CARBOHYDRATES

Carbohydrates are manufactured in plants from carbon dioxide and water in the presence of chlorophyll and sunlight (photosynthesis). This food is usually in the form of starch, is stored in the root system, stem or seed for future use. This group consists of sugars, starches and cellulose.

Chemistry

There are several types of carbohydrates but they all contain three elements: carbon, oxygen and hydrogen. Hydrogen and oxygen are present in the same proportions as they are in water (H_20), hence the term hydrate. (To make something absorb water). Carbohydrates therefore are organic substances that contain the elements of carbon (C), hydrogen (H) and oxygen (O).

Classification of carbohydrates

Carbohydrates can be divided into three groups according to their structure.

a) Monosaccharide
b) Disaccharides
c) Polysaccharides

Monosaccharide (simple sugars)

These are sometimes called simple sugar as they are the common basic units of which other carbohydrates are built, and they are single or one – unit sugars and cannot be broken down into any simpler sugars. They are soluble in water and of varying sweetness. Monosaccharide quickly supplies energy because they need not be digested when consumed as they go directly into the blood stream. The chemical formula for monosaccharide is $C_6H_{12}O_6$

There are three main monosaccharide.

Glucose

Glucose is the form of carbohydrates that the body uses for energy, and all other carbohydrates are converted to glucose during digestion. The glucose is then circulated around the blood stream to the body cells where it is oxidized to release energy.

Glucose is found in ripe fruit and some vegetable e.g. onions, beet root. It is also available commercially in powdered, liquid, or tablet form. It provides a fast source of energy and is often taken by athletes for this reason.

Fructose

Fructose is sometimes called “fruit sugar” because it is found predominately in fruits, plant juices and honey.

Galactose

Galactose is found in the milk of mammals, where it forms part of the milk sugar, lactose.

Disaccharide (double sugar)

These are sometimes called double sugars as they are composed of two monosaccharide units joined together. They are soluble in water and their chemical formula is $C_{12}H_{22}O_{11}$

There are three main disaccharides

Sucrose

Sucrose is formed from one unit of glucose and one unit of fructose.
Sucrose is most commonly used in cookery, and is obtained by refining sugar or beet (plants with a root that is used as vegetable for making sugar). It is also present in some fruits and vegetable.

Lactose
Lactose is formed from one unit of glucose and one unit of galactose.
Lactose is found in milk of mammals, to supply the infant with a source of energy. It is not as sweet as sucrose.

Maltose
Maltose is formed from two units of glucose molecules joined together.

It is sometimes called malt sugar and is found in cereals such as barley where it is formed during germination.

During digestion, disaccharides are broken down to monosaccharide before being absorbed into the blood stream.

Polysaccharides **(complex sugar)**

These are formed (when many monosaccharide are chemically joined together) from a varying number of monosaccharide units- the prefix “poly” meaning “many”. They are usually insoluble in cold water and are tasteless.

There are five main polysaccharide:

Starch

Starch is formed from many glucose units joined together like links in a chain.

(G)- (G)-(G)-(G) (G)-(G)-(G)

It is formed during photosynthesis in plants as a chief food reserve in particular root vegetables, cereals and pulses.

During digestion, the chains of glucose units are broken down into smaller chains, then into disaccharide, and finally into single glucose units, which are absorbed into the blood.

Dextrin

Dextrin is formed when foods containing starch e.g. bread, are heated i.e. baked or toasted. The large starchy molecules nearest the heat break down into simpler but still fairly large, molecules called dextrin. The dextrin forms part of the crust (hard brown outer surface of bread) on such food and is more soluble than starch.

Cellulose

Cellulose is formed by plants from glucose units joined in such away that a strong, structural material is produced. Hence it forms the structural frame work of plants. The plant uses this for support found in all stems, leaves and husks of seeds, and bark. It is foods of plant origin.

Despite being composed of glucose, it cannot be digested by man (hence not a nutrient), but it is of great value to the body as dietary fiber (roughage). I.e. assist in the movement of food through the intestines and so aids excretion.

Pectin.

A substance similar to sugar that forms in ripe fruits and is used to make jam and jelly.

Pectin is formed in some plants e.g. apples, in their fruits and roots. It is a complex polysaccharide. It is essential for the setting of jams and preserves it but has no function in the body.

