Carbohydrates

By

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The word carbohydrates is used to designate a large number of substances which are composed of three elements carbon, hydrogen and oxygen. The hydrogen and oxygen always appears in proportion to form water, that is there were two atoms of hydrogen and one of oxygen and the carbon atoms in groups of six or multiples of six. It is difficult to give a positive definition of the term carbohydrates and the above is not always true in the strictest sence, as there are some substances containing the same elements with the hydrogen and oxygen in proportion to form water; yet they are not carbohydrates Among these substances may be mentioned lactic and acetic acids which are two of the products of the digested and decomposed carbo-hydrates.

Carbohydrates or hydrates of carbon are very abundant in nature especially in plant life. As protein form the chief part of the solids of animal tissues, so carbohydrates form the chief part of plant structure. They are found in the tissues of animals as such only in small quantities either free or in combination with

other complex bodies.

Carbohydrates have no physical properties, or characteristics which are common throughout the whole groups, on the contrary their physical properties are found to differ very widely in the various members. Of all the sciences which have to do with food, Chemistry is by far the most important, and among the chemical reactions which they are thought to have in common are;—

"1. Reduction of alkaline and metallic solution

2 Rotation of polarized light

3. Subject to alcoholic fermentation by yeast

4 Formation of levulonic acid

5 Formation of characteristic compounds with phenol hydrazines.

6 Gives certain color reaction

7. Decomposition by heat" — Tollens —

From the chemical stand point we classify carbohydrates into three groups each containing the same number of atoms to the molecule but varies in the arrangement of these atoms. The first of these groups are the monosaccharides. ($C_6H_{12}O_6$. Among the more important members of this group we find glucose or dextrose

laevulose and galactose.

Ordinary Glucose is the most important member of this family. It exists in many fruits as in grapes or raisins, in honey which is composed of a mixture of glucose and laevulose. It occurs when pure in a crystalline masses and may be seen in raisins in the form of small yellowish white granular masses, has a sweet taste but possesses much less sweeten-ing power than cane sugar. It easily undergoes alcoholic fermentation.

Commercial Glucose is dextrose made by starch by drolysis usually from the starch of indian corn or maize. The conversion of starch into sugar is called inversion and is accomplish-ed by boiling it in water containing from one to one and one half solution of sulphuric acid. The boiling is often done under pressure as it takes less time to convert the starch thus. The reaction taking place in the change is that the starch is made to unite chemically with water. The acid is removed by adding powdered chalk and filtering through animal char-coal and it is then evaporated to the proper consistancy. The manufacturing of glucose

has become an immence industry in the United States and the products both in solid and liquid form are extensively used in many kinds of syrups to give them body and the light color which is desirable it is used also in the manufacturing of liquors while the solid is used as confectionary and as sugar. In this country the term glucose is usually applied only to the liquid product the solid being called corn sugar. The reason that glucose is often considered harmful is due principally to the bleaching agent used in preparing it, and to the fact that they have not been properly removed after doing their work. If it is properly made, the prepared glucose is no more harmful to use than that found in fruits or nature.

Another important member of this family is laevulose which is commonly known as fruit sugar and is found in the juice of most fruits. It's an almost uncrystallizable sugar

The second great group of carbohydrates is the group known as the Disaccharides or Sucroses, $C_{12}H_{22}O_{11}$. These are also composed of sugars but they differ from the other

sugars in being a crystaline group. The most common member of this group is cane sugar, others are, beet sugar, milk sugar or lactose, and malt sugar or maltose.

Cane sugar is very widely distributed in nature, but it can be made on a commercial scale only from a limited number of plants such as, the sugar cane, sugar beet and the sugar maple. It is found in the circulation of the roots and stems of many fleshy plants, as the turnip, carrot, and sweet potato, and in the sap of trees, as found in the maple, date palm, boxelder and others. also in the nectar of flowers.

