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TONGUE ACCEPTS SWEET *IN-VITRO* AND STOMACH PRODUCES BIOLOGICAL TWEET *IN-VIVO*

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Abstract: Sugar is the generic name for sweet-tasting, soluble carbohydrates, many of which are used in food. Simple sugars, also called monosaccharides, include glucose, fructose, and galactose. Compound sugars, also called disaccharides or double sugars, are molecules made of two bonded monosaccharides; common examples are sucrose (glucose + fructose), lactose (glucose + galactose), and maltose (two molecules of glucose). White sugar is a refined form of sucrose. In the body, compound sugars are hydrolysed into simple sugars. Longer chains of monosaccharides (>2) are not regarded as sugars, and are called oligosaccharides or polysaccharides. Starch is a glucose polymer found in plants, the most abundant source of energy in human food. Some other chemical substances, such as glycerol and sugar alcohols, may have a sweet taste, but are not classified as sugar.

Sugars are found in the tissues of most plants. Honey and fruits are abundant natural sources of simple sugars. Sucrose is especially concentrated in sugarcane and sugar beet, making them ideal for efficient commercial extraction to make refined sugar. In 2016, the combined world production of those two crops was about two billion tonnes. Maltose may be produced by malting grain. Lactose is the only sugar that cannot be extracted from plants. It can only be found in milk, including human breast milk, and in some dairy products. A cheap source of sugar is corn syrup, industrially produced by converting corn starch into sugars, such as maltose, fructose and glucose. Diabetes, obesity and cardiovascular disorders are associated with high sugar intake directly or indirectly. Consumption of more sugar having several difficulties on human health which diminishes quality of life. In this situation artificial sweeteners are play beneficial role in controlling blood sugar level. They also have several health benefits like they have zero calories, they do not have any adverse effect on Dental cavities. They are supportive in controlling body weight. Therefore artificial sweeteners are decent alternatives of glucose. Honey and stevia like natural sweeteners are helpful in diabetes and cardiovascular complication.

Keywords: Glucose, Fructose, Galactose, Oxane, Oxolane, Sucrose, Lactose, Maltose, Stevia Sweeteners, Date sugar, Grape juice concentrate, Honey, Maple sugar, Maple syrup, Molasses, Acesulfame, Aspartame, Neotame, Saccharin, Sucralose, Xylitol, Sorbitol, Mannitol, Erythritol, Sodium cyclamate, Dulcin and Agave nectar

Introduction: Sucrose is used in prepared foods (e.g. cookies and cakes), is sometimes added to commercially available processed food and beverages, and may be used by people as a sweetener for foods (e.g. toast and cereal) and beverages (e.g. coffee and tea). The average person consumes about 24 kilograms (53 pounds) of sugar each year, with North and South Americans consuming up to 50 kg (110 lb) and Africans consuming under 20 kg (44 lb).[1]

As sugar consumption grew in the latter part of the 20th century, researchers began to examine whether a diet high in sugar, especially refined sugar, was damaging to human health. Excessive consumption of sugar has been implicated in the onset of obesity, diabetes, cardiov ascular disease, and tooth decay. Numerous studies have tried to clarify those implications, but with varying results, mainly because of the difficulty of finding populations for use as controls that

consume little or no sugar. In 2015, the World Health Organization recommended that adults and children reduce their intake of free sugars to less than 10%, and encouraged a reduction to below 5%, of their total energy intake.[2]

Chemistry of Sugar:

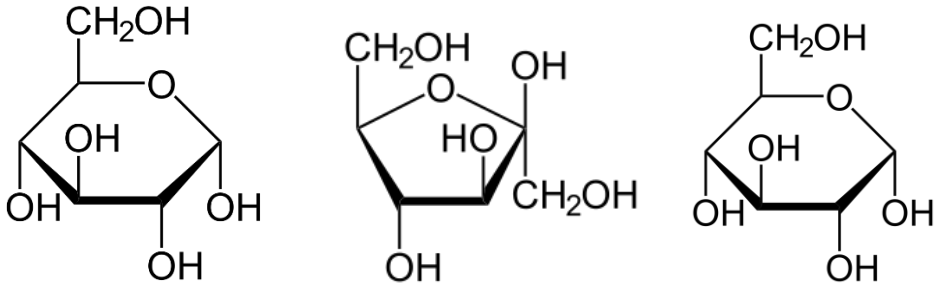


Figure-1: Monosaccharide: Glucose, Fructose and Galactose

Scientifically, *sugar* loosely refers to a number of carbohydrates, such as monosaccharides, disaccharides, or oligosaccharides. Monosaccharides are also called "simple sugars", the most important being glucose. The names of typical sugars end with *-ose*, as in "glucose" and "fructose". Sometimes such words may also refer to any types of carbohydrates soluble in water. The acyclic mono- and disaccharides contain either aldehyde groups or ketone groups. These carbon-oxygen double bonds (>C=O) are the reactive centers. All saccharides with more than one ring in their structure result from two or more monosaccharide joined by glycosidic bonds with the resultant loss of a molecule of water (H_2O) per bond.[3]