Glycogen / animal starch

Just like plants store energy in the form of starch, animals have the ability to convert glucose into a similar substance to starch in order to store it as an energy reserve. Glycogen is formed after digestion in man and other animals. To ensure that the body has a reserve of energy that can be quickly utilized, some glucose is converted to glycogen for temporary storage in the liver and muscles. When energy is required, it is converted to glucose.

Sources of carbohydrates

Sugar: occurs naturally in fruits, honey, sugar cane, sugar beet and in sweetened products like cakes, biscuits, jams and soft drinks.

More nourishing sources are milk, fruit, honey and vegetable e.g. carrots.

Starch: cereals and their products, pasta, potatoes and root vegetables.

Pectin: fruits e.g. apples, blackcurrants

Cellulose: husks of cereals, fruits and vegetables.

Non – Starchy Polysaccharides (NSP)

These include cellulose, pectin and gums such as carrageenan, gum Arabic locust bean gum. They make up what is called / known as the dietary fiber. They are not digested by micro-organisms in the late intestines and are very important in removing waste from the digestive system.

Carbohydrate requirement

Proteins and carbohydrates rich food should be eaten together e.g. meat and potatoes, bread and cheese so that protein can be used for body growth and repair instead of being wasted by providing energy.

If more carbohydrates than the body requires is eaten, the excess will be converted to fat and stored as adipose tissues beneath/under the skin. This is one of the major causes of obesity.

Functions of carbohydrates

Carbohydrates are oxidized to provide heat and energy. This is the principle function of carbohydrates and a constant supply is necessary for the functioning of muscles. 1gram of carbohydrates yields about 4 kilocalories regardless of the source; mono, di and polysaccharides.

Excess carbohydrates are converted to fats and stored in adipose tissue beneath the skin which helps to reduce heat loss and protecting delicate body organs like the heart, kidney.

Carbohydrates exert a protein sparing action. If insufficient, the body will convert proteins to carbohydrates (glucose) in order to supply energy. Therefore for maximum or proper utilization of amino acids for protein formation, carbohydrates must be supplied continuously.

The presence of carbohydrates is necessary for normal fat metabolism. If there is insufficient carbohydrates large amounts of fat are used for energy and oxidation is incomplete.

Carbohydrate [glucose] is the main source of energy for the central nervous system [brain], therefore constant supply of glucose from blood is essential for the proper functioning of nerve tissues. Any lack of glucose or oxygen for its oxidation cause irreversible damage of the brain.

Cellulose that is present in many carbohydrates stimulates the muscular movement of the digestive tract (peristalsis).

Cellulose holds a lot of water. This means that the contents of the bowel (faeces) remain soft and also are easily passed out of the body. This prevents constipation and other related disorders.

Effects of carbohydrate deficiency

Except in the case of actual starvation, it is rare to find inufficient carbohydrate in the diet as it is the cheapest food available and marasmus occurs if there is inadequacy of food.

MARASMUS

Actually marasmus means unbalanced starvation i.e. the total intake of all nutrients is inadequate but the deficiency of energy in the diet is the major problem.

Normally occurs in children of 0-1years.

Marasmus is usually associated with causes listed below;

- Inadequate artificial feeding.
- Early weaning.
- No lactation at all
- Prolonged breastfeeding without solids.

Many other reasons similar to those of kwashiorkor so it is advisable to breastfeed for at least six months then also introduce solid foods.

Symptoms of Marasmus (Clinical Signs)

- Usually their weight is below 60% of the expected weight for age.
- Grossly emaciated (thin) child.
- The child has a skinny and bony look.
- Muscles waste off as a result of lack of subscutaneous fat.
- Skin is dehydrated i.e. dry and wrinkled.
- Eyes are protruding (bulging with an anxious eager look like a monkey's appearance in fact the body gets a look of a little old man i.e. little old man's look.
- Has extremely high appetite.
- Occasionally the child may have diarrhoea.
- Growth retardation.
- Has "beads" on the ribs.
- The hair is sometimes longer than usual.

