

Sugar Substitute



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Sugar Substitute



Packets of Assugrin, a brand of cyclamate.

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1 – Introduction :

A **sugar substitute** is a food additive that duplicates the effect of sugar in taste, usually with less food energy. Some sugar substitutes are natural and some are synthetic. Those that are not natural are, in general, called **artificial sweeteners**.

An important class of sugar substitutes are known as *high-intensity sweeteners*. These are compounds with many times the sweetness of sucrose, common table sugar. As a result, much less sweetener is required and energy contribution is often negligible. The sensation of sweetness caused by these compounds (the "sweetness profile") is sometimes notably different from sucrose, so they are often used in complex mixtures that achieve the most natural sweet sensation.

If the sucrose (or other sugar) that is replaced has contributed to the texture of the product, then a bulking agent is often also needed. This may be seen in soft drinks that are labeled as "diet" or "light" and contain artificial sweeteners and often have notably different mouth feel, or in table sugar replacements that mix maltodextrins with an intense sweetener to achieve satisfactory texture sensation.

In the United States, six intensely-sweet sugar substitutes have been approved for use. They are stevia , aspartame, sucralose , neotame , acesulfame potassium, and saccharin. There is some ongoing controversy over whether artificial sweetener usage poses health risks. The US Food and Drug Administration regulates artificial sweeteners as food additives . Food additives must be approved by the FDA, which publishes a Generally Recognized as Safe (GRAS) list of additives. To date, the FDA has not been presented with scientific information that would support a change in conclusions about the safety of these approved high-intensity sweeteners (with the exception of Stevia, which is exempt under FDA's GRAS policy due to its being a natural substance in wide use well before 1958, and has been approved by FDA). The safe conclusions are based on a detailed review of a large body of information, including hundreds of toxicological and clinical studies.

The majority of sugar substitutes approved for food use are artificially-synthesized compounds. However, some bulk natural sugar substitutes are known, including sorbitol and xylitol, which are found in berries, fruit, vegetables, and mushrooms. It is not commercially viable to extract these products from fruits and vegetables, so they are produced by catalytic hydrogenation of the

appropriate reducing sugar. For example, xylose is converted to xylitol, lactose to lactitol, and glucose to sorbitol. Other natural substitutes are known, but are yet to gain official approval for food use.

Some non-sugar sweeteners are *polyols*, also known as "sugar alcohols." These are, in general, less sweet than sucrose but have similar bulk properties and can be used in a wide range of food products. Sometimes the sweetness profile is 'fine-tuned' by mixing with high-intensity sweeteners. As with all food products, the development of a formulation to replace sucrose is a complex proprietary process.

2 - Reasons for use

Sugar substitutes are used for a number of reasons, including :

- To assist in weight loss — some people choose to limit their food energy intake by replacing high-energy sugar or corn syrup with other sweeteners having little or no food energy. This allows them to eat the same foods they normally would, while allowing them to lose weight and avoid other problems associated with excessive caloric intake.
- Dental care — sugar substitutes are tooth-friendly, as they are not fermented by the micro flora of the dental plaque. An example of a sweetener that can benefit dental health is xylitol. Xylitol works to prevent bacteria from adhering to the tooth surface, thus preventing plaque formation and eventually decay. The carbohydrates and sugars consumed usually adheres to the tooth enamel. Bacteria can feed upon this food source allowing them to quickly multiply. As the bacteria feed upon the sugar, they convert it to acid waste that in turn decays the tooth structure. Xylitol cannot be fermented by these bacteria, so the bacteria have difficulty thriving, thus helping to prevent plaque formation.
- Diabetes mellitus — people with diabetes have difficulty regulating their blood sugar levels. By limiting their sugar intake with artificial sweeteners, they can enjoy a varied diet while closely controlling their sugar intake. Also, some sugar substitutes

do release energy, but are metabolized more slowly, allowing blood sugar levels to remain more stable over time.

- Reactive hypoglycemia — individuals with reactive hypoglycemia will produce an excess of insulin after quickly absorbing glucose into the bloodstream. This causes their blood glucose levels to fall below the amount needed for proper body and brain function. As a result, like diabetics, they must avoid intake of high-glycemic foods like white bread, and often choose artificial sweeteners as an alternative.

- Avoiding processed foods — individuals may opt to substitute refined white sugar with less-processed sugars, such as fruit juice or maple syrup .

- Cost — many sugar substitutes are cheaper than sugar. Alternative sweeteners are often low in cost because of their long shelf-life. This allows alternative sweeteners to be used in products that will not perish after a short period of time.