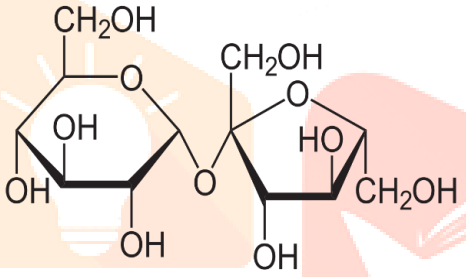
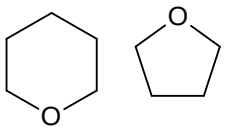


Figure-2: Sucrose: a disaccharide of glucose (left) and fructose (right), important molecules in the body.

After digestion and absorption the principal monosaccharides present in the blood and internal tissues include glucose, fructose, and galactose. Many pentoses and hexoses can form ring structures. In these closed-chain forms, the aldehyde or ketone group remains non-free, so many of the reactions typical of these groups cannot occur. Glucose in solution exists mostly in the ring form at equilibrium, with less than 0.1% of the molecules in the open-chain form. Pyranose is a collective term for saccharides that have a chemical structure that includes a six-membered ring consisting of five carbon atoms and one oxygen atom. There may be other carbons external to the ring. A furanose is a collective term for carbohydrates that have a chemical structure that includes a five-membered ring system consisting of four carbon atoms and one oxygen atom. The name derives from its similarity to the oxygen heterocycle furan, but the furanose ring does not have double bonds. Pyranose ring [six member] is also known as oxane and furanose ring [five member] is also known as oxolane.[4]



Natural Polymers: Biopolymers of sugars are common in nature. Through photosynthesis, plants produce glyceraldehyde-3-phosphate (G3P), a phosphated 3-carbon sugar that is used by the cell to make monosaccharides such as glucose ($C_6H_{12}O_6$) or (as in cane and beet) sucrose ($C_{12}H_{22}O_{11}$). Monosaccharides may be further converted into structural polysaccharides such as cellulose and pectin for cell wall construction or into energy reserves in the form of storage polysaccharides such as starch or inulin. Starch, consisting of two different polymers of glucose, is a readily degradable form of chemical energy stored by cells, and can be converted to other types of energy. Another polymer of glucose is cellulose, which is a linear chain composed of several hundred or thousand glucose units. It is used by plants as a structural component in their cell walls. Humans can digest cellulose only to a very limited extent, though ruminants can do so with the help of symbiotic bacteria in their gut. DNA and RNA are built up of the monosaccharides deoxyribose and ribose, respectively. Deoxyribose has the formula $C_5H_{10}O_4$ and ribose the formula $C_5H_{10}O_5$.[5]

Flammability and heat response:

Figure-3: Magnification of grains of refined sucrose, the most common free sugar.

Because sugars burn easily when exposed to flame, the handling of sugars risks dust explosion. The risk of explosion is higher when the sugar has been milled to superfine texture, such as for use in chewing gum. The 2008 Georgia sugar refinery explosion, which killed 14 people and injured 36, and destroyed most of the refinery, was caused by the ignition of sugar dust. In its culinary use, exposing sugar to heat causes caramelization. As the process occurs, volatile chemicals such as diacetyl are released, producing the characteristic caramel flavor.[6]

Types:

Monosaccharides: Fructose, galactose, and glucose are all simple sugars, monosaccharides, with the general formula $C_6H_{12}O_6$. They have five hydroxyl groups (−OH) and a carbonyl group (C=O) and are cyclic when dissolved in water. They each exist as several isomers with dextro- and laevo-rotatory forms that cause polarized light to diverge to the right or the left.

Fructose, or fruit sugar, occurs naturally in fruits, some root vegetables, cane sugar and honey and is the sweetest of the sugars. It is one of the components of sucrose or table sugar. It is used as a high-fructose syrup, which is manufactured from hydrolyzed corn starch that has been processed to yield corn syrup, with enzymes then added to convert part of the glucose into fructose.

Galactose generally does not occur in the Free State but is a constituent with glucose of the disaccharide lactose or milk sugar. It is less sweet than glucose. It is a component of the antigens found on the surface of red blood cells that determine blood groups.[8]

Glucose occurs naturally in fruits and plant juices and is the primary product of photosynthesis. Starch is converted into glucose during digestion, and glucose is the form of sugar that is transported around the bodies of animals in the bloodstream. Although in principle there are two enantiomers of glucose (mirror images one of the other), naturally occurring glucose is D-glucose. This is also called **dextrose**, or *grape sugar* because drying grape juice produces crystals of dextrose that can be sieved from the other components. Glucose syrup is a liquid form of glucose that is widely used in the manufacture of foodstuffs. It can be manufactured from starch by enzymatic hydrolysis. For example, corn syrup, which is produced commercially by breaking down maize starch, is one common source of purified dextrose. However, dextrose is naturally present in many unprocessed, whole foods, including honey and fruits such as grapes. **Disaccharides:** Lactose, maltose, and sucrose are all compound sugars, disaccharides, with the general formula $C_{12}H_{22}O_{11}$. They are formed by the combination of two monosaccharide molecules with the exclusion of a molecule of water.

