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Textbook on

Nutrition & Dietetics

for Post Basic BSc Nursing Students



I Clement

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Chapter 2

Review of Macro- and Micro-nutrition

▶ INTRODUCTION

Nutrients, which are needed by the body for good nutritional status, are provided by food. An individual nutritional status is dependent on the provision of sufficient nutrients and the good utilization of these nutrients. Power status of nutrition may be caused by eating that is inadequate in amount and kind or it may be caused by failure in digestion and utilization of these nutrients. The nutrients present in foods fall into three major categories, i.e. proximate, vitamins and minerals. The proximate usually referred to as proximate principles include only those nutrients that yield energy on oxidation, i.e. carbohydrates, proteins and fats. Nutrients are organic and inorganic complexes contained in food.

▶ MACRO- AND MICRO-NUTRIENTS

Macronutrients

Carbohydrates, proteins and fats are macronutrients, which are often called 'proximate principles' because they form a main bulk of the food as given below:

- Carbohydrate: 65%–80%
- Protein: 7%–15%
- Fats: 10%–30%.

Micronutrients

Vitamins and minerals are called micronutrients because they are required in small amounts. A vitamin is an organic

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compound that cannot be manufactured by the body and is needed in small quantities to catalyze metabolic process. When this vitamins are lacking in the diet, metabolic deficits results. Minerals are found in organic compounds and inorganic compounds as free ions. On oxidation, minerals leave an ash, which can be acid or alkaline.

▶ CARBOHYDRATES

Carbohydrates are macronutrients containing carbon, hydrogen and oxygen. They are primary energy yielder, present in plant foods as well as animal foods. Polyhydroxy aldehyde or ketone group occurs in some sugar units. Glucose is physiologically significant among carbohydrate.

Carbohydrates are the chief, cheapest and main source of energy. Carbohydrate normally should provide 50%–60% of total caloric requirements. All the carbohydrates contain carbon, hydrogen and oxygen. All the carbohydrates are changed in the body to simple form called glucose (Table 2.1).

Composition

Carbohydrates are organic compounds composed of carbon, hydrogen and oxygen with the later elements in the ratio of 2:1. The general formula is $C_nH_{2n}O_n$. They are viewed as hydrated carbon atoms.

Classification

Carbohydrates are chemically known as saccharides. They are classified according to number of sugar units present in the molecular structure. The classifications of carbohydrate are shown in the Figure 2.1.

Monosaccharides

Monosaccharides are simple form of carbohydrates, which yields only one molecule of sugar on hydrolysis, e.g. glucose, fructose and galactose:

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1. Trioses—glyceraldehyde and dihydroxyacetone.
2. Tetroses—erythrose, threose.
3. Pentoses—arabinose, xylose, ribose and deoxyribose.

Table 2.1: Sources of carbohydrate

Sl No	Source	Percentage
1.	Arrowroot powder	83%
2.	Sago	87%
3.	Syrup, jelly, jam	65%–85%
4.	Rice	79%
5.	Barley, dried dates	75%
6.	Mango powder	64%
7.	Ragi	72%
8.	Tapioca	38%
9.	Jaggery	90%
10.	Bread	55%
11.	Honey	79%

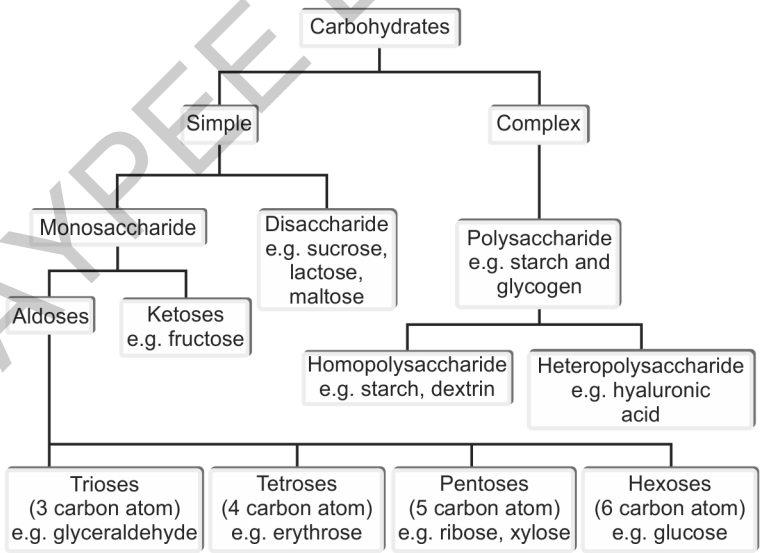

Fig. 2.1: Classification of carbohydrates

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Disaccharides

1. Boise—glycolic bald headed.

Oligosaccharides

Oligosaccharides yield 2–10 molecules of monosaccharides on hydrolysis, e.g. disaccharides (maltose, lactose and sucrose), trisaccharides (raffinose) and tetrasaccharides (stachyose).