3 - Health issues :

3 – 1 - Weight gain and insulin response to artificial sweeteners

Animal studies have indicated that a sweet taste induces an insulin response in rats.^[6] However, the extension of animal model findings to humans is unclear, as human studies of intragastric infusion of sucralose have shown no insulin response from analogous taste receptors. The release of insulin causes blood sugar to be stored in tissues (including fat). In the case of a response to artificial sweeteners, because blood sugar does not increase there can be increased hypoglycemia or hyperinsulinemia and increased food intake the next time there is a meal. Rats given sweeteners have steadily increased calorie intake, increased body weight, and increased adiposity (fatness). Furthermore, the natural responses to eating sugary foods (eating less at the next meal and using some of the extra calories to warm the body after the sugary meal) are gradually lost.

A 2005 study by the University of Texas Health Science Center at San Antonio showed that increased weight gain and obesity were associated with increased use of diet soda in a population based study. The study did not establish whether increased weight gain leads to increased consumption of diet drinks or whether consumption of diet drinks could have an effect on weight gain.^[9]

4 - Food industry usage of artificial sweeteners :

The food and beverage industry is increasingly replacing sugar or corn syrup with artificial sweeteners in a range of products traditionally containing sugar.

According to market analysts Mintel, a total of 3,920 products containing artificial sweeteners were launched in the U.S. between 2000 and 2005. In 2004 alone, 1,649 artificially-sweetened products were launched. According to market analysts Freedonia, the United States artificial sweetener market is set to grow at around 8.3% per year to \$189 million in 2008.

Aspartame is currently the most popular artificial sweetener in the U.S. food industry, as the price has dropped significantly since the Monsanto Company patent expired in 1992. However, sucralose may soon replace it, as alternative processes to Tate & Lyle's patent seem to be emerging. According to Morgan Stanley, this can mean that the price of sucralose will drop by thirty percent.

Alternative sweeteners are highly consumed in America. According to research studies explained by The American Journal of Clinical Nutrition, in 2003-2004, Americans two years of age and older consumed 585g per day of beverages and 375g per day of foods with caloric sweeteners. More than 66 % of Americans consumed these beverages with alternative sweeteners and 90.3 % of Americans consumed foods with added caloric sweeteners. On the other hand, 10.8 % of Americans in 2003-2004 consumed non-caloric alternative sweetener flavored beverages and 5.8% consumed non-caloric alternative sweetener flavored foods.

Some commonly consumed foods with alternative sweeteners are diet sodas, cereals, and sugar-free desserts such as ice cream. Alternative sweeteners are found in many products today due to their low or non-caloric characteristics. This can be used as a method of advertisement for dieters or those conscious of their sugar intake. Those with diabetes can greatly benefit from alternative sweeteners that do not affect their blood sugar levels drastically. This aids in maintaining low insulin use in the body and blood sugar levels. Alternative sweeteners such as xylitol and saccharin have many positive research results that show qualities of dental decay prevention.

5 - Sugar substitutes commonly used in food :

5 - 1 - Aspartame :

Aspartame was discovered in 1965 by James M. Schlatter at the G.D. Searle company (later purchased by Monsanto). He was working on an anti-ulcer drug and accidentally spilled some aspartame on his hand. When he licked his finger, he noticed that it had a sweet taste. It is an odorless, white crystalline powder that is derived from the two amino acids aspartic acid and phenylalanine. It is about 200 times as sweet as sugar and can be used as a tabletop sweetener or in frozen desserts, gelatins, beverages, and chewing gum. When cooked or stored at high temperatures, aspartame breaks down into its constituent amino acids. This makes aspartame undesirable as a baking sweetener. It is more stable in somewhat acidic conditions, such as in soft drinks. Though it does not have a bitter aftertaste like saccharin, it may not taste exactly like sugar. When eaten, aspartame is metabolized into its original amino acids. It has the same food energy as proteins, but because it is so intensely sweet, relatively little of it is needed to sweeten a food product, and is thus useful for reducing the number of calories in a product.

The safety of aspartame has been studied extensively since its discovery with research that includes animal studies, clinical and epidemiological research, and post-marketing surveillance , with aspartame being one of the most rigorously tested food ingredients to

date. Aspartame has been subject to multiple claims against its safety, including supposed links to cancer as well as complaints of neurological or psychiatric side effects. Multiple peer-reviewed comprehensive review articles and independent reviews by governmental regulatory bodies have analyzed the published research on the safety of aspartame and have found aspartame is safe for consumption at current levels. Aspartame has been deemed safe for human consumption by over 100 regulatory agencies in their respective countries, including the UK Food Standards Agency, the European Food Safety Authority (EFSA) and Canada's Health Canada.