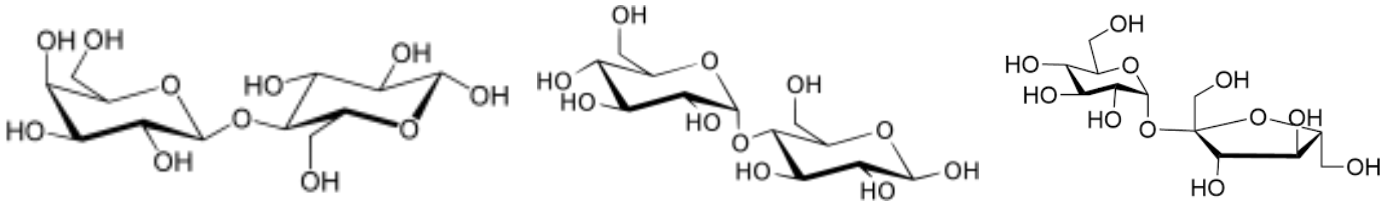


Figure-4: Disaccharide [lactose, maltose & sucrose]

Lactose is the naturally occurring sugar found in milk. A molecule of lactose is formed by the combination of a molecule of galactose with a molecule of glucose. It is broken down when consumed into its constituent parts by the enzyme lactase during digestion. Children have this enzyme but some adults no longer form it and they are unable to digest lactose.[9]

Maltose is formed during the germination of certain grains, the most notable being barley, which is converted into malt, the source of the sugar's name. A molecule of maltose is formed by the combination of two molecules of glucose. It is less sweet than glucose, fructose or sucrose. It is formed in the body during the digestion of starch by the enzyme amylase and is itself broken down during digestion by the enzyme maltase.

Sucrose is found in the stems of sugarcane and roots of sugar beet. It also occurs naturally alongside fructose and glucose in other plants, in particular fruits and some roots such as carrots. The different proportions of sugars found in these foods determines the range of sweetness experienced when eating them. A molecule of sucrose is formed by the combination of a molecule of glucose with a molecule of fructose. After being eaten, sucrose is split into its constituent parts during digestion by a number of enzymes known as sucrases.

Sources: The sugar contents of common fruits and vegetables are presented in Table 1. The fructose to fructose plus glucose ratio is calculated by including the fructose and glucose coming from the sucrose. In November 2019, scientists reported detecting, for the first time, sugar molecules, including ribose, in meteorites, suggesting that chemical processes on asteroids can produce some fundamentally essential bio-ingredients important to life, and supporting the notion of an RNA World prior to a DNA-based origin of life on Earth, and possibly, as well, the notion of panspermia.[10]

Table 1. Sugar content of selected common plant foods (g/100g)

Food item	Total carbohydrate including dietary fiber	Total sugars	Free fructose	Free glucose	Sucrose	Fructose/ (Fructose+Glucose) ratio	Sucrose as a % of total sugars
Fruits							
Apple	13.8	10.4	5.9	2.4	2.1	0.67	20
Apricot	11.1	9.2	0.9	2.4	5.9	0.42	64
Banana	22.8	12.2	4.9	5.0	2.4	0.5	20
Fig, dried	63.9	47.9	22.9	24.8	0.9	0.48	1.9
Grapes	18.1	15.5	8.1	7.2	0.2	0.53	1
Navel orange	12.5	8.5	2.25	2.0	4.3	0.51	51
Peach	9.5	8.4	1.5	2.0	4.8	0.47	57
Pear	15.5	9.8	6.2	2.8	0.8	0.67	8
Pineapple	13.1	9.9	2.1	1.7	6.0	0.52	61
Plum	11.4	9.9	3.1	5.1	1.6	0.40	16
Strawberry	7.68	4.89	2.441	1.99	0.47	0.55	10
Vegetables							
Beet, red	9.6	6.8	0.1	0.1	6.5	0.50	96
Carrot	9.6	4.7	0.6	0.6	3.6	0.50	77
Corn, sweet	19.0	6.2	1.9	3.4	0.9	0.38	15
Red pepper, sweet	6.0	4.2	2.3	1.9	0.0	0.55	0
Onion, sweet	7.6	5.0	2.0	2.3	0.7	0.47	14
Sweet potato	20.1	4.2	0.7	1.0	2.5	0.47	60
Yam	27.9	0.5	Tr	tr	Tr	Na	tr
Sugar cane		13–18	0.2–1.0	0.2–1.0	11–16	0.50	high
Sugar beet		17–18	0.1–0.5	0.1–0.5	16–17	0.50	high

