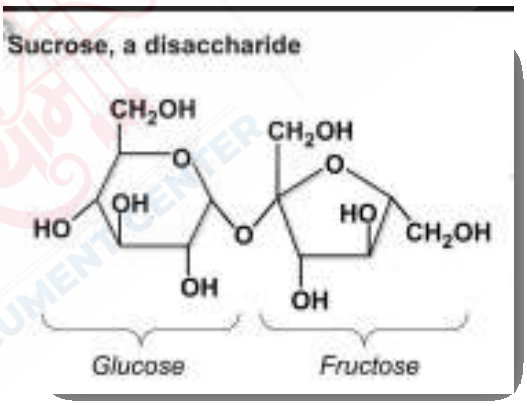
CHAPTER 2

CARBOHYDRATES

A) Introduction: Carbohydrates contain carbon, hydrogen and oxygen. It means "hydrate of carbon" i.e. in the carbohydrate molecule; hydrogen and oxygen are present in the same proportion as in water and attached to the carbon. In this word, the suffix hydrate indicates that hydrogen and oxygen occur in carbohydrate in the same proportion as in water.

Carbohydrate are organic compounds with the basic structure $C_x(H_2O)_y$. Among the most important types of carbohydrates in food are the sugars, dextrin, starches, cellulose, hemicelluloses, pectin and certain gums. Simple carbohydrates are called sugars. One of the simplest carbohydrates is the six carbon sugar glucose. Glucose and other simple sugars form ring structures of the following form:

STRUCTURE



Classification of Carbohydrates

Carbohydrates are classified on the basis of the number of sugar units or saccharide units, which are present in their structures:

1. **Monosaccharides:** These are the simplest forms of carbohydrates found in nature. Three monosaccharides are of importance in human nutrition. They are glucose, fructose and galactose.
   a. **Glucose:** It is the primary carbohydrate used by the body.
   b. **Fructose:** It is the sweetest of all sugars and is also known as fruit sugar because it is found in fruits and honey.
   c. **Galactose:** It is found in combination with glucose in the disaccharide lactose in milk. This sugar is converted to glucose in human body

2. **Disaccharides:** These are double sugars composed of two monosaccharides linked together with the removal of a molecule of water. The disaccharides which are of importance in the diet are sucrose, maltose and lactose.
   a. **Sucrose:** It is the name given to sugar which we use daily. It is prepared from sugar cane and sugar beet. It is the most common of all the disaccharides. It is present in some fruits and vegetables, and forms a substantial part of the diet of children and adults because of the increase in consumption of junk foods, processed foods and fast foods. It is made up of one unit of glucose and one unit of fructose.
   b. **Lactose:** It is the sugar present in milk. It is made up of one unit of glucose and one unit of galactose. It is the least sweet of all the sugars and is easily fermented to lactic acid by lactic acid bacteria

while preparing curds and cheese. Lactic acid, which is formed from lactose, helps in setting curds and curdling milk.

c. **Maltose:** It is formed when whole grains are sprouted and in the commercial preparation of malt from starch. In the body, maltose is formed during digestion of starch. It is composed of two units of glucose.

3. **Oligosaccharides:** They are composed of three to ten monosaccharide units. Example includes: **Raffinose** and **Stachyose.**

4. **Polysaccharides:** These are complex carbohydrates made up of 100-2000 glucose units linked to each other in a chain or branched form. The number of glucose units, their arrangement and linkage to one another influence the properties of polysaccharides.

   a. **Starches:** They form approximately half the dietary carbohydrates which are consumed. They are present in abundance in cereals, pulses, tapioca, sago, roots and tubers.

   b. **Glycogen:** This is also called animal starch as it is the form in which the animal body stores carbohydrates as a reserve source of energy. One third of the glycogen is stored in the liver and two thirds is stored in the muscles. Approximately 340 g of glycogen is stored in the body. This store is sufficient to meet the energy needs for less than a day. However, animal liver or muscle is not a source of glycogen in the diet as it is immediately converted to lactic acid when the animal is slaughtered.

   c. **Dextrin:** This is formed in the first stage of starch breakdown either by enzymes during digestion, or by the action of dry heat on starch during toasting bread or browning flour.

Pectin

It is the name given to a mixture of polysaccharides found in same fruits and roots. It can form gel in the presence of adequate sugar and acid. It is not affected by animal enzymes.

Food Sources

They are produced by photosynthesis in green plants and are nature's way of storing energy from sunlight. It occurs in several forms. Starch is found in plant seeds such as cereals and pulses and roots and tubers; sugar in fruits, honey, plant juice (sugarcane, beetroot, and palm). Cereals supply a large part of the carbohydrate (starch) in the Indian Dietary.

Functions

1. It plays a major role in biological systems and in foods. The main function of carbohydrates is to provide energy. Each gram of starch or sugar gives 4-killo calories (is a unit of heat) to the body. In the Indian dietary, about 65 to 80 percent of energy is supplied by the carbohydrates, mainly in the form of starch. Glucose is the source of energy for the central nervous system.
2. Another important function is to spare proteins for their main function of tissue building and maintenance.
3. The third function is related to proper utilization of fat from the diet. It is said that fats burn in the flame of carbohydrates indicating the need for major part of energy to be supplied in the form of carbohydrates.

