# UNIT 3: NUTRIENTS

# Macro Nutrient

## CARBOHYDRATES

- Carbohydrates are an important group of nutrients. It is present in various forms in the foods we cook, processed food which we purchase and forms the bulk of our diet.
- They are mainly present in food in the form of sugars, starches, and fibres. They are organic compounds made up of C, H &. O
- They are called carbohydrates because H & O are present in the same proportion as found in water i.e. 2:1.
- They are processed in plants by the process of photosynthesis.
- Chlorophyll is a green pigment that absorbs energy from sunlight and enables plants to build up carbohydrates from CO2 and H20 in plants.
- Glucose cannot be stored on a large scale so it is converted to starch with the removal of water and is stored in various parts of the plant. E.g. in cereal grains and potatoes, CHO is stored as starch.
- In bananas, mango and sugar beets it is stored as sugar.
- However, the reverse is seen in the fruits, immature fruits contain starch which is converted into sugar as the fruit ripens.
- The various parts of the plant where CHO is stored form the main source of CHO in the diet.

## Definition

The carbohydrates are technically hydrates of carbon. It is a group of organic compounds occurring in living tissues and foods in the form of starch, cellulose, and sugars.

Carbohydrates are also called saccharides which is a Greek word and it means sugar because almost all the carbohydrates have a sweet taste.

## Classification of Carbohydrates

Carbohydrates are broadly classified into two categories i.e. simple carbohydrates and complex carbohydrates.

Simple Carbohydrates vs Complex Carbohydrates:

| Simple Carbohydrate | Complex Carbohydrate |
|---|---|
| Simple carbohydrates contain single molecule or smaller chains of sugar. | Complex carbohydrates contain longer chains of sugar molecules than simple carbohydrates. |
| Simple carbohydrates are quicker to digest than complex carbohydrates. | Complex carbohydrates take longer to digest and are a more stable source of energy. |
| Simple carbohydrates are in foods such as table sugar and syrups. | Complex carbohydrates are present in foods such as bread and pasta. |
| Milk and milk products contain simple carbohydrate. These foods do not contain fiber but are rich in protein, calcium, and vitamin D | Complex carbohydrates found in whole foods tend to be highly nutritious. |

Classification of carbohydrates on the basis of their structure and function are:

## Monosaccharide

The monosaccharides are the simplest of the carbohydrates since they contain only one polyhydroxy aldehyde or ketone unit and cannot be further hydrolysed into simpler units. (Mono: one, Saccharide: sugar).

There are two major classes of monosaccharides:

1. Aldoses:

Sugars containing an aldehydic group are known as aldoses, e.g., Glucose, galactose, mannose, and glycerose.

2. Ketoses:

Sugars containing a ketonic group are known as ketoses. e.g., Dihydroxyacetone, fructose, and ribulose.

## Disaccharide

Sugars containing two monosaccharides linked through glycosidic bond are known as disaccharides.

The three most common disaccharides are:

1. Maltose

α-D-glucose + α-D-glucose = Maltose

Also known as malt sugar. It is found in germinating grain (such as barley) and is formed during the hydrolysis of starch to glucose during digestion.

2. Lactose

β-D-galactose + α-D-glucose = Lactose

It is present in milk hence, known as milk sugar. Lactose constitutes 5% of cow's milk and 7% of human milk. It is digested by the enzyme lactase.

3. Sucrose

α-D-glucose + β-D-fructose = Sucrose

Also known as table sugar. Both anomeric carbons of glucose and fructose are tied together in the glycosidic linkage. Sucrose is abundant in sugar cane and sugar beets; maple syrup contains about 65% sucrose, with glucose and fructose present as well; caramel is the solid residue formed from heating sucrose.

## Oligosaccharide

Oligosaccharides contain from 3 to 10 monosaccharide units. Oligosaccharides can have many functions including cell recognition and cell binding.

Raffinose is an example of oligosaccharide.

