Lactose being less soluble than any other sugars, it remains in the intestines for long enough to encourage the growth of intestinal bacteria useful in the synthesis of B group vitamins.
13. Lactose also enhances the absorption of calcium by forming calcium lactate which is soluble.

Functions of Carbohydrates in cookery

- Carbohydrates such as vegetables are used as accompaniments to protein and fatty dishes so as to make a balanced meal for example steamed matooke + fish stew, chips + fried chicken.
- Sugars are important sweeteners in a variety of dishes like fruit juices, cakes and puddings. This improves the taste and appetite.
- Sugar is used as a preservative in jam, soft drinks like soda, quencher and dried fruits.
- Pectin is an important setting agent of jam and jellies.
- Carbohydrates like flour act as a base in many baked products like cakes, biscuits, bread and pizza
- Sugar is a basic ingredient in baking due to its caramelisation properties. This helps them to form a fine brown texture of biscuits, cakes, bread, buns, puddings and sweets.
- Starch, sugar and maltose are important raw materials during the fermentation process to give alcohol.
- Carbohydrate foods provide plenty of bulk in the diet due to the presence of starch and indigestible cellulose. This is useful in satisfying hunger.
- They add variety and flavour in the diet since they can be cooked in various ways e.g. fried, baked, roasted, steamed or eaten raw.

- Starch is used as a thickening agent of liquids like soup, gravies and sauces.
- Carbohydrates are the cheapest foods available which makes them to be eaten in larger amounts by any group of people or individuals.

Food Sources of Carbohydrates

Food sources of Sugar

- All sweet fruits and vegetables like bananas, apples, mangoes, melons, beet roots, cherries
- Bee honey
- Jam, Sugar canes
- Sweetened food products like soft drinks

Food sources of Cellulose

- Skins of fruits and vegetables
- Whole grain cereals like maize, wheat, oats and barley

Food sources of Starch

- Cereals e.g. wheat, maize, rice, barley, millet
- Root vegetables like cassava, yams, potatoes, carrots
- All types of flour i.e. wheat flour, maize flour, millet flour

Activity:

Select any two functions of carbohydrates in cookery and utilize them to prepare dishes that you will enjoy with your family members.

Summary;

In this lesson you have learnt; the physical and chemical properties of carbohydrates, functions of carbohydrates in the body and sources of carbohydrates. You have also learnt the functions and sources of carbohydrates.

Lesson 3: Recommended Daily Allowance and effects of deficiency of carbohydrates

Specific objectives:

By the end of this lesson, you will be able to:

- State the RDA of carbohydrates for different age groups and categories of people
- Describe the effects of deficiency of carbohydrates

Requirements you will need:

- Time
- Note book
- Pen pencil
- Internet
- Text books

Deficiency of Carbohydrates

Insufficient supply of carbohydrates in the diet is very rare as it is the cheapest food available but can occur in cases of actual starvation and can lead to marasmus.

Marasmus is a protein energy malnutrition (PEM) disease mainly due to lack of a number of nutrients but especially carbohydrates. It has the following signs and symptoms;

Extreme body thinness (muscle wasting)

- Lack of energy (body weakness)
- General body fatigue (tiredness)
- Low body weight
- Retardation of growth especially in children
- Constipation and diarrhoea
- Dryness of the skin and mucous membranes
- Little or no body fat

Activity:

Find out the RDA of carbohydrates for different age groups and categories of people

Summary;

In this lesson you have learnt the effects of deficiency of carbohydrates. You have also discovered the recommended daily allowance for the different categories of people.

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