Cane sugar in appearance is well known to most every one; it is a white crystalline substance very easily dissolved in cold water, but still more so in hot water. It is much sweeter to taste than any of the others sugars, and is from one to one and a half sweeter than grape sugar. On applying heat to cane sugar, we find that it will melt at about 320° F into a light straw colored liquid, which if heated still more will take on an amber hue. In this state it is called caramelized sugar and is used to color liquors and other substances. If it is allowed to cool

in this stage it is very brittle hard and glassy, but if it is heated still more it becomes bitter and finally decompose

The manufacturing of cane sugar is an important industry in many countries. The process used in making sugar is as follows; The juice is crushed out of the canes between heavy rollers. It is then bleached with sulphuric acid neutralized by the use of lime which also prevents fermentation from taking place. It is then heated to separate the albuminous substance which rises to the top in a scum when coagulated; next it is filtered and evaporated and the uncrystallizable sugar, which is glucose, is separated from the crystals and sold as molasses or is make rum. We then have left the raw cane sugar containing many impurities and must be farther refined. This is accomplished by redissolving the crystals in a one to one and a half solution of sulphuric acid and filtering through animal charcoal, it is then carefully evaporated. After this is finished it is practically a pure chemical substance one of the purest foods on the market.

Cane sugar is a native of India and China and has been in use in the world for many ages. Sugar from the sugar cane was probably known to the

Chinese two thousand years before it was used in Europe. About the time Europe first began to trade with the eastern countries, sugar was brought from those countries into Europe in very small quantities, with spices and other articles and was thought by them to be a rare and priceless article and was used only for the preparation of medicine. It was spoken of by the Greeks as "indian salt" a number of centuries before the Christian Era began, but not until about the time of the middle ages did the Europeans have any idea of what it really was; they it to be a kind of gum which seeped from the stem of a plant and dried there, after which it was gathered by the natives. During the fourteenth and fifteenth century, it was found that the sugar cane could be grown in Africa and after it was once introduced there, they began to grow it in quantities and, from this time on, the use and culture of the plant greatly increased until now it is one of the standard articles of food.

The beet is another very common source of cane sugar, about two thirds of the sugar now in the market is derived from the sugar beets. It is manufactured practically the same as that from sugar cane except that the beet is

sliced and subjected to the action of warm water, which is called diffusion, and is not marked between rollers as is the sugar cane. The fact that the beet contained crystalline sugar exactly identical to that of cane was discovered in the year seventeen hundred and forty seven by Maggorf, a chemist of Berlin and during the latter part of that century the first manufactury was established by one of his pupils. It takes about nine and twenty five hundred thousand tons of beets to make one ton of sugar.

Lactose is the carbohydrate found in milk it is commonly known as milk sugar and the amount found in milk varies from four to five per cent It is almost free from a sweet taste and is not easily fermented. It is the best form for infants to take their sugar in, for the reason that it does not ferment easily and form lactic acid and gas. It is also a very valuable means of supplementing the carbohydrates of a diet

Maltose is made by evaporating an infusion of malted barley at a low temperature in a vacuum. Malt extracts are lauded for their diastatic power and for their capacity

to digest starch. It occurs in company with dextrin in starch solutions which have been treated with sulphuric acid.

The third and last great group of carbohydrates is known as the polysaccharides or Amyloids, $C_6H_{10}O_5$. The important members of this group are starch, cellulose, dextrin, glycogen and gum.

Starch is found in every plant to a greater or less extent, but the greater part of it occurs in large fleshy tubers, roots, tree trunks and seeds. It is prepared for commercial purposes principally from maize, rice, cereals and potatoes. The method by which starch is obtained is simply one of separating it from the other constituents of the plant. In extracting the starch from wheat for example, the clean grain is steeped three hours in water, or until it is soft enough to grind. It is then crushed between rollers or ground between millstones and washed upon sieves and the milky liquid containing the starch is allowed to flow over inclined planes where the starch granules are deposited, and into large tanks; here the nitrogenous substances settle and are mixed with the husks and sold as bran.

To farther refine the starch is to remove all nitro-

-genous substances this is done by washing it in dilute alkili as caustic soda and again allowing it to settle and this liquid carries off all nitrogenous and fatty matter. After the starch is again washed to remove the alkili we have the pure starch granules and about one half the bulk with which we started. The process is accomplished quite rapidly and single factories can convert about two thousand bushels of wheat per day

Potato starch is obtained by simply steeping crushing and washing the pulp without the use of alkili In rice, the alkili must be used but rice contains a greater amount or percent of starch than any of the cereals.