β-D-galactose + α-D-glucose + β-D-fructose = Raffinose

An oligosaccharide found in peas and beans; largely undigested until reaching the intestinal flora in the large intestine, releasing hydrogen, carbon dioxide, and methane).

# Polysaccharide

Carbohydrates made up of more than 10 monosaccharide units are called polysaccharides. They are also known as glycans.

They are further classified as homopolysaccharides and heteropolysaccharides.

1. Homopolysaccharides:

Those polysaccharides which contain only one kind of monosaccharide unit are called homopolysaccharides. e.g., starch, glycogen, cellulose, dextran, inulin, agar, chitin, etc.

*Starch*: Starch is a polymer consisting of D-glucose units. Starches (and other glucose polymers) are usually insoluble in water because of the high molecular weight, but they can form thick colloidal suspensions with water. It is the chief carbohydrates present in plants and forms the main source of dietary energy sources to humans.

*Glycogen*: Glycogen, also known as animal starch, is made up of α-D-glucose units linked by α-1 → 4 linkages in the linear and α-1 → 6 linkages at the branching points. Glycogen is abundant in the liver and muscles; on hydrolysis, it forms glucose, which maintains normal blood sugar level and provides energy.

*Cellulose*: Cellulose is a polymer consisting of long, unbranched chains of D-glucose connected by β(1→4) glycosidic linkages. It is the most abundant carbohydrate in nature. It forms the woods of the plant. Cellulase enzyme is absent in human being and hence it becomes non-utilizable.

2. Heteropolysaccharides:

heteropolysaccharides (heteroglycans) contain two or more different monosaccharide units. Usually, they provide extracellular support for organisms of all kingdoms: the cell envelope of bacteria, or the matrix that holds individual cells together in animal tissues, and provides protection, shape, and support to cells, tissues, and organs.

They include chondroitin sulphate, hyaluronic acid, and heparin.

## Other Classification of Carbohydrates

*Available Carbohydrates*: Carbohydrates that are digested in the human body and yield energy when they are oxidized in the body are available carbohydrates. E.g. sugars, starch, glycogen, etc.

*Unavailable Carbohydrates*: Carbohydrates that cannot be digested because the human body does not contain the enzymes necessary for their breakdown are unavailable Carbohydrates. They do not provide any energy to the body but are necessary as they perform some important functions in the body such as regular elimination of faecal waste. E.g. soluble fiber and insoluble fiber.

# Dietary Sources of Carbohydrates

| | Carbohydrates | Dietary Sources |
|---|---|---|
| MONOSACCHARIDES | Fructose | Fruits, vegetables, and honey, also derived from the digestion of sucrose |
| | Glucose | Small amounts are found in some fruits, vegetables, and honey, manufactured foods, digestion and conversion of other carbohydrates |
| | Galactose | Digestion of lactose |
| DISACCHARIDES | Sucrose | from sugar cane and sugar beet, sweet root vegetables such as beetroot and carrots, table sugar, manufactured foods |
| | Maltose | Malted wheat and barley, malt extract, beer |
| | Lactose | Milk, Milk products |
| | Trehalose | Mushrooms and edible fungi |
| OLIGOSACCHARIDES | Raffinose, stachyose, verbascose, inulin, fructose and galacto-oligosaccahrides | Legumes, onion, artichoke, fennel, asparagus, Pre-biotics |
| POLYSACCHARIDES | Starch | Cereal foods, potato, small amounts in other root vegetables and unripe fruit |
| | Non-starch polysaccharides | Vegetables, fruit, wholegrain, cereals, pulses |

## Functions

There are five primary functions of carbohydrates in the human body. They are energy production, energy storage, building macromolecules, sparing protein, and assisting in lipid metabolism.

*Energy Production*

The primary role of carbohydrates is to supply energy to all cells in the body. Many cells prefer glucose as a source of energy versus other compounds like fatty acids. Some cells, such as red blood cells, are only able to produce cellular energy from glucose. The brain is also highly sensitive to low blood-glucose levels because it uses only glucose to produce energy and function (unless under extreme starvation conditions). About 70 percent of the glucose entering the body from digestion is redistributed (by the liver) back into the blood for use by other tissues. Cells that require energy remove the glucose from the blood with a transport protein in their membranes.