Refining: Refined sugar is made from raw sugar that has undergone a refining process to remove the molasses. Raw sugar is sucrose which is extracted from sugarcane or sugar beet. While raw sugar can be consumed, the refining process removes unwanted tastes and results in refined sugar or white sugar. The sugar may be transported in bulk to the country where it will be used and the refining process often takes place there. The first stage is known as affination and involves immersing the sugar crystals in a concentrated syrup that softens and removes the sticky brown coating without dissolving them. The crystals are then separated from the liquor and dissolved in water. The resulting syrup is treated either by a carbonatation or by a phosphatation process. Both involve the precipitation of a fine solid in the syrup and when this is filtered out, many of the impurities are removed at the same time. Removal of color is achieved by using either a granular activated carbon or an ion-exchange resin. The sugar syrup is concentrated by boiling and then cooled and seeded with sugar crystals, causing the sugar to crystallize out. The liquor is spun off in a centrifuge and the white crystals are dried in hot air and ready to be packaged or used. The surplus liquor is made into refiners' molasses.

The International Commission for Uniform Methods of Sugar Analysis sets standards for the measurement of the purity of refined sugar, known as ICUMSA numbers; lower numbers indicate a higher level of purity in the refined sugar. Refined sugar is widely used for industrial needs for higher quality. Refined sugar is purer (ICUMSA below 300) than raw sugar (ICUMSA over 1,500). The level of purity associated with the colors of sugar, expressed by standard number ICUMSA, the smaller ICUMSA numbers indicate the higher purity of sugar.[11]

Forms and uses

Crystal size:

- Coarse-grain sugar, also known as sanding sugar, composed of reflective crystals with grain size of about 1 to 3 mm, similar to kitchen salt. Used atop baked products and candies, it will not dissolve when subjected to heat and moisture.
- Granulated sugar (about 0.6 mm crystals), also known as table sugar or regular sugar, is used at the table, to sprinkle on foods and to sweeten hot drinks (coffee and tea), and in home baking to add sweetness and texture to baked products (cookies and cakes) and desserts (pudding and ice cream). It is also used as a preservative to prevent micro-organisms from growing and perishable food from spoiling, as in candied fruits, jams, and marmalades.
- Milled sugars are ground to a fine powder. They are used for dusting foods and in baking and confectionery. Caster sugar, sold as "superfine" sugar in the United States, with grain size of about 0.35 mm. Powdered sugar, also known as confectioner's sugar or icing sugar, available in varying degrees of fineness (e.g., fine powdered or 3X, very fine or 6X, and ultra-fine or 10X). The ultra-fine variety (sometimes called 10X) has grain size of about 0.060 mm that is about ten times smaller than granulated sugar

Figure-5: Misri crystals & rock candy [coloured]

- Snow powder, a non-melting form of powdered sugar usually consisting of glucose, rather than sucrose. Screened sugars are crystalline products separated according to the size of the grains. They are used for decorative table sugars, for blending in dry mixes and in baking and confectionery.[12]

Shapes

Figure-6: Sugar cubes

- Sugar cubes (sometimes called sugar lumps) are white or brown granulated sugars lightly steamed and pressed together in block shape. They are used to sweeten drinks.
- Sugarloaf was the usual cone-form in which refined sugar was produced and sold until the late 19th century. This shape is still in use in Germany (for preparation of *Feuerzangenbowle*) as well as Iran and Morocco.

Brown sugars: Brown sugars are granulated sugars, either containing residual molasses, or with the grains deliberately coated with molasses to produce a light- or dark-colored sugar. They are used in baked goods, confectionery, and toffees.[13]

Figure-7: Brown sugar examples: dark brown (left), light brown (middle), white sugar (right)

Their darkness is due to the amount of molasses they contain. They may be classified based on their darkness or country of origin. For instance:

- Light brown, with little content of molasses (about 3.5%)
- Dark brown, with higher content of molasses (about 6.5%)
- Non-centrifugal cane sugar, unrefined and hence very dark cane sugar obtained by evaporating water from sugarcane juice, such as:
  - Panela, also known as rapadura, chancaca, piloncillo.
  - Some varieties of muscovado, also known as Barbados sugar. Other varieties are partially refined by centrifugation or by using a spray dryer.
  - Some varieties of jaggery. Other varieties are produced from date fruits or from palm sap, rather than sugarcane juice.[14]

