CARBOHYDRATE

INTRODUCTION

Dear viewers, let us learn about carbohydrate .Carbohydrate means sugar or polymers of sugars, such as starch. These polymers on hydrolysis yields simple sugars, through the action of digestive enzymes or by heating with dilute acids. Carbohydrates are the major source of energy in human diets. Earlier, they were just considered as a means of obtaining energy. But, now it is recognized as an important food component with many physiological effects. These physiological effects associated with dietary carbohydrates depends on the rate and extent of their digestion. Digestion and absorption takes place in the small intestine and fermentation in the large intestine.

Glycogen is the storage polysaccharide and is deposited in liver and skeletal muscles. It is structurally similar to starch. Glycogen is the storage polysaccharide from animal source. Through the action of digestive enzymes, carbohydrate breaks down to mono saccharide and gets absorbed by the small intestine. Few studies have indicated that the consumption of readily available sugar leads to an increase in plasma glucose level. This has been proven to be detrimental to the health.

This session will cover the following aspects on carbohydrates:

1) Classification
2) Functions
3) Absorption and digestion
4) Metabolism of carbohydrates
5) **Deficiency of carbohydrates**
6) **Excess of carbohydrates**

2. CLASSIFICATION OF CARBOHYDRATES

Carbohydrates have been classified into three major classes namely; monosaccharide, disaccharides and polysaccharides. Glucose, fructose, galactose and mannose are categorized as monosaccharides. The major disaccharides are sucrose, lactose and maltose. Polysaccharides generally include; cellulose, hemicelluloses, pectins, gums and mucilages which are largely regarded as insoluble fractions. Now let us study each of these classifications in detail.

1. Monosaccharide

These are the compounds which comprise simple sugars and cannot be further hydrolyzed to simpler compounds. Glucose, galactose and mannose are known as monosaccharides. Glucose is also referred to as dextrose. Glucose is the end product obtained after the digestion of disaccharide and polysaccharide. Glucose circulates in the blood and gets utilized by various cells in the body for energy . Fructose is normally known as fruit sugar which is highly soluble and the unique feature is that it does not readily crystallize. It is found in honey, ripe fruits and certain vegetables. Fructose is also present in invert sugar which is a syrup prepared from sucrose and used extensively in the food industry. Galactose is the hydrolysed product of lactose not found abundantly in nature. Other forms of monosaccharide might be found in wider range in plant based foods and are largely considered to be quantitatively insignificant. Detail on classification and source of carbohydrates.

2. Disaccharide

These are formed when two hexoses are combined along with loss of one molecule of water.

Sucrose – sucrose is a disaccharide of glucose and fructose. Table sugar is 99% pure sucrose and is found naturally in many fruits and vegetables. Commercial sucrose is extracted from sugar beet and sugar cane. It can be readily hydrolyzed to glucose and fructose by the action of acid and enzyme sucrase in the small intestine. Many fruits and vegetables contains small amount of sucrose.

Lactose – Lactose is the disaccharide of glucose and galactose which occurs naturally in milk and milk products and hence, the named milk sugar. Its solubility is comparatively lesser than other disaccharides. It can be readily hydrolyzed by the enzyme lactase. However, individuals

lacking this enzyme are prone to develop lactose intolerance. Its awareness potency is only 1/6th of the glucose. It is the only carbohydrate which is synthesized by mammals.

Maltose – it is an intermediate product produced during the hydrolysis of starch. It can be synthesized during malting and fermentation of grains. Beer and malted breakfast cereals are considered to have appreciable amounts. Commercial processed products are often prepared using maltose and are sold as sugar free products.

Dextrose – is a glucose and is formed during the hydrolysis of corn starch.

Trehalose – it is a disaccharide of glucose. It is generally known as mushroom sugar since 15% of dry matter of mushroom comprises trehalose. It is also present in insects.

Functions of Carbohydrates

A. As Source of energy – carbohydrates containing foods are the concentrated sources of energy. One gram of carbohydrate on oxidation provides 4 Kcal.

B. As Protein sparing action – when the diet comprises adequate amount of carbohydrate, it is used as a source of energy and the available protein is used solely for tissue building. If the diet does not supply sufficient calories from carbohydrate, the dietary protein tends gets oxidized and utilized as a source of energy to carry out the physiological functions.

C. For Oxidation of fats- β-oxidation of fat takes place in the presence of adequate amount of carbohydrate. The acetyl CoA formed during the oxidation of fatty acids reacts with oxaloacetic acid formed from carbohydrate and the metabolism of amino acid. They react to form citric acid which gets oxidized through TCA cycle back to oxaloacetic acid. This mechanism is medicated by a series of reaction. These reactions gets impaired in the absence of adequate carbohydrate. Consequently impaired reactions leads to the accumulation of intermediary products of fat oxidation. This finally results to a condition termed as ketosis.

D. As source of energy for nervous system- glucose is the primary source of energy for central nervous system. Prolonged hypoglycemic condition is known to cause irreversible damage to the brain tissues.