*Energy Storage*

If the body already has enough energy to support its functions, the excess glucose is stored as glycogen (the majority of which is stored in the muscles and liver). A molecule of glycogen may contain in excess of fifty thousand single glucose units and is highly branched, allowing for the rapid dissemination of glucose when it is needed to make cellular energy.

The amount of glycogen in the body at any one time is equivalent to about 4,000 kilocalories—3,000 in muscle tissue and 1,000 in the liver. Prolonged muscle use (such as exercise for longer than a few hours) can deplete the glycogen energy reserve.

*Building Macromolecules*

Although most absorbed glucose is used to make energy, some glucose is converted to ribose and deoxyribose, which are essential building blocks of important macromolecules, such as RNA, DNA, and ATP. Glucose is additionally utilized to make the molecule NADPH, which is important for protection against oxidative stress and is used in many other chemical reactions in the body. If all of the energy, glycogen-storing capacity, and building needs of the body are met, excess glucose can be used to make fat. This is why a diet too high in carbohydrates and calories can add-on the fat pounds.

*Sparing Protein*

In a situation where there is not enough glucose to meet the body's needs, glucose is synthesized from amino acids. Because there is no storage molecule of amino acids, this process requires the destruction of proteins, primarily from muscle tissue. The presence of adequate glucose basically spares the breakdown of proteins from being used to make glucose needed by the body.

*Lipid Metabolism*

As blood-glucose levels rise, the use of lipids as an energy source is inhibited. Thus, glucose additionally has a "fat-sparing" effect. This is because an increase in blood glucose stimulates the release of the hormone insulin, which tells cells to use glucose (instead of lipids) to make energy. Adequate glucose levels in the blood also prevent the development of ketosis. Ketosis is a metabolic condition resulting from an elevation of ketone bodies in the blood. Ketone bodies are an alternative energy source that cells can use when glucose supply is insufficient, such as during fasting. Ketone bodies are acidic and high elevations in the blood can cause it to become too acidic.

*Other Functions*

- Glucose is indispensable for the maintenance of the integrity of nervous tissue (some central nervous system areas are able to use only glucose for energy production) and red blood cells.
- They take part in detoxifying processes. For example, at hepatic level glucuronic acid, synthesized from glucose, combines with endogenous substances, like hormones, bilirubin, etc., and exogenous substances, like chemical or bacterial toxins or drugs, making them atoxic, increasing their solubility and allowing their elimination.
- They are also found linked to many proteins and lipids. Within cells, they act as signals that determine the metabolic fate or the intracellular localization of the molecules which are bound. On the cellular surface, their presence is necessary for identification processes between cells that are involved e.g. in the recognition between spermatozoon and oocyte during fertilization, in the return of lymphocytes in the lymph nodes of provenance or still in the leukocyte adhesion to the lips of the lesion of a blood vessel.
- Two homopolysaccharides, cellulose and chitin (probably, next to cellulose, the second most abundant polysaccharide in nature), serve as structural elements, respectively, in plant cell walls and exoskeletons of nearly a million species of arthropods (e.g. insects, lobsters, and crabs).
- Heteropolysaccharides provide extracellular support for organisms of all kingdoms: in bacteria, the rigid layer of the cell wall is composed in part of a heteropolysaccharide contained two alternating monosaccharide units while in animals the extracellular space is occupied by several types of heteropolysaccharides, which form a matrix with numerous

functions, as hold individual cells together and provide protection, support, and shape to cells, tissues, and organs.

## Dietary Fibre

Dietary fiber is a type of carbohydrate that cannot be digested by our bodies' enzymes. It is found in edible plant foods such as cereals, fruits, vegetables, dried peas, nuts, lentils, and grains. Fiber is grouped by its physical properties and is called soluble, insoluble or resistant starch. All three types of fiber have important roles to play.