Polysaccharides

Polysaccharides yield more than ten molecules of monosaccharide on hydrolysis such as given below:

1. Pentosans: For example, araban, xylan.
2. Hexosans:
   a. Starch, dextrin and glycogen.
   b. Cellulose, inulin, mannan.

Complex polysaccharides: They are not digested by human enzymes, e.g. hemicelluloses, gums, mucilages and pectins.

Functions of Carbohydrate

Carbohydrates perform the following functions.

Yield Energy

Principle function of carbohydrates is to serve as a major source of energy for the body. Each gram of carbohydrate yields 4 kcal of energy regardless of its source. In Indian diets, 60%–80% of energy is derived from carbohydrate.

Glucose Maintenance

Glucose maintenance is indispensable for the maintenance of the functional integrity of the nervous tissue and is the sole source of energy for the proper functioning of the brain. Prolonged lack of glucose may cause irreversible damage to the brain.

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Protein Sparing Action

Carbohydrates exert a protein sparing action. If sufficient amounts of carbohydrates are not available in the diet, the body will convert protein to glucose in order to supply energy. Hence, to spare proteins for tissue building, carbohydrates must be supplied in optimum amounts in the diet. This is called the protein sparing action of carbohydrates.

Fat Metabolism

Carbohydrates are essential to maintain normal fat metabolism. Insufficient carbohydrates in the diet results in larger amounts of fat being used for energy than the body are equipped to handle. This leads to accumulation of acidic intermediate products called ketone bodies.

Synthesis of Body Substances

Carbohydrates aid in the synthesis of non-essential amino acids, glycoproteins (which function as antibodies) and glycolipids (which form a part of cell membrane in body tissues especially brain and nervous system). Lactose remains in the intestine longer than other disaccharides and thus, encourages growth of beneficial bacteria.

Precursors of Nucleic Acid

Carbohydrates and products derived from them, serve as precursors of compounds like nucleic acids, connective tissue matrix and galactosidase of nervous tissue.

Detoxification Function

Glucuronic acid, a metabolite of glucose serves as a detoxifying agent. It combines with harmful substances containing alcohol or phenolic group converting them to harmless compounds, which are later excreted.

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Roughage of the Diet

Insoluble fibers known as composite carbohydrates can absorb water and give bulk to the intestinal contents, which aids in the elimination of waste products by stimulating peristaltic movements of the gastrointestinal tract (GIT).

Other Roles

Carbohydrate has a variety of functions in the animal and human body. It plays crucial role in biological system they are:

1. Carbohydrate of 1 g provides 4 kcal on oxidation.
2. Protein sparing action helps to regulate protein metabolism. When carbohydrate and fat is in adequate amount in the diet, major protein is used for tissue building.
3. Ketone body from fat metabolism is prevented when carbohydrate is sufficient.
4. Pentose (five-carbon sugar) is utilized in the formation of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
5. It supplies fuel to brain tissues, otherwise irreversible damage occurs.
6. If carbohydrate exceeds the normal requirement, fat synthesis in adipose tissue.
7. Lactose in gastrointestinal tract promotes the growth of bacteria, which is responsible for the synthesis of B complex vitamins.
8. Complex polysaccharides cellulose and hemicellulose contribute bulk to the stool.
9. Carbohydrate in well-balanced diet keeps the blood sugar level within normal limits.

Digestion and Absorption of Carbohydrates

Digestion

The first stage of digestion of carbohydrate takes place in the mouth. Chewing breaks up food, and exposes starch and sugars to the action of enzymes. Saliva contains salivary amylase

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(ptyalin). It converts starch to maltose, but time limits the action of salivary amylase, because as food enters the stomach, the acid present in the stomach blocks the action of salivary amylase.