The purest starch is used for food, in making syrup and sugars, for laundrying and in various industrial arts. As has been said before carbohydrates are the most important constituents of plants. Starch being the form in which carbohydrates, are stored up in the plants while sugar is the form in which they circulate through the plant and if it makes more than it needs for its present use, the extra supply of nourishment is stored up in some part of the plant as starch and when it is again needed it is changed back into the soluble sugar, the form in

which the plant can use it as nourishment; this is done by means of a diastase which is an albuminous ferment started to action by means of the heat from the sun. In this way the plant looks out for its future life and for that of its offspring, for here it stores the starch in the seed, bulb or part where it expects new life to spring from. The reason why nature stores the plant food in the form of starch in place of sugar is to free it from the action of rain and make it safe so it will not be washed away. The plant manufactures its own food, starch and sugar, from carbon dioxide, water and various substances taken from the soil and air. It is accomplished by the action of sunlight on the green coloring matter or, chlorophyll of the leaves and stems. Starch and cellulose have been likened to the bullion or store house in the treasury, and the sugar and dextrin to the money in circulation.

The characteristic appearance of starch. It is to the naked eye a white shiny powder, but when seen under the microscope we find it to be composed of minute cells or granules varying in size and shape according to the source from which they come. Those of the potato being comparatively large while the rice granules are extremely small

The outer layers are composed of cellulose which is insoluble in water and protect the inner Granulose or starchy portion of the cell.

Cellulose constitutes the fundamental material or frame work of all plant cells. It acts as a sort of connective tissue binding and holding together the various organs of the plants. Woody tissue is not wholly cellulose but consists of cellulose and other substances quite similar to it, known as encrusting material, but it contains some nitrogenous substance and too much hydrogen for cellulose also traces of resin and alcohol. The best linen and cotton is composed of nearly pure cellulose the foreign material having been removed in the process of making the material.

Pure cellulose is insoluble in nearly all ordinary solvents; it is tasteless and odorless.

For a long time it was considered wholly indigestible but now it is thought to be digested to some extent. It dissolves in an ammoniacal solution of cupric hydroxide and in a strong solution of sulfuric acid it forms a gummy substance which may be converted into dextrose and from that into alcohol; so we see that old

linen rags may be converted into alcohol. Cellulose may also be converted into a substance called vegetable parchment by stepping unsized paper in a solution of one half sulphuric acid and one half water for a few seconds and then washing it in dilute ammonia. Although it still has the same composition as cellulose it is much stronger than ordinary paper and withstands the rain; for this reason it is used for baggage labels also used in confectionaries for tying down jars containing jams, and for other purposes.

There are three forms of cellulose in wheat, the lignified or woody cellulose which is entirely removed from flour, the parenchymatous is the second form and it is the cellulose composing the wall of the endosperm, and lastly that surrounding the starch granule.

Dextrin is principally a manufactured starch that is made from starchs, but it occurs in small quantities as a natural constituent in most plants. It is usually prepared by the action of heat upon starch and is a transparent solid resembling gum arabic.

The history of carbohydrates as a food is

little known but they were spoken of by the early Greeks. In very early times man eat the uncooked starch in the form of grain and otherwise as is shown by the worn molars of graminiverous when dug up Since he had to grind the grain with his teeth and of course very slowly, it was thus subjected for a long period to the starch digesting enzyme, ptyalin, of the saliva and its conversion into sugar, soluble dextrin, and grape sugar, was fairly good and when it reached the pancreatic juice and underwent the action here it was pretty well digested. But later man came to grind his food and had not the value of cooking been discovered about this time the grinding would have become a disadvantage rather than an advantage for he could eat faster and the digestive enzyme of the saliva would not have time to do its proper work. Hence the stomach would soon become over loaded with indigestible starch. but the cook did away with this danger There were at first two objections to eating starch, the first was that

it was never designed to be eaten for our teeth were not designed to crush the grain. The second objection was that the raw starch was not digestible by man to any extent. But since it was found that it can be converted into a soluable sugar or dextrose the form in which sugar is furnished us in fruit and nuts which were originally the natural food of man. Then it is just and proper that we should use it as food. We find the starch granules being cooked for two reasons, one is crack the cellulose and form channels by which the saliva may come in contact with the starch or granulose and the second and more important reason is to convert the insoluble starch into a soluble dextrin. Hence we find that grinding and cooking lessoned the labor of the jaw and of the digestive tract and juices very greatly; the change taking place being a process of hydration.