*Significance of Dietary fiber*

Fiber helps to keep our digestive system healthy and helps to prevent constipation. For example, fiber bulks up stools, make stools softer and easier to pass and make the waste move through the digestive tract more quickly.

Cardiovascular disease (heart disease and stroke) and type 2 diabetes:

Foods such as oats and barley contain a type of fiber known as beta-glucan, which may help to reduce cholesterol levels if you consume 3g or more of it daily, as part of a healthy diet.

Research has increasingly shown how important the bacteria in our gut may be to our health, and it has been suggested that a fiber-rich diet can help increase the good bacteria in the gut. Some fiber types provide a food source for 'friendly' gut bacteria helping them to increase and produce substances that are thought to be protective such as short-chain fatty acids.

Dietary fiber play role in energy intake control and reduced risk for the development of obesity. The role of dietary fiber in energy intake regulation and obesity development is related to its unique physical and chemical properties that aid in early signals of satiation and enhanced or prolonged signals of satiety.

| Functions | Benefits |
|---|---|
| Adds bulk to the diet, making feel full faster | May reduce appetite |
| Attracts water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose | Lowers variance in blood sugar levels |
| Lowers total and LDL cholesterol | Reduces risk of heart disease |
| Regulates blood pressure | May reduce onset risk or symptoms of metabolic syndrome and diabetes |
| Speeds the passage of foods through the digestive system | Facilitates regularity |
| Adds bulk to stool | Alleviates constipation |
| Balances intestinal pH and stimulates intestinal fermentation production of short-chain fatty acids | May reduce risk of colorectal cancers |

## *Sources of Dietary Fiber*

Fiber-rich foods include:

- Wholegrain breakfast cereals, wholewheat pasta, wholegrain bread and oats, barley and rye
- Fruit such as berries, pears, melon and oranges
- Vegetables such as broccoli, carrots, and sweetcorn
- Peas, beans, and pulses
- Nuts and seeds
- Potatoes with skin

## Fiber Intake

| Age (years) | Recommended intake of fibre |
|---|---|
| 2-5 | 15g per day |
| 5-11 | 20g per day |
| 11-16 | 25g per day |
| 17 and over | 30g per day |

## Deficiency of carbohydrates

carbohydrate inadequacy results in increased production of organic compounds called ketones (a condition, known as ketosis), which imparts a distinctive sweet odour to the breath.

Ketosis and other untoward effects of a very-low-carbohydrate diet can be prevented by the daily consumption of 50 to 100 grams of carbohydrate.

## Excess of Carbohydrates

Here are some of the harmful effects of too many carbohydrates in your diet:

*Obesity*

Carbs are a concentrated source of calories, at 4 calories per gram. And large servings of carb-heavy dishes like rice, pasta and bread can contain hundreds of — or in some cases, over a thousand — calories. If you're habitually overeating carbohydrates, the excess calories could lead to Obesity.

*Type 2 Diabetes*

Type 2 diabetes has been linked to the overconsumption of refined carbohydrates, which include white bread, pasta, and many packaged

snack foods. These types of carbs digest quickly and cause a rush of glucose into the blood. This increases the body's need for insulin and the pancreas does not produce enough insulin. Insulin's job is to move glucose out of the blood, having too little means that blood sugar is able to linger in our bloodstream and this raises our blood sugar level causing diabetes.

*Atherosclerosis*

Excess carbs change into the excess fat of your body. When your body fat reaches an extreme point, this fat causes the arteries' walls to thicken up. Consumption of saturated fat encourages the plaque in the arteries to build up, thus narrowing the space for blood flow. This causes a disruption in the bloodstream, thus increasing the chances of a heart attack or a stroke. This condition is known as atherosclerosis.

*Vascular Diseases*

Consuming too many carbs increases the number of triglycerides in your blood, which then raises the risk of developing heart diseases. It also causes the arteries to swell and blood clots may occur in your heart and blood. Triglycerides beat the amount of good cholesterol in the body, potentially giving you numerous vascular diseases