Control of blood sugar

All metabolizing cells require a supply of glucose in order to continue functioning. The nervous system is especially sensitive to any reduction in the normal glucose level of 90mg glucose in 100cm^3 blood. Any rise in blood sugar level can be equally dangerous.

The liver plays a role in glucose homeostasis. It can add glucose in blood in two ways

i. by breakdown of glucose (glycogenolysis)
ii. by converting protein into glucose (gluconeogenesis)

It can remove glucose from blood by converting it into glycogen (glycogenesis) which it stores in the liver and muscles.

The interconversion of glucose and glycogen is largely under the control of two hormones produced by the pancreas. Throughout the pancreas are groups of histological different cells known as the islets of langerhans.
The cells within them are of two types which produce the hormone glucagon and β-cells which produce the hormone insulin. Both hormones are discharged directly into the blood.

Effects of heat of carbohydrates

Sugar

Dry heat

When exposed to dry heat, sugar will melt producing a clear liquid. Then it caramelize, the colour gradually darkening from pale yellow to dark brown and on further heating, they give off water and thick acrid fumes. Finally charring occurs (forming charcoal) leaving a shinny black cork. Caramelization leads to pleasant flavour and aroma in foods.

Millard reaction this results from the effect of amino acids on sugars when dry heat is applied leading to formation of brown compounds that also give a good flavour to foods e.g bread and other baked items.

Wet heat

Sugar first dissolves, then becomes a syrup which caramelizes and finally at160^0C burns or carbonize when water has evaporated

Starch

Dry heat

Dry heat causes grains to burst e.g. popcorn. They happen to a lesser extent when baking bread and pastry

Over heat causes starch to carbonize or burn.

Dry heat causes the starch grain of the outside to darken and change to dextrin. For example the crust forming on bread. Starch changes to dextrin

Moist heat

Starch grain first soften then absorb water and swell, as the temperature raises the cell well break releasing starch cells which thicken the liquid. This is what happens when porridge is cooked. This process is called ***Gelatinization*** and makes food more digestible e.g. white sauce.

Moist heat causes the cell wall of vegetable to soften and become more digestion. If over cooked, vegetable will eventually disintegrate for example boiled potatoes.

Properties of carbohydrates

Monosaccharide and disaccharides

All sugars are sweet crystalline solids

All sugars are soluble in water, dissolving more easily in worm water.

If too much sugar is added to water it becomes oversaturated. Crystals of sugar are deposited at the edge of the container.

Some sugar (glucose, fructose, maltose) have reducing power i.e. the property of removing oxygen from a substance.

When sucrose, (cane sugar) is boiled in water with an acid added, hydrolysis takes place producing a mixture of glucose and fructose both of which are reducing sugars.

The combination of glucose and fructose is called invert sugar.

Sugar turns brown and caramelizes at high temperature (150^0C).

Polysaccharides

Starch is insoluble in cold water but will dissolve and thicken in hot water but cellulose is insoluble in both cold and hot water.

When mixed with water it forms a sticky paste. Starchy foods need to be carefully blended with liquid before cooking and stirred during cooking as the as the starch grain tendency to stick together and form clumps.

Starch gelatinizes at approximately 65^0C to 70^0c.

Uncooked starch is indigestible and needs to be cooked before eating.

It absorbs water or water vapour (steam). Starch (rice flavor or corn) is often mixed with the bread soda/ cream of tartar mixture in baking powder to absorb any moisture in air, thus preventing the acid and alkali acting prematurely on one another

Pectin.

When combined with sugar in an acid solution forms agel and is essential for the setting of jams.

When heated, starch grains swell and burst making cooked starchy food more easily digestible.

Dry heat like in baking, changes starch to dextrin at temperatures exceeding 150^0c.

Assignment

Describe the digestion and absorption of carbohydrates in the human digestive system.

Vitamins

These are essential nutrients needed by the body in small amounts for various roles. They are chemically related organic substances distinct from fats, carbohydrates and protein required by the body, in small or minute amounts for its normal physiological function.

General Uses of Vitamins

- Vitamins are required to regulate the maintenance and growth of the body.
- They are also used to control metabolic reactions in body cells.
- A diet lacking in one or more vitamins will result in specific deficiency diseases.