The use of starchy foods such as grains, tubers root and others, came about from the fact that they could not always obtain these natural foods- fruits, nuts and others, could not always be obtained. The climate was too cold, dry or something and their disappearance along with

mans struggle for existance led to the use of the carbohydrates as food.

In tracing the absorbtion and assimilation of the carbohydrates, we find that they are more completely absorbed than any other nutritive constituent of food. Sugar scarcely ever fails to enter the blood and starch is almost always absorbed except when taken in a form most difficult for digestion as in green raw and coursely divided vegetables. Not only are the carbohydrates well absorbed themselves but they also aid in the absorbtion of other food. as an example we have the production of organic acids by carbohydrates of a mixed diet have a restraining influence upon the destruction of proteids by putrefactive bacteria.

The cooked starch granule is acted upon very readily when it enters the mouth, by the ptyalin, an enzym of saliva. The molecule is split up by hydrolysis and thus converted into cane sugar to some extent. In passing into the stomach this action ceases and no more action upon starch takes place until the gastric juice is met with in the intestines and here we have another

enzym similar to ptyalin called amylopsin which exerts a powerful influence on starch converting it into dextrose and laevulose, soluble sugars. At this time they are absorbed. and a little later in the lower part of the intestines the carbohydrates are decomposed into lactic and acetic acid, carbon di oxide and hydrogen. The absorbtion of the carbohydrates takes place in the upper part of the intestines. the only forms being assimilated are the laevulose and dextrose. If it is in any other form when it enters the body it must be changed to this form. From the dietetic standpoint we might speak of sucroses as the undigested and the glucoses as the predigested sugars. After the carbohydrates are digested they are absorbed or taken into circulation. and they are found in abundance in the portial vein and are taken to the liver which regulates their supply in the blood and stores up what is not needed in the form of animal starch or glycogen & is given out as needed to the blood. after being converted into sugar again the same as that which takes place in plants, it is taken from the blood and stored up in the muscles to be used as work.

The great cheapness of sugar and its very concentrated form leads us to make us consume more carbohydrates and less fat. They can replace fat as fuel and energy yielder in the body and they are more rapidly opidized than fat and for this reason are more efficient proteid sparers. and are very valuable They also form fatty tissue which serves as a further reserve food; the process of fat formation is unknown but since carbohydrates contain a simpler molecule than fats, it must be a process of synthesis. Thus we have carbohydrates furnishing heat and muscular force in the body serving as a tissue sparer both of fat and proteids.

The amount of carbohydrates in the diet varies greatly in different places and for different people of different circumstances As a general rule among the wealthier classes of people there is a relatively greater amount of protein and fat used in the diet than there is of carbohydrates; while in the poorer classes the amount of carbohydrates increase in proportion as the amount of fats and proteids decrease. likewise people living where meat is plentiful

and carbohydrates or vegetables are scarce as in the colder countries much more protein and fat will be used and on the other hand where vegetation is plentiful as in the tropics more carbohydrates will be consumed. It is not best to use all carbohydrate food as it gives too great a bulk especially is this true of the starchy food. The chief carbohydrate constituents of the ordinary diet are starch and cane sugar with a certain amount of grape sugar and the most important plants containing these are cereals, vegetables and fruits. The fuel value of carbohydrates is about the same as that of protein and 100 and one fourth times less than that of fat while in regard to cost the purely vegetable diet would be much cheaper than one composed of protein or mixed foods, but as before stated we would have to use too much bulk to get the proper amount of protein and fat. This disadvantage would affect the outdoor laborer much less than one engaged in indoor work as office, studying and other occupations.

The outdoor laborer actually requires more carbohydrates to furnish the muscular force necessary for him to perform his work and in eating

this large quantity. he is apt to get the proper amount of fat and protein required.

Therefore we find carbohydrates are one of the greatest food principals of man, second only to the protein group and the greatest food of many animals especially the herbiverous animals while in the plant it is of the greatest necessity to their growth. Altho proteid is a necessity to cell development, the carbohydrates form their principal food.