E. Role of carbohydrates in muscle- the major source of energy for muscular work is derived from carbohydrate. During the process of muscle contraction, the glycolysis step breaks down glycogen to lactic acid. In the recovery stage, the lactic acid tends to undergo oxidation and yields pyruvic acid and acetyl CoA. This is further oxidized to carbon dioxide and water and thus produces energy for carrying out muscular work.

F**. Role of carbohydrate in liver** – one of the most important functions of the carbohydrates is the detoxifying action. Carbohydrate regulates the metabolism of protein and fat. Liver serves as a storage site for glycogen. Liver resists the harmful effects of certain poisons such as carbon tetrachloride, alcohol, arsenic and certain bacterial toxins.

G. Primary source of energy for heart muscle – Glucose is used as the main source of energy. In hypoglycemic condition a drastic change in the functioning of the heart can be seen.

H. Synthesis of ribose from glucose – ribose is found in RNA and in nucleotides. It is synthesized in the body through a process known as hexose monophospahte pathway.

I. Storage function--Excess calories from carbohydrate will be stored as fat in adipose tissues. Depending on body need the stored fat would be mobilized for energy purpose. e.g during illness, fasting etc

J**.Enhancement of gut microflora**: Lactose sugar promotes the growth of desirable bacteria in the gastro intestinal tract. Some of them are considered highly beneficial for the synthesis of B complex vitamins

K. The process of glucose oxidation provides the carbon skeleton required for the synthesis of alanine, aspartic acid and glutamic acid.

L. Carbohydrates are designated as one of the most important structural components of many organisms particularly fiber fractions of plant, exoskeleton of some insects and cell wall of micro organisms.

Digestion of Carbohydrates

Digestion of starch or carbohydrate begins in mouth by the enzyme ά- amylase. The partial hydrolysis of polysaccharide to dextrin and maltose takes place by pancreatic amylase.

Maltose, sucrose and lactose gets hydrolyzed by maltase, surcease and lactase present in the intestinal juice. Starch present in whole grains and seeds is thought to be physically inaccessible by pancreatic amylase. Size reduction techniques such as crushing, chopping and milling influence the accessibility of starch molecules.

Gelatinization and dispersion of starch granule is the most important characteristic property of starch and this particular mechanism is known to be facilitated by hydrolysis of starch. Starch from raw cereals digest at slower pace and are known to exert modest amount of glycemic response.

Absorption of Carbohydrates

The blood stream mainly absorbs glucose, galactose and fructose. Through the capillaries of the villi simple sugars pass to the portal circulation. Further, they are transported to the liver where fructose and galactose would be converted to glycogen the storage form of carbohydrate. The stored glycogen can be reconverted to glucose based on the requirement for the energy. Glucose and galactose are absorbed at a much faster rate than fructose. Whereas ,pentoses are absorbed at a relatively slower rate. The total amount of sodium ions in the intestinal lumen is regarded as the major determinant of glucose absorption.The glucose influx into the intestinal mucosal cells is mediated by a high concentration of sodium ions. While lower concentration tends to inhibit glucose influx. This is mainly due to the fact that both glucose and sodium ions utilize same co-transporter carrier protein.

The glucose transport mechanism also transports galactose. Fructose absorption mainly takes place through a carrier mediated diffusion system and its absorption is not dependent on the concentration of sodium ions. Some fractions of fructose will be converted to glucose in the mucosal cells. It has been estimated that about 97-98% of the ingested carbohydrate would be digested and absorbed.

3. METABOLISM OF CARBOHYDRATES

Glucose is oxidized with the help of enzymes to yield carbon dioxide, water and heat. The specified compounds like adenosine tri-phosphate (ATP) is enzymatically broken down and

releases energy as per the requirement. Through a series of steps, glucose is broken down into two molecules of pyruvate. This is further converted into acetyl co-enzyme A along with releasing small amount of ATP. In the next step through a series of reaction acetyl coenzyme A enters into TCA cycle. This in turn releases carbon dioxide and hydrogen atoms. These later enter into electron transport system and releases ATP. The complete oxidation process of one molecule of glucose yields 36 ATP molecules, 6 molecules of carbon dioxide and 6 molecules of water.

CONVERSION TO GLYCOGEN

Consumption of excess carbohydrate through the diet is known to be converted into a reserve form of energy known as glycogen. Both liver as well as muscle synthesize glycogen from the excess amount of glucose. Liver is capable of storing only limited amount of glycogen. When the need arises the reserve store is quickly converted to glucose. The muscle can store 150g of glycogen and the liver stores about 90g which mainly exercises control over blood sugar and this mechanism is well regulated by hormones. The liver stores of glycogen can last only for about 12-18 hours of fasting.

FACTORS AFFECTING ABSORPTION OF CARBOHYDRATE

- Absorption is totally dependent on the rate at which carbohydrate enters the small intestine. This depends on the mobility of the stomach, control of duodenal sphincter muscle and the pyloric valve.
- The degree of competition for the absorption sites is thought to be depended on the composition of the food and the existence of carrier system
- The condition of intestinal membrane and the total contact time of carbohydrate with the membrane is known to exert greater influence on the digestion process. Abnormalities in mucosal tissues and the rapid movement of carbohydrate in the intestine are known to hinder absorption.
- Normal endocrine activity and the other related functions of thyroid is the basic essentiality for normal absorption.