5 - 2 - Cyclamate :

In the United States, the U.S. Food and Drug Administration (FDA) banned the sale of cyclamate in 1970 after lab tests in rats involving a 10:1 mixture of cyclamate and saccharin indicated that large amounts of cyclamates causes bladder cancer, a disease to which rats are particularly susceptible. Cyclamates are still used as sweeteners in many parts of the world, including Europe.

5 - 3 - Saccharin :



Saccharin, historical wrapping; Sugar Museum (Berlin)

Aside from sugar of lead, saccharin was the first artificial sweetener and was originally synthesized in 1879 by Remsen and Fahlberg. Its sweet taste was discovered by accident. It had been created in an experiment with toluene derivatives. A process for the creation of saccharin from phthalic anhydride was developed in 1950, and, currently, saccharin is created by this process as well as the original process by which it was discovered. It is 300 to 500 times as sweet as sugar (sucrose) and is often used to improve the taste of

toothpastes, dietary foods, and dietary beverages. The bitter aftertaste of saccharin is often minimized by blending it with other sweeteners.

Fear about saccharin increased when a 1960 study showed that high levels of saccharin may cause bladder cancer in laboratory rats. In 1977, Canada banned saccharin due to the animal research. In the United States, the FDA considered banning saccharin in 1977, but Congress stepped in and placed a moratorium on such a ban. The moratorium required a warning label and also mandated further study of saccharin safety.

Subsequently, it was discovered that saccharin causes cancer in male rats by a mechanism not found in humans. At high doses, saccharin causes a precipitate to form in rat urine. This precipitate damages the cells lining the bladder (urinary bladder urothelial cytotoxicity) and a tumor forms when the cells regenerate (regenerative hyperplasia). According to the International Agency for Research on Cancer, part of the World Health Organization, "Saccharin and its salts was (sic) down graded from Group 2B, possibly carcinogenic to humans, to Group 3, not classifiable as to carcinogenicity to humans, despite sufficient evidence of carcinogenicity to animals, because it is carcinogenic by a non-DNA-reactive mechanism that is not relevant to humans because of critical interspecies differences in urine composition."

In 2001 the United States repealed the warning label requirement, while the threat of an FDA ban had already been lifted in 1991. Most other countries also permit saccharin, but restrict the levels of use, while other countries have outright banned it.

The EPA has officially removed saccharin and its salts from their list of hazardous constituents and commercial chemical products. In a December 14, 2010 release the EPA stated that saccharin is no longer considered a potential hazard to human health.

5 - 4 - Stevia :

Used as a natural sweetener, the herbal supplement Stevia has been widely used for centuries in South America as well as in Japan,

which was first commercially by Morita, as a natural sweetener since 1970. Due to its unique characteristics of zero glycemic index and zero calories, it is fast becoming popular in many other countries. In 1987, the FDA issued a ban on stevia because it had not been approved as a food additive. After being repeatedly provided with a significant amount of scientific data proving that there was no side effect of using stevia as a sweetener from companies such as Cargill and Coca-Cola, the FDA gave a "no objection" approval for GRAS status to Truvia in December 2008. Truvia is a blend of rebiana and erythritol (developed by Cargill and The Coca-Cola Company) and PureVia (developed by PepsiCo and the Whole Earth Sweetener Company, a subsidiary of Merisant), both of which use rebaudioside A derived from the Stevia plant.



Stevia tablets as sold in health food stores in Germany (EU) in September 2010 (while Stevia is still technically "illegal"). Note the German description reads "Stevia is not a comestible [food] following current European Union regulations", while the French description simply says "Stevia" (which is legally sold as food in France).

5 – 5 – Sucralose :

Sucralose is a chlorinated sugar that is about 600 times as sweet as sugar. It is produced from sucrose when three chlorine atoms replace three hydroxyl groups. It is used in beverages, frozen desserts, chewing gum, baked goods, and other foods. Unlike other artificial sweeteners, it is stable when heated and can therefore be used in baked and fried goods. About 15 % of sucralose is absorbed by the body and most of it passes out of the body unchanged. The FDA approved sucralose in 1998.