In the stomach, the acid causes hydrolysis of sucrose. In the small intestine, pancreatic amylase and intestinal amylase digest starch up to the stage of maltose:

$$\text{Starch} \xrightarrow[\textit{Salivary amylase}]{\textit{Pancreatic amylase}} \text{Maltose + Isomaltose}$$

Glycogen is also broken by these enzymes to disaccharides. Enzymes maltase, sucrase and lactase present in the brush borders of the columnar cells of small intestine convert disaccharides to monosaccharides:

$$\text{Maltose} \xrightarrow{\textit{Maltase}} \text{Glucose + Glucose}$$

$$\text{Lactose} \xrightarrow{\textit{Lactase}} \text{Glucose + Galactose}$$

$$\text{Sucrose} \xrightarrow{\textit{Sucrase}} \text{Glucose + Fructose}$$

Cellulose and other polysaccharides are not digested by enzymes, so undigested material passes to large intestine forming bulk, which contributes to feces.

The end products of carbohydrate digestion are monosaccharides—glucose, galactose and fructose. They are absorbed by process of active absorption by the mucosa of the small intestine.

Metabolism

Metabolism occurs inside the various cells of the body.

There are two types of metabolism: Anabolism (building up) and catabolism (breaking down):

1. The major carbohydrate anabolic pathways are conversion of glucose into glycogen (glycogenesis), which takes place in the liver and muscles.

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2. The conversion of glucose into fat (lipogenesis) takes place in the liver and adipose tissue.
3. Carbohydrates follow two major catabolic pathways:
   a. The breakdown of glucose releasing energy (glycolysis) and converting it into usable energy adenosine triphosphate (ATP) and which in turn gets converted to glycogen glucose (glycogenolysis).
   b. After digestion and absorption of glucose into the bloodstream, it is utilized directly by the tissues for energy. When the absorbed glucose exceeds the body's need for energy, it is stored as glycogen in the liver and muscle, and excess glucose is converted to triglycerides and stored as fat in adipose tissue.

Glucose Formation from Non-carbohydrate Sources

1. Glucose can be formed by the metabolism of protein and from the glycerol of fat. It has been estimated that the glycerol present in 100 g of fat can give rise to 50–60 g glucose.
2. Lactate, which is formed from glucose, can be reconverted into glucose in the liver.

Regulation of Blood Sugar

1. Blood circulates glucose continuously to each and every cell of the body as a source of energy, and for the synthesis of a number of substances.
2. In fasting state, blood sugar level is 60–85 mg/100 mL of blood. Soon after a meal, it raises to 140–150 mg/100 mL.
3. If the body is in a good carbohydrate metabolic pathway, the concentration will fall down to a normal blood sugar level of 60–85 mg/100 mL.
4. The liver very efficiently maintains the normal blood sugar level. The liver is the only organ in our body, which can either supply glucose to the circulation or to remove the excess sugar from blood.
5. If the blood sugar concentration is high, the condition is known as hyperglycemia. Hypoglycemia occurs when the

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blood sugar level is below normal level. This occurs in certain abnormalities of liver function or when insulin is produced in excessive amount by the pancreas.

Carbohydrate Requirements

As carbohydrate is utilized as main source of energy, at least 40% of the total energy in the food should come from carbohydrates. In our country, 60%–80% of a day's energy needs are met from carbohydrates in the form of starch furnished by cereals and pulses. In developed countries, only 30%–40% of days energy needs are met from carbohydrates:

1. The body has a specific need for carbohydrates as a source of energy for the brain and other tissue cells, for synthesis of lactose of milk (lactating women) and galactose, and other sugars present in the cerebrosides, mucopolysaccharides, etc.
2. Carbohydrate is essential for the oxidation of fat and for the synthesis of certain non-essential amino acids.
3. The carbohydrate calories should be at least 40% in well -balanced diets. The level of carbohydrates calories in the diet will also depend on the availability of fat and the economic conditions of the people as fat is about twice as costly as cereals on equicalorie basis in the developing countries and per capita production of fat per day is low (10–15 g).
4. The optimal levels of carbohydrates in the diet, taking into physiological needs for proteins and fats are given in Table 2.2.