- The other factors such as the presence of intact plant cell walls and dense structure of starchy foods and the presence of proteins and fats have strong bearing on the absorbability of carbohydrates.
- Increased meal frequency tends to slow down the rate of absorption in the small intestine.

DEFICIENCY

Carbohydrates are the concentrated source of energy. The primary effect of carbohydrate deficiency causes malnutrition among children less than five years of age. Young children are more prone to develop energy deficiency. The clinical conditions such as kwashiorkor and marasmus are caused due to the continuous deficiency of protein and calories. The major symptoms involves wasting of muscles due to starvation, impaired growth is also noticed. Immune responses are known to be affected seriously in a child suffering from marasmus. The other condition known as ketosis is associated with many other factors. ketosis can also occur as a result of carbohydrate deficiency and is frequently reported in those individuals who are on low carbohydrate diets. In the absence of adequate amounts of carbohydrates, the body starts using the available proteins and convert it to sugars. This causes ketosis and the accumulation of ketones in the body can be seen. Excess ketones results in water loss and removal of sodium from the body. This may cause tiredness and lethargy. The major symptoms include fatigue, exercise intolerance, nausea, headaches, dehydration and flu-like symptoms.

Hypoglycemia, also known as low blood sugar or low blood glucose. This condition is seen when the glucose levels in the blood drop below the critical level. While hypoglycemia is often associated with diabetes, it can be caused by lack of carbohydrates in the diet of healthy people. Carbohydrates are the main source of glucose because they are broken down into simple sugars during digestion and enter the cells with the help of insulin for further utilization by the cells. Symptoms of hypoglycemia include tiredness, weakness, light-headedness, confusion and hunger.

EFFECTS OF EXCESSIVE CONSUMPTION OF CARBOHYDRATE

Consuming excessive amounts of carbohydrate, especially those which are known to have high glycemic load, can increase the risk of several disorders, including Type 2 diabetes. This can cause sudden rise in blood glucose and. high demand on pancreas for insulin secretion. This significantly increases the likelihood of developing Type 2 diabetes. A diet containing too many carbohydrates can raise the blood level of triglycerides, a type of unhealthy fat that circulates in the blood. It can also lower the blood levels of high-density lipoprotein. This alteration in the ratio of LDL:HDL could be considered as a major determinant in diagnosing the cardiovascular diseases. The other effect observed due to the over consumption of carbohydrate is obesity. Obesity is highly prevalent both among developed as well as developing countries. The combined effect of excessive carbohydrate intake coupled with sedentary life style increases risk of obesity. This in turn causes several life style related disorders such as diabetes, cardiovascular diseases, certain type of cancer.

4. RECOMMENDED DIETARY ALLOWANCES FOR CARBOHYDRATE

We are aware about the fact that excess carbohydrate is converted to fat and stored in adipose tissues. Hence, it has to be consumed only in sufficient quantities. The minimum recommendation for carbohydrate is 100g per day which is very much needed for preventing ketosis.. Our daily diet is known to contain much higher levels than this. A normal balanced diet should provide 60% calories from carbohydrate. A 2000Kcal diet should contain 275-300g carbohydrate. About 100$ should be obtained from sugar and the remaining should be from complex carbohydrate sources.

SOURCES OF CARBOHYDRATES

Whole grains are an excellent source of complex carbohydrates and dietary fiber. Some grains that contain carbohydrates include rice, corn, wheat, barley, oats and buckwheat. Whole grains like brown rice and whole grain wheat are the best sources of complex carbohydrates. The consumption of complex carbohydrates through whole grain is proven to be highly beneficial for maintaining the overall health. Most of the ready to eat cereals contain a good amount of sugar even though they claim to be whole grain. Legumes rank next in importance to cereals as good food sources. Just like grains and nuts, legumes are also rich in complex carbohydrates. They too are beneficial for regulating the blood glucose level. Roots and

tubers are another group of foods providing maximum amount of carbohydrate. Sweet potatoes provide ample amount of carbohydrate. An eight ounce of sweet potato contains 240 calories and 55 grams of carbohydrate. Among the fruits banana is the richest source of carbohydrate. Berries of different kinds like strawberries and blueberries are rich sources of carbohydrates. The form of sugar present in them is simple sugar. So, they are digested quickly and increase the level of blood sugar. The other sources like sugar, jiggery and honey are also known to contribute significant amount of carbohydrate.

5. CONCLUSION

A carbohydrate is a chemical compound made up of carbon, hydrogen and oxygen.The basic unit of carbohydrate is monosaccharide. Carbohydrate are stored in the form of starch in plants and glycogen in animals. All digestible forms of carbohydrates are broken by the action of enzyme ptyalin in mouth. Further, digestion and absorption continues by pancreatic and intestinal enzyme amylase and mailtase to the simple sugar glucose. Adequate supply of carbohydrates determines the amount of fat to be metabolized for energy. Carbohydrates have an anti-ketogenic effect which prevents harmful excess of ketone accumulation in the body. On the other hand excess of carbohydrates converts to fats as storage cause obesity.