Liquid sugars

Figure-8: A jar of liquid sugar and honey

- Honey, mainly containing unbound molecules of fructose and glucose, is a viscous liquid produced by bees by digesting floral nectar.
- Syrups are thick, viscous liquids consisting primarily of a solution of sugar in water. They are used in the food processing of a wide range of products including beverages, hard candy, ice cream, and jams.
  - Syrups made by dissolving granulated sugar in water are sometimes referred to as liquid sugar. A liquid sugar containing 50% sugar and 50% water is called simple syrup.
  - Syrups can also be made by reducing naturally sweet juices such as cane juice, or maple sap.
  - Corn syrup is made by converting corn starch to sugars (mainly maltose and glucose).
  - High-fructose corn syrup (HFCS), is produced by further processing corn syrup to convert some of its glucose into fructose.
  - Inverted sugar syrup, commonly known as invert syrup or invert sugar, is a mixture of two simple sugars—glucose and fructose—that is made by heating granulated sugar in water. It is used in breads, cakes, and beverages for adjusting sweetness, aiding moisture retention and avoiding crystallization of sugars.
- Molasses and treacle are obtained by removing sugar from sugarcane or sugar beet juice, as a byproduct of sugar production. They may be blended with the above-mentioned syrups to enhance sweetness and used in a range of baked goods and confectionery including toffees and licorice.[15]
  - Blackstrap molasses, also known as black treacle, has dark color, relatively small sugar content and strong flavour. It is sometimes added to animal feed, or processed to produce rum, or ethanol for fuel.
  - Regular molasses and golden syrup treacle have higher sugar content and lighter color, relative to blackstrap.
- In winemaking, fruit sugars are converted into alcohol by a fermentation process. If the must formed by pressing the fruit has a low sugar content, additional sugar may be added to raise the alcohol content of the wine in a process

called chaptalization. In the production of sweet wines, fermentation may be halted before it has run its full course, leaving behind some residual sugar that gives the wine its sweet taste.[16]

Other sweeteners

- Low-calorie sweeteners are often made of maltodextrin with added sweeteners. Maltodextrin is an easily digestible synthetic polysaccharide consisting of short chains of three or more glucose molecules and is made by the partial hydrolysis of starch. Strictly, maltodextrin is not classified as sugar as it contains more than two glucose molecules, although its structure is similar to maltose, a molecule composed of two joined glucose molecules.
- Polyols are sugar alcohols and are used in chewing gums where a sweet flavor is required that lasts for a prolonged time in the mouth.
- Several different kinds of zero-calorie artificial sweeteners may be also used as sugar substitutes.

Consumption: In most parts of the world, sugar is an important part of the human diet, making food more palatable and providing food energy. After cereals and vegetable oils, sugar derived from sugarcane and beet provided more kilocalories per capita per day on average than other food groups. In 1750 the average Briton got 72 calories a day from sugar. In 1913 this had risen to 395. In 2015 it still provided around 14% of the calories in British diets. According to one source, per capita consumption of sugar in 2016 was highest in the United States, followed by Germany and the Netherlands.[17]

Nutrition and flavour: Brown and white granulated sugar are 97% to nearly 100% carbohydrates, respectively, with less than 2% water, and no dietary fiber, protein or fat (table). Brown sugar contains a moderate amount of iron (15% of the Reference Daily Intake in a 100 gram amount, see table), but a typical serving of 4 grams (one teaspoon), would provide 15 calories and a negligible amount of iron or any other nutrient. Because brown sugar contains 5–10% molasses reintroduced during processing, its value to some consumers is a richer flavor than white sugar.

Health effects

Sugar industry funding and health information: Sugar refiners and manufacturers of sugary foods and drinks have sought to influence medical research and public health recommendations, with substantial and largely clandestine spending documented from the 1960s to 2016. The results of research on the health effects of sugary food and drink differ significantly, depending on whether the researcher has financial ties to the food and drink industry. A 2013 medical review concluded that "unhealthy commodity industries should have no role in the formation of national or international NCD [non-communicable disease] policy". There have been similar efforts to steer coverage of sugar-related health information in popular media, including news media and social media.[18]

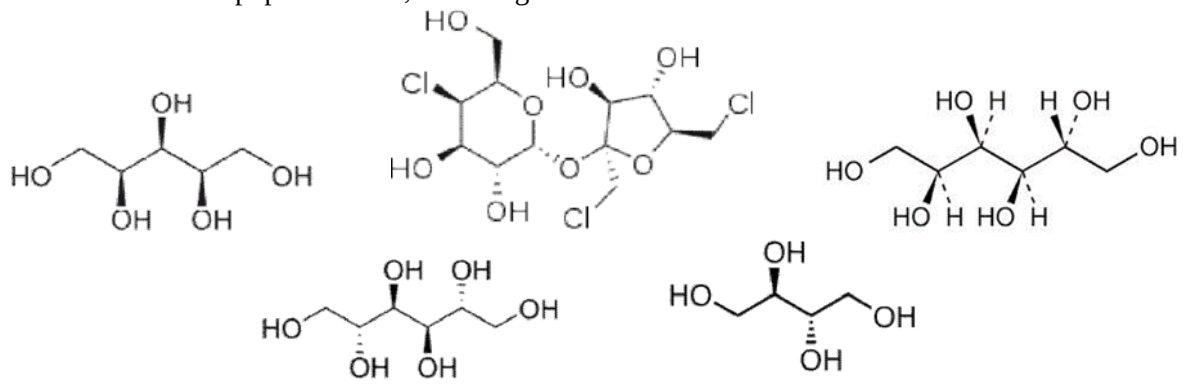


Figure-9: Other sweeteners [xylitol, sucralose, sorbitol, mannitol & erythritol]