Table 2.2: Carbohydrate requirements of various age groups

Sl No	Age group	Optimal level of carbohydrate calories as % of total calories
1.	Adults	50%–70%
2.	Expectant and nursing mothers	40%–60%
3.	Infants (1–12 month)	40%–50%
4.	Preschool children (1–5 year)	40%–60%
5.	Older children and adolescents	50%–70%

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Deficiencies

1. Low level of glucose (40 mg% or below) in the blood is called hypoglycemia. This is not common in healthy individual. Diabetic people may get this condition on poor or irregular treatment.
2. The signs and symptoms of diabetes are tiredness, convulsions, dizziness, tingling, faintness, headache, firmness, tachycardia, palpation, confusion, slurred speech, staggering gait, lack of coordination and coma.
3. Low carbohydrate with high-protein and high-fat foods are dangerous, leads to weight loss, ketosis, dehydration, electrolyte deficits, retention of uric acid and some symptoms of gout.

Diabetes Mellitus

1. Diabetes mellitus is a chronic disease in which blood glucose level is raised above 180 mg/dL of blood and glucose is excreted in urine.
2. The disease is primarily due to the insufficient production of the hormone, insulin by the β-cells of the islets of Langerhans of the pancreas.

▶ FIBER

Fiber or roughage consists of cellulose and hemicellulose. These parts of carbohydrates are not digested by digestive juice. They are left unchanged after digestion. Dietary fiber is defined as that portion of plant material ingested in the diet that is resistant to digestion by gastrointestinal secretions. It consists of hemicellulose, cellulose, lignins, oligosaccharides, pectins, gums and waxes.

Some bacteria in the large intestine can degrade some components of fiber releasing products that can be absorbed into the body and used as energy source. Two categories of fiber are found in food. Crude fiber (CF) is defined as the residue remaining after the treatment with hot sulfuric acid, alkali and alcohol.

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The major component of CF is a polysaccharide called cellulose. CF is a component of dietary fiber. Several other carbohydrate and related compounds are called pectins; hemicellulose and lignins are the second category found in plant foods and are also resistant to digestion. These together with cellulose are collectively known as dietary fiber.

Role

Fibers are indigestible substance of plant foods, roughage not digested by human enzyme contribute bulk to the stool. For example, fibrous foods contain whole cereals, fenugreek, cabbage and greens. Fiber part of the foods is cellulose hemicellulose and lignin.

Functions

1. Fiber absorbs water and this increases the bulk of the stool and helps to reduce the tendency of constipation by encouraging bowel movements.
2. The cholesterol-lowering effect of certain types of dietary fiber appears firmly established.
3. Fiber may also have a role in weight reduction; people who eat well-balanced diets obtain enough roughage.
4. Prevents constipation and reduce the effects of carcinogens.
5. Increases the motility of small intestine, colon and decreases the transit time.

▶ PROTEINS

In Greek, proteins mean the first importance. They are nitrogenous constituents made up of chain of amino acids present in both plant and animal foods.

The name 'protein' was suggested by Mulder in 1838 to the complex organic nitrogenous substances found in animal and plant tissues. Protein constitute about one fifth (20%) of animal body on the fresh weight basis. They are essential for life processes. They plan an important role in many biochemicals, biophysical processes in the body.

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Proteins differ from carbohydrates and fats in that they contain nitrogen in addition to carbon, hydrogen and oxygen and a few contain sulfur. Most of the proteins also contain phosphorus and some specialized proteins contain iron, iodine, copper and other organic elements. Contribution made by proteins to the energy value of most well-balanced diets is usually between 10% and 15% of the total. But they are most important because every cell in the body is composed of proteins, which are subjected to continuous wear and replacement.

Chemical Composition

Proteins contain carbon, hydrogen, oxygen and nitrogen. They are distinguished from carbohydrates and fats by the presence of nitrogen.

Protein is synthesized from basic units called amino acids. Protein molecules, which contain up to hundred amino acids, are much larger than carbohydrates or lipid molecule. Chemically amino acids are composed of a carbon atom to which is attached a carboxyl (COOH) group, a hydrogen atom (H), an amino group (NH_2) and an amino acid radical (R) as shown below.

The carboxyl group, the amino group and the hydrogen atom are the same for all amino acids. The R group however distinguishes one amino acid from another. R varies from a single hydrogen atom as found in glycine to longer chain of up to 7 carbon atoms. A protein molecule is made up of chains of amino acids joined to each other by a peptide linkage. The amino group of one amino acid is linked to the carboxyl group of another amino acid by removal of water.

Thus, two amino acids form dipeptide and three forms a tripeptide. Proteins consist of hundreds of such linkages, hence called polypeptides:

1. Proteins contain carbon, hydrogen, nitrogen and sulfur and also some contain phosphorus.
2. Proteins are large molecules formed from the combination of a number of simpler substances known as amino acids.

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