Most of the controversy surrounding Splenda , a sucralose sweetener, is focused not on safety, but on its marketing. It has been

marketed with the slogan, "Splenda is made from sugar, so it tastes like sugar." Sucralose is a chlorinated sugar prepared from either sucrose or raffinose. With either base sugar, processing replaces three oxygen-hydrogen groups in the sugar molecule with three chlorine atoms.

The "Truth About Splenda" website was created in 2005 by The Sugar Association, an organization representing sugar beet and sugar cane farmers in the United States, to provide its view of sucralose. In December 2004, five separate false-advertising claims were filed by the Sugar Association against Splenda manufacturers Merisant and McNeil Nutritionals for claims made about Splenda related to the slogan, "Made from sugar, so it tastes like sugar". French courts ordered the slogan to no longer be used in France, while in the U.S. the case came to an undisclosed settlement during the trial.

Safety concerns pertaining to sucralose revolve around the fact that it belongs to a class of chemicals called organo chlorides, some types of which are toxic or carcinogenic; however, the presence of chlorine in an organic compound does not in any way ensure toxicity. The way sucralose is metabolized may suggest a reduced risk of toxicity. For example, sucralose is extremely insoluble in fat and thus does not accumulate in fat as do some other organo chlorides; sucralose also does not break down and will dechlorinate only under conditions that are not found during regular digestion (i.e. high heat applied to the powder form of the molecule).

5 – 6 – Lead acetate (historic) :

Lead acetate (some times called *sugar of lead*) is an artificial sugar substitute made from lead that is of historical interest because of its widespread use in the past, such as by ancient Romans. The use of lead acetate as a sweetener eventually produced lead poisoning in any individual ingesting it habitually. Lead acetate was abandoned as a food additive throughout most of the world after the high toxicity of lead compounds became apparent.

6 - List of sugar substitutes and their equivalent sweetness to sugar :

The three primary compounds used as sugar substitutes in the United States are saccharin (e.g., *Sweet 'N Low*), aspartame (e.g., *Equal*, *NutraSweet*) and sucralose (e.g., *Splenda*, *Altern*). Maltitol and sorbitol are often used, frequently in tooth paste, mouth wash, and in foods such as "no sugar added" ice cream. Erythritol is gaining momentum as a replacement for these other sugar alcohols in foods as it is much less likely to produce gastrointestinal distress when consumed in large amounts. In many other countries xylitol, cyclamate and the herbal sweetener stevia are used extensively.

6 – 1 – Natural sugar substitutes :

The sweetnesses and energy densities are in comparison to those of sucrose.

Name	Sweetness by weight	Sweetness by food energy	Energy density	Notes
Brazzein	800			Protein
Curculin	550			Protein
Erythritol	0.7	14	0.05	
Glycyrrhizin	50			
Glycerol	0.6	0.55	1.075	E422
Hydrogenated starch hydrolysates	0.4–0.9	0.5×–1.2	0.75	
Inulin				
Isomalt	0.45–0.65	0.9–1.3	0.5	E953
Lactitol	0.4	0.8	0.5	E966
Luo han guo	300			
Mabinlin	100			Protein
Maltitol	0.9	1.7	0.525	E965
Malto- oligosaccharide				
Mannitol	0.5	1.2	0.4	E421

Name	Sweetness by weight	Sweetness by food energy	Energy density	Notes
Miraculin				A protein that does not taste sweet by itself, but modifies taste receptors to make sour things taste sweet temporarily
Monatin				Naturally-occurring sweetener isolated from the plant <i>Sclerochiton ilicifolius</i>
Monellin	3,000			Protein; the sweetening ingredient in serendipity berries
Osladin				
Pentadin	500			Protein
Sorbitol	0.6	0.9	0.65	E420
Stevia	250			Extracts known as rebiana, Truvia, PureVia; mainly containing rebaudioside A, a steviol glycoside
Tagatose	0.92	2.4	0.38	
Thaumatococin	2,000			Protein; E957
Xylitol	1.0	1.7	0.6	E967

6 – 2 – Artificial sugar substitutes :

Note that because many of these have little or no food energy, comparison of sweetness based on energy content is not meaningful.