Xylitol is a sugar alcohol that is used as a sugar substitute. It occurs naturally and it is found in the fibrous vegetables and fruit, as well as in corn cobs and various hardwood trees such as birch. In fact, it is produced naturally in our bodies. It is roughly as sweet as sucrose but only has two thirds of the energy. It is used in cooking, baking, in beverages, chewing gum, mints, and other products such as nasal and mouth washes. Research has confirmed that plaque is reduced when xylitol is consumed as it attracts and then starves harmful microorganisms allowing the mouth to demineralize damaged teeth with less interruption. Xylitol is a five-carbon sugar, which means it is an antimicrobial, preventing the growth of bacteria. Xylitol is safe for teeth as it does not encourage tooth decay, and may actively aid in repairing minor cavities. Xylitol does not contribute to high blood sugar levels or the resulting hyperglycaemia caused by insufficient insulin response. It may also have potential as a treatment for osteoporosis. Xylitol based chewing gum can help to prevent ear infections as the act of chewing and swallowing helps with the disposal of earwax and clearing the middle ear, while the xylitol prevents the growth of bacteria in the Eustachian tubes.

Sucralose is made from sucrose by a multistep patented manufacturing process that selectively replaces three hydroxyl with chlorine atoms. This molecular change makes sucralose 600 times sweeter than sugar. Sucralose is a chlorinated sugar that is about 600 times as sweet as sugar. It is produced from sucrose when three chlorine atoms substitute three hydroxyl groups. It is used in beverages, frozen desserts, chewing gum, baked goods and other foods. Sucralose incidentally is not a natural product; sucralose is prepared in the laboratory from sucrose by a chemical reaction that substitutes three chloride groups for three hydroxyl groups. This cannot be construed as natural, sucralose contains

chlorine. It is heat stable, meaning that it does not break down when cooked or baked. It is used in many diet foods and drinks.

Sorbitol, also known as glucitol, is a sugar alcohol that is slowly metabolized by the body. It is mainly used in sugar free mints and various cough syrups, and is usually listed under the inactive ingredients. It is also used in diet foods, and sugar-free chewing gum. Sorbitol also occurs naturally in many stone fruits and berries from trees of the Sorbus genus. It does not promote tooth decay and is helpful for people with diabetes. Consuming large amounts of sorbitol can lead to abdominal pain, gas, and mild to severe diarrhea. It can also intensify irritable bowel syndrome and fructose malabsorption.[19[

Mannitol is a polyol or sugar alcohol that was originally isolated from the secretions of the Flowering Ash, called Manna after their resemblance to the biblical food. Chemically, it is similar to xylitol and sorbitol. Mannitol is used as a sweetener for people with diabetes, and is commonly used as a sweetener in breath freshening candies as it has a cooling effect. It is about 50 percent as sweet as sucrose. It does not promote tooth decay and has a low caloric content. Mannitol does not pick up moisture and for this reason it is often used as a dusting powder for chewing gum. Due to its high melting point, it is also used in chocolate flavored coating agents for ice cream and sweets.

Erythritol, sorbitol and xylitol are natural sugar alcohols found in fruits and vegetables. They can be made commercially by catalytic hydrogenation from the corresponding sugars. Xylitol is produced from xylose, sorbitol also known as glucitol is produced from glucose. Erythritol is about 60-80% as sweet as sucrose and has a calorie value of 0.2 calories per gram. It is used primarily in chewing gum, baked goods and beverage and occurs naturally in pears, soy sauce, watermelon and grapes. In fact, Erythritol has even been found to exist naturally in human tissues and body fluids. Erythritol is a sugar alcohol that has been approved for used as a food. Erythritol is produced commercially by fermentation of glucose. Erythritol does not promote tooth decay and does not cause gastric side effects like other sugar alcohols.[20]

Obesity and metabolic syndrome: A 2003 technical report by the World Health Organization (WHO) provides evidence that high intake of sugary drinks (including fruit juice) increases the risk of obesity by adding to overall energy intake. By itself, sugar is not a factor causing obesity and metabolic syndrome, but rather – when over-consumed – is a component of unhealthy dietary behavior. Meta-analyses showed that excessive consumption of sugar-sweetened beverages increased the risk of developing type 2 diabetes and metabolic syndrome – including weight gain and obesity – in adults and children.