Classification

They are distinguished from each other on the basis of their solubility in fat or water. They are simply therefore classified into;

i) Fat soluble vitamins e.g. vitamin A, D, E and K.
ii) Water soluble vitamins e.g. vitamin B complex and vitamin C.

Unlike water soluble vitamins that need regular replacement in the body, Fat soluble vitamins in the liver and fatty tissues are eliminated much more slowly than water soluble vitamins.

Fat soluble vitamins are stored for long periods and are generally of a greater risk for toxicity than water soluble vitamins when consumed in excess. However taking vitamin supplements that contain mega doses of vitamin A, D, E and K may lead to toxicity or a condition referred to as hypervitaminosis.

Fat soluble vitamins

These are soluble in fat; they are characterized by the following.

- Needed in the body in small amounts to maintain good health.
- Fat soluble vitamins are stable to heat.
- They are relatively stable during processing processes.
- While diseases caused by the lack of fat soluble vitamins are rear, symptoms of mild deficiency can develop without adequate amount of vitamins in the body.
- Additionally some healthy problems may decrease absorption of fat and in turn decrease the absorption of vitamins A, D, E and K.

Vitamin A (retinol)

Vitamin A is a fat-soluble vitamin. It exists in two forms i.e. Retinal and as Carotene (pro-vitamin A). Two different types of vitamin A are found in the diet. Preformed vitamin A (Retinal) is found in animal products such as meat, fish, poultry and dairy foods. The other type, pro-vitamin A is found in plant-based foods such as fruits and vegetables. The most common type of pro-vitamin A is beta-carotene.

Vitamin A is also available in dietary supplements, usual in the form of retinyl acetate or retinylpalmitate (preformed vitamin A), beta-carotene (pro-vitamin A) or a combination of preformed and pro-vitamin A.

Properties of vitamin A

- Pale yellow to almost colourless vitamins.
- It is stable to heat at ordinary cooking temperatures. (I.e. less than 100^0C)
- It is susceptible to oxidation being unsaturated alcohol especially under the influence of light.
- It is easily destroyed if the fats that contain it become rancid.
- Unstable in the presence of mineral elements but stable in alkaline and acids.
- Stable during processing operations.
- Losses occur during dehydration especially with old fashion of preservation e.g. sun drying.

Food Sources of vitamin A

As retinol

Vitamin A comes from animal sources, such as egg yolks, liver, butter, meat, fortified milk, cheese, cream, liver, kidney, cod, and halibut fish oil.

As carotene (Provitamin A)

- Bright yellow and orange fruits such as bananas, cantaloupe, pink grapefruit, and apricots
- Vegetables such as carrots, tomatoes, pumpkin, sweet potatoes, and winter squash
- Other sources of beta-carotene include broccoli, spinach, and most dark green, leafy vegetables.

The more intense the colour of a fruit or vegetable, the higher the beta-carotene content. Vegetable sources of beta-carotene are fat- and cholesterol-free.

Functions of vitamin A

- Vitamin A helps form and maintains healthy skin, teeth, skeletal and soft tissue, and mucus membranes. The gastro intestinal tract, nasal lining etc.
- Vitamin A promotes good vision, especially in low light. (Night vision).
- Vitamin A increases resistance to infections and boosts body immunity.

- Vitamin A promotes reproduction through production of steroid hormones.
- Vitamin A regulates growth in children.
- Vitamin A it is required for the maintenance and health of the skin.
- Beta carotene is an anti oxidant and protects the body against cancer / ulcers. Antioxidants protect cells from damage caused by substances called free radicals. Free radicals are believed to contribute to certain chronic diseases and play a role in the aging processes.

Deficiency of vitamin A

There are two types of deficiency in vitamin A i.e. primary and secondary deficiency.

a) Primary deficiency – results from inadequate intake of vitamin A rich foods relative to the physiological needs. It is also known as direct deficiency.
b) Secondary deficiency – it is indirect in that the intake of vitamin A may be adequate but absorption may be inadequate due other digestive disorders or diseases.