Certain carbohydrates have special role in the body:

1. **Lactose Acids:** The absorption of calcium
2. **Ribose :** A 5 carbon sugar, is a part of the important compound (Deoxy) DNA and RNA (Ribonucleic Acid)
3. **Cellulose and other indigestible carbohydrates:** Aid the movements of food through the digestive tract by their capacity to absorb water and help to maintain muscle tone.

Fibre cellulose, hemicellulose and pectins, which are components of the skins of fruits, covering of seeds and the structural parts of edible plants are usually referred to as Fibre.

Fibre is not digested by the body. However, it is useful to the body. It helps in the elimination of intestinal wastes, stimulates peristaltic movements of the intestinal tract by absorbing water and thus adding bulk to the intestinal contents. Lack of fiber in the diet could lead to constipation and other disturbances of the colon. **This could be corrected by including foods containing whole grains cereals, fruits and vegetables in the diet.**

B) Effect of Cooking

A number of changes occur in the food components as a result of preparations. It is necessary to understand and manipulate the changes to obtain an acceptable food product.

Starches are the major component of cereals, millets, dals, roots, tubers and sago. Starches are bland in taste, not readily soluble in cold water but absorb water when soaked in hot water. When starch

granules are added to cold water, a temporary suspension is formed, the starch tends to settle out as soon as the mixture is allowed to stand.

When dry starch is mixed with warm or hot water, the part which comes in contact with water becomes sticky and the starch granules cling together in lumps. Heating does not help to separate the granules, because once formed the lumps stay intact. If one of the lumps is broken open, raw starch is found inside.

The change in texture, color and physical state, which occurs when starch is heated in water, is known as **Gelatinization** of starch. In roots and tubers, the presence of starch which absorbs the water during cooking, results in retention of size.

Gelatinization: When starch granules are mixed with cold water, they do not dissolve but form a suspension. When the water is heated, the granules begin to swell. The heat energy breaks the hydrogen bonds in the starch granules and facilitates the entry of water into the granules. At the same time, some amylose from the granule leaches into the cooking water. The temperature at which the granules swell is called the gelatinization temperature and is characteristic for each starch.

The starch chains in the granules absorb moisture and begin to uncoil from their tightly packed configuration. The size of the granule increases as more and more water enters. The water in the granule gets bonded to amylose and amylopectin. The mixture becomes viscous and translucent after continuous heating. The increase in viscosity is due to the water bonded to starch and increase in size of starch granule as well as reduction in free water in the mixture. Swollen grains find it difficult to move past each other, adding

to the viscosity of the mixture. This process of swelling of the starch grains and formation of viscous starch pastes is called **GELATINIZATION.**

RETROGRADATION: Amylose chains have a tendency to recoil and partially recrystallize and form gels more readily but these gels are unstable. Some hydrogen bonds which holds the gel together break and amylose molecules move around forming new bonds. As the gel stales, amylose molecules rearrange themselves in an orderly manner in crystalline regions. This is accompanied by loss of solubility and release of water from the gel, causing food defects.

A starch gel which has retrograded loses its smooth texture and feels gritly when eaten. The rate and extent of retrogradation are influenced by temperature, size, shape and concentration of starch. Starch retrogrades rapidly at **zero degree Celcius.**

Retrogradation occurs when a starch gel stales or when it is frozen. Bread and starch thickened puddings stored in the refrigerator develop undesirable textural changes because of retrogradation by formation of crystalline aggregates of amylose.

The texture defects caused by retrogradation in foods, which can be heated, are temporarily corrected by warming the food containing starch. Heat energy breaks the hydrogen bonds which hold amylose

molecules together forming crystalline areas. Stale bread becomes soft when it is covered and reheated, but as it cools it develops an undesirable texture once again.

The problem of retrogradation is of concern in cold starch-based gels. This can be corrected by using starches which are stable to freezing and thawing. A number of modified starches are available in the market today.

C) Factors Affecting Texture of CHO

Stiffness of CHO Gel: When a gel stales or its structure is disrupted by cutting the gel, water which is trapped in the gel is released and the gel collapses. This 'weeping' or loss of moisture from a gel is called syneresis.

(**Aging of a gel**: In a starch gel, water is trapped as the dispersed phase within the gel water is also bonded by hydrogen bonding to amylose molecules and starch granules which form the matrix of the gel)

Dextrinization: When a starch is heated without any water, the temperature rises rapidly beyond 100 degree celcius. Water which is naturally present in flour and the high temperature brings about the chemical degradation of flour splitting the starch molecule at one or more of the 1,4-alpha-glucosicidic linkages. This reaction is called dextrinization, and the short chain starch molecules of varying lengths formed are called dextrins. Dextrinization is seen when flour is browned while making brown roux for gravies and sauces. Browned flour has lesser thickening ability because of formation of shorter chain dextrins.

D) <u>Uses of carbohydrates in Food Preparation</u>

Starch from various sources in its natural form is used as a thickening and gelling agent in a wide range of products. It is the primary thickening agent in soups and roux-based mother sauces such as béchamel, veloute and espagnole sauces. These sauces are used for casseroles and vegetable and meat based preparations, salads and pastas. It is used in custard sauce, pudding, pie fillings and soufflés.

Carboxymethly cellulose (CMC), pectins, gums and alginates have varied applications in their natural and modified forms. Commercially, starch derivates are used for an exhaustive range of products.