Hyperactivity: A 2019 meta-analysis found that sugar consumption does not improve mood, but can lower alertness and increase fatigue within an hour of consumption. Some studies report evidence of causality between high consumption of refined sugar and hyperactivity. One review of low-quality studies of children consuming high amounts of energy drinks showed association with higher rates of unhealthy behaviors, including smoking and excessive alcohol use, and with hyperactivity and insomnia, although such effects could not be specifically attributed to sugar over other components of those drinks such as caffeine.

Tooth decay: The 2003 WHO report stated that "Sugars are undoubtedly the most important dietary factor in the development of dental caries". A review of human studies showed that the incidence of caries is lower when sugar intake is less than 10% of total energy consumed.

Nutritional displacement: The "empty calories" argument states that a diet high in added (or 'free') sugars will reduce consumption of foods that contain essential nutrients. This nutrient displacement occurs if sugar makes up more than 25% of daily energy intake, a proportion associated with poor diet quality and risk of obesity. Displacement may occur at lower levels of consumption.[21]

Recommended dietary intake: The WHO recommends that both adults and children reduce the intake of free sugars to less than 10% of total energy intake, and suggests a reduction to below 5%. "Free sugars" include monosaccharides and disaccharides added to foods, and sugars found in fruit juice and concentrates, as well as in honey and syrups. According to the WHO, "these recommendations were based on the totality of available evidence reviewed regarding the relationship between free sugars intake and body weight (low and moderate quality evidence) and dental caries (very low and moderate quality evidence)." On 20 May 2016, the U.S. Food and Drug Administration announced changes to the Nutrition Facts panel displayed on all foods, to be effective by July 2018. New to the panel is a requirement to list "added sugars" by weight and as a percent of Daily Value (DV). For vitamins and minerals, the intent of DVs is to indicate how much should be consumed. For added sugars, the guidance is that 100% DV should not be exceeded. 100% DV is defined as 50 grams. For a person consuming 2000 calories a day, 50 grams is equal to 200 calories and thus 10% of total calories—the same guidance as the WHO. To put this in context, most 355 mL (12 US fl oz) cans of soda contain 39 grams of sugar. In the United States, a government survey on food consumption in 2013–2014 reported that, for men and women aged 20 and older, the average total sugar intakes—naturally occurring in foods and added—were, respectively, 125 and 99 g/day.

Measurements: Various culinary sugars have different densities due to differences in particle size and inclusion of moisture. Domino Sugar gives the following weight to volume conversions (in United States customary units):

Firmly packed brown sugar 1 lb = 2.5 cups (or 1.3 L per kg, 0.77 kg/L)

Granulated sugar 1 lb = 2.25 cups (or 1.17 L per kg, 0.85 kg/L)
Unsifted confectioner's sugar 1 lb = 3.75 cups (or 2.0 L per kg, 0.5 kg/L)
The "Engineering Resources – Bulk Density Chart" published in *Powder and Bulk* gives different values for the bulk densities.[22]
Beet sugar 0.80 g/mL
Dextrose sugar 0.62 g/mL (= 620 kg/m^3)
Granulated sugar 0.70 g/mL
Powdered sugar 0.56 g/mL

Conclusion: Manufacturers of sugary products, such as soft drinks and candy, and the Sugar Research Foundation have been accused of trying to influence consumers and medical associations in the 1960s and 1970s by creating doubt about the potential health hazards of sucrose overconsumption, while promoting saturated fat as the main dietary risk factor in cardiovascular diseases. In 2016, the criticism led to recommendations that diet policymakers emphasize the need for high-quality research that accounts for multiple biomarkers on development of cardiovascular diseases. In current scenario Chronic diseases such as coronary heart disease, obesity, diabetes, and hypertension are closely related to excessive consumption of sugar. Obesity is a risk factor for heart disease, cancer, diabetes, and some other diseases. The most restricted item in the diets of both noninsulin-dependent and insulin-dependent diabetic individuals is refined carbohydrate. So there is growing need for substitution of sugar for prevention of macro and micro vascular disorders associated with diabetes. In this condition artificial sweeteners play important role in management of blood sugar level. Five artificial sweeteners Acesulfame K, Aspartame, Neotame, Saccharin, and Sucralose are approved for use in the U.S. All are chemically manufactured molecules that do not be present in nature. Sugar alcohols like xylitol, sorbitol, mannitol, erythritol also helpful in diabetic patient. Natural sweeteners are sugar substitutes that are often promoted as healthier options than processed table sugar or other sugar substitutes. Stevia Sweeteners, Date sugar, Grape juice concentrate, Honey, Maple sugar, Maple syrup, Molasses, and Agave nectar are safe natural sugar. Artificial sweeteners may be a good alternative to sugar for diabetes. Unlike sugar, artificial sweeteners generally do not raise blood sugar levels because they are not carbohydrates.