Vitamin A deficiency (signs and symptoms)

- Keratinisation of the epithelial surfaces of the body resulting in the build up of keratin in the pores of the skin and over the surface of the eyes causing the condition of xelopthalamia with subsequent blindness.
- Retarded growth if deficiencies occur early in life plus bone deformities.
- Night blindness and defective dim light vision.
- Intestinal infection and increased risk or infections and death.
- Diarrhea

Toxicity / excess intake

- When too much vitamin A is taken in the body, it might result in ***hypervitaminosis A.***
- If you get too much vitamin A, you can become sick. Large doses of vitamin A can also cause birth defects.
- Acute vitamin A poisoning usually occurs when an adult takes several hundred thousand IUs of vitamin A. Symptoms of chronic vitamin A poisoning may occur in adults who regularly take more than 25,000 IU a day. Babies and children are more sensitive to vitamin A, and can become sick after taking smaller doses of vitamin A or vitamin A-containing products such as retinol (found in skin creams).
- Large amounts of beta-carotene will not make you sick. However, increased amounts of beta-carotene can turn the skin yellow or orange. The skin color will return to normal once you reduce your intake of beta-carotene.

Effects of toxicity of Vitamin A

- Irritability
- Retarded growth.
- Blurred vision
- Enlargement of the liver and spleen.
- Loss of hair
- Bone impairment
- Increased pressure in the skull.
- Change in the skin colour. Excess carotene turns the skin yellow as high carotene levels are stored in the lipid layer below the skin.

Recommended daily allowances.

The best way to get the daily requirement of essential vitamins is to eat a wide variety of fruits, vegetables, fortified dairy foods, legumes (dried beans), lentils, and whole grains.

The Food and Nutrition Board of the Institute of Medicine -- Dietary Reference Intakes (DRIs) Recommended Intakes for Individuals of Vitamin A are as below.

Infants (average intake)

- 0 - 6 months: 400 micrograms per day (mcg/day)
- 7 - 12 months: 500 mcg/day

The Recommended Dietary Allowance (RDA) for vitamins is how much of each vitamin most people should get each day. The RDA for vitamins may be used as goals for each person.

Children (RDA)

- 1 - 3 years: 300 mcg/day
- 4 - 8 years: 400 mcg/day
- 9 - 13 years: 600 mcg/day

Adolescents and Adults (RDA)

- Males age 14 and older: 900 mcg/day
- Females age 14 and older: 700 mcg/day

How much of each vitamin you need depends on your age and gender. Other factors, such as pregnancy and your health status, are also important. Ask your doctor what dose is best for you.

Vitamin D (cholecalciferol)

It is referred to as anti – rickets. It occurs in several forms but the two important forms are.

i) Vitamin D_2 (Ergocalciferol).
ii) Vitamin D_3 (cholecaliciferol).

Vitamin D is referred to as a calciferol meaning a calcium bearing alcohol because of its function in calcium absorption.

Properties of vitamin D

- It is the most stable vitamin, not affected by heat, water, acids or alkalis.
- It is not oxidized.
- Its losses during cooking are negligible.

Physiological functions

- Vitamin D, calcium and phosphorous are important in bone and teeth formation in early childhood as it controls the laying down of calcium in children. (Calcification process)
- Vitamin D controls the levels of alkaline enzymes phospholactate therefore influencing overall PH.
- It aids the absorption and distribution of calcium in the body.
- It initiates the synthesis of specific calcium binding protein that increases the absorption of calcium.
- It increases the re - absorption of phosphorous and calcium in the body preventing excessive excretion of these minerals.
- It is important in regulation of heat.

Can be obtained by the body in two ways

a) Directly from food as vitamin D or
b) By the action of sun light on the skin

It is a white crystalline substance and occurs in the food as natural vitamin D.
Relatively few people can obtain vitamin D
The main sources are fatty fish, butter and eggs but these only contain small amounts
If sufficient sun light is received on the body the need for vitamin D from food will be very much reduced.

Sources of vitamin D

- Vitamin D fortified dairy products e.g. yoghurt, ice cream.
- Liver
- Fish oils e.g.cod-liver oil.
- Oily fish, e.g. herring, pilchard, sardine It is also found in smaller amounts in
- Egg yolk
- Milk and dairy products

- Sun light is also an important source of vitamin i.e. the action of sun light on the skin.