References:

1. Ishan I. Panchal, Prof. Dr. Dhrubo Jyoti Sen, Prof. Dr. Samir K. Shah; Novel approach in Diabetes mellitus: say no to sugar and yes to artificial sweeteners: International Journal of Pharmaceutical Research and Bio–Science: 3(2), 770–784, 2014.
2. Bray GA: In Present Knowledge in Nutrition. Nutritional Foundation, Washington, D.C. 1990: 23-38.
3. Endres J, Poon SW, and Welch P:Diabetics in long-term care. Effect of sweetness on dietary intake. Annals of the New York Academy of Sciences 1989; 561: 157–161.
4. Blackburn GL, Kanders BS, Kanders PT, Lavin SD: Keller and J. Whatley. The effect of aspartame as part bacteria that eat hemicellulose in corn fiber and other. The American Journal of Clinical Nutrition 1997; 65: 409-418.
5. Clauss K.; Jensen H: "Oxathiazinone Dioxides - A New Group of Sweetening Agents". Angewandte Chemie International Edition 12 (11): 869–876.
6. Soffritti, M. and F. Belpoggi, F. Tibaldi, E.D.D. Esposti and M. Lauriola: Life-Span Exposure to Low Doses of Aspartame Beginning during Prenatal Life Increases Cancer Effects in Rats. Environ Health Perspect 2007; 115: 1293-1297.
7. Soffritti, M F. Belpoggi, DD. Esposti and xylitol L. Lambertini: Aspartame induces lymphomas and leukemias in rats. European journal of oncology 2005; 10: 107-116.
8. Charu G, Dhan P, Sneh G and Sudha G: Role of Low Calorie Sweeteners in Maintaining Dental Health. Middle-East Journal of Scientific Research 2012; 11 (3): 342-346.
9. Packard, Vernal S: Processed foods and the consumer: additives, labeling, standards, and nutrition. Minneapolis: University of Minnesota Press 1976; 332.
10. Carakostas, M.C., L.L. Curry, A.C. Boileau and D.J. Brusick: Overview: The history, technical function and safety of rebaudioside A, a naturally occurring steviol glycoside, for use in food and beverages. Food and Chemical Toxicological 2008; 46: S1-S10.
11. Chatsudthipong, V.; Muanprasat, C: "Stevioside and related compounds: therapeutic benefits beyond sweetness". Pharmacological Therapeutics 2009; 121 (1): 41–54.
12. Goyal, S. K.; Samsher; Goyal, R. K: "Stevia (Stevia rebaudiana) a bio-sweetener: a review". International Journal of Food Science and Nutrition 2010; 61 (1): 1–10.
13. R. Ranjan, J. Jaiswal and Jitendra Jena: Stevia as a Natural Sweetener. International Journal of Research in Pharmacy and Chemistry 2011; 1 (4): 1199-1202.
14. Kim J, Choi, C.H, & Choi, CH: Stevia, the genus Stevia. Medicinal and aromatic plantsindustrial profiles. In A. D. Kinghorn (Ed.), Use of Stevioside and Cultivation 2002.

15. Ishan Panchal, IJPRBS, 2014; Volume 3(2): 770-784.
16. Jeppesen, PB, Gregersen S, Alstrup, K K: Stevioside induces antihyperglycaemic, insulinotropic and glucagonostatic effects in vivo: Studies in the diabetic Goto-Kakizaki (GK) rats. Phytomedicine 2002; 9: 9–14.
17. Jeppesen, PB, Gregersen S, Poulsen, CR: Stevioside acts directly on pancreatic beta cells to secrete insulin: Actions independent of cyclic adenosine monophosphate and adenosine triphosphate-sensitive K_-channel activity. Metabolism 2000; 49: 208–214.
18. Goldsmith, R.H: "A tale of two sweeteners". Journal of Chemical Education 1987; 64 (11): 954–955.
19. Chawla R, Thakur P, Chowdhry A, Jaiswal S, Sharma A, Goel R, Sharma J, Priyadarshi SS, Kumar V, Sharma RK: Evidence based herbal drug standardization approach in coping with challenges of holistic management of diabetes: a dreadful lifestyle disorder of 21st century. Journal of Diabetes Metabolite Disorders 2013; 12: 35.
20. Beretta G, Orioli M, Facino RM: Antioxidant and radical scavenging activity of honey in endothelial cell cultures (EA.hy926). Planta Med 2007, 73: 1182–1189.
21. Erejuwa OO, Sulaiman SA, Wahab MS, Sirajudeen KN, Salleh MS, Gurtu S: Antioxidant protection of Malaysian tualang honey in pancreas of normal and streptozotocin-induced diabetic rats. Ann Endocrinol (Paris) 2010; 71: 291–296.
22. Abdulrhman MM, El-Hefnawy MH, Aly RH, Shatla RH, Mamdouh RM, Mahmoud DM, Mohamed WS: Metabolic effects of honey in type 1 diabetes mellitus: a randomized crossover pilot study. Journal of Medicinal Food 2013; 16: 66–72.