Deficiency of vitamin D

- Inadequate absorption of calcium and phosphorous leads to faulty mineralization of bones and teeth due to vitamin D deficiency.
- In children it leads to rickets which causes mal formation of bones. The bones bend under the heavy weight of the body when babies begin to walk. Rickets in children is characterized by; bowled legs and enlargement of junction between the ribs and their cartilaginous collection to the breast bone resulting in a pigeon chest, narrow pelvis and spinal curvature. This results in death due to respiratory failure.
- Enlargement of knee joints which leads to knock knees.
- Skull deformation leads to a bossy fore head.
- Weakness in the muscles
- Nervous irritability.
- Retarded growth in children.

In adults it leads to Osteomalacia. This is characterized by;

- Weakening of bones
- Deformation of bones
- Pain in the bones of leg and lower back
- Difficulty in walking.

Osteoporosis in adults especially in women above 50 years (post menopause) with low calcium intake.

Dental decay

Deficiency occurrences (people at risk)

- Poor dietary intake e.g. people on vegetarian diet (the fiber element in the vegetable make the vitamin unavailable).
- Lack of exposure to sunlight e.g. people who keep in doors or all those who cover their bodies completely.
- Increased requirement especially the pregnant, lactating mothers.
- Infants most especially those not breast fed.
- People who consume mineral oils which reduce the absorption of the vitamin.
- The old especially the women in their post menopause stage.

Recommended daily allowances

Children

0 – 2 years	10 ml per day
2 – 5 years	12 ml per day
5 – 9 years	25 ml per day
Adolescents boys, girls	30 ml per day
Pregnant and lactating	50 ml per day

Toxicity

Excess consumption of vitamin D results in hypervitaminosis D which is largely due to high calcium levels in blood. (hypercalcaemia). This is characterized by;

- Nausea
- Weight loss
- Headaches
- Movement of calcium from bones in to soft tissues.
- Nervous irritability
- Kidney failure / damage
- Soft tissue in children.

VITAMIN E (Tocopherol)

Chemistry and properties

- It is an oily yellow liquid completely soluble in fat and fatty elements.
- It is a stable vitamin not affected by boiling and long periods of storage.
- It decomposes if exposed to air light or when it comes into contact with copper or iron.
- It oxidizes readily and can therefore be used as an anti – oxidant in foods to protect other foods especially vitamin A and C and poly unsaturated acids.

Physiological functions

- It is essential in the synthesis of heam (part of the heamoglobin molecule) used as a body hormone.
- It is used as an anti – oxidant ie prevents the oxidation of vitamins A and C and poly unsaturated fatty acid thus preventing their destruction.
- It interferes with blood clotting process thus promoting blood clotting.
- It stabilizes and protects cell membranes from damage i.e. oxidation of PUFA, vitamin K.

- It slows down aging since it blocks the free radicals believed to participate in the formation of aging pigments from reacting.

Deficiency of vitamin E

It is very rare except under starvation or defects on fats. If it appears, it is characterized by.

- Anaemia in low birth weight infants or babies
- Nervous irritability.
- Pathology of nervous system, liver vascular system and festis.

Sources of vitamin E

- Vegetable oils i.e. mukwano, tamu cooking oils.
- Vitamin E fortied foods e.g. butter, margarine, shortening (cow boy, kimbo) etc
- Wheat germ, whole grain cereals i.e. rice, oats, barley, simsim
- Nuts, e.g. coconut.
- Egg yolk
- Meats e.g. liver, kidney, beef, mutton.

VITAMIN K (coagulations vitamin) - anti haemorrhagic

It is sometimes called anti-haemorrhagic vitamin

Haemorrhage- is a medical condition in which there is a severe bleeding inside a person's body.

Functions

It assists in the formation of prothrombin a protein essential for the normal clotting of blood.

Sources of vitamin K

- Vitamin K is widely(spread)distributed in food, especially in the leafy vegetables such as spinach, liver, especially pig's liver, eggs and milk
- Bacteria which are normally present in the intestinal tract also produce useful supply of vitamin K , which the body is able to use.(it is manufactured by the bacteria present in the intestine)

Effect of deficiency

- Deficiency would result into the inability of the blood to clot and this would be dangerous after accidents and operations.

Recommended dietary (daily) allowance

- A good mixed diet supplies adequate amounts but extra would be required after loss of blood as in case of haemorrhage or sugar.