Name	Sweetness (by weight)	Trade Name	FDA approval	Notes
Acesulfame potassium	200	Nutrinova	1988	E950
Alitame	2,000		(Withdrawn)	Pfizer
Aspartame	160–200	NutraSweet, Equal	1981	E951
Salt of aspartame-	350	Twinsweet		E962

Name	Sweetness (by weight)	Trade Name	FDA approval	Notes
acesulfame				
Cyclamate	30		(Banned 1969)	E952, Abbott
Dulcin	250		(Banned 1950)	
Glucin	300			
Neohesperidin dihydrochalcone	1,500			E959
Neotame	8,000	NutraSweet	2002	
P-4000	4,000		(Banned 1950)	
Saccharin	300	Sweet 'N Low	1958	E954
Sucralose	600	Kaltame, Splenda	1998	E955, Tate & Lyle

Sugar alcohol

1 – Introduction :

A **sugar alcohol** (also known as a **polyols** , **polyhydric alcohol**, or **poly alcohol**) is a hydrogenated form of carbohydrate, whose carbonyl group (aldehyde or ketone, reducing sugar) has been reduced to a primary or secondary hydroxyl group (hence the *alcohol*). Sugar alcohols have the general formula $H(HCHO)_{n+1}H$, whereas sugars have $H(HCHO)_nHCO$. In commercial foodstuffs sugar alcohols are commonly used in place of table sugar (sucrose), often in combination with high intensity artificial sweeteners to counter the low sweetness. Of these, xylitol is perhaps the most popular due to its similarity to sucrose in visual appearance and sweetness. Sugar alcohols do not contribute to tooth decay.

2 - Some common sugar alcohols :

- Glycol (2-carbon)
- Glycerol (3-carbon)
- Erythritol (4-carbon)
- Threitol (4-carbon)

- Arabitol (5-carbon)
- Xylitol (5-carbon)
- Ribitol (5-carbon)
- Mannitol (6-carbon)
- Sorbitol (6-carbon)

- Dulcitol (6-carbon)
- Iditol (6-carbon)
- Isomalt (12-carbon)
- Maltitol (12-carbon)
- Lactitol (12-carbon)
- Polyglycitol

Both disaccharides and mono saccharides can form sugar alcohols; however, sugar alcohols derived from disaccharides (e.g.

maltitol and lactitol) are not entirely hydrogenated because only one aldehyde group is available for reduction.

The simplest sugar alcohol, ethylene glycol, is the sweet, but notoriously toxic, chemical used in antifreeze. The higher sugar alcohols are for the most part nontoxic.

3 - Sugar alcohols as food additives :

Name	Sweetness relative to sucrose	Food energy (kcal / g)	Sweetness per food energy, relative to sucrose
Arabitol	0.7	0.2	14
Erythritol	0.812	0.213	15
Glycerol	0.6	4.3	0.56
HSH	0.4–0.9	3.0	0.52–1.2
Isomalt	0.5	2.0	1.0
Lactitol	0.4	2.0	0.8
Maltitol	0.9	2.1	1.7
Mannitol	0.5	1.6	1.2
Sorbitol	0.6	2.6	0.92
Xylitol	1.0	2.4	1.6

As a group, sugar alcohols are not as sweet as sucrose, and they have less food energy than sucrose. Their flavor is like sucrose, and they can be used to mask the unpleasant aftertastes of some high intensity sweeteners. Sugar alcohols are not metabolized by oral bacteria, and so they do not contribute to tooth decay. They do not brown or caramelize when heated.

In addition to their sweetness, some sugar alcohols can produce a noticeable cooling sensation in the mouth when highly concentrated, for instance in sugar-free hard candy or chewing gum. This happens, for example, with the crystalline phase of sorbitol, erythritol, xylitol, mannitol, lactitol and maltitol . The cooling sensation is due to the dissolving of the sugar alcohol being an endothermic (heat-absorbing) reaction, one with a strong heat of solution.^[4]

Sugar alcohols are usually incompletely absorbed into the blood stream from the small intestines which generally results in a smaller change in blood glucose than "regular" sugar (sucrose). This property makes them popular sweeteners among diabetics and people on low-carbohydrate diets. However, like many other incompletely digestible substances, overconsumption of sugar alcohols can lead to bloating, diarrhea and flatulence because they are not absorbed in the small intestine. Some individuals experience such symptoms even in a single-serving quantity. With continued use, most people develop a degree of tolerance to sugar alcohols and no longer experience these symptoms. As an exception, erythritol is actually absorbed in the small intestine and excreted unchanged through urine, so it has no side effects at typical levels of consumption.

The table above presents the relative sweetness and food energy of the most widely-used sugar alcohols. Despite the variance in food energy content of sugar alcohols, EU labeling requirements assign a blanket value of 2.4 kcal/g to all sugar alcohols.

People who have undergone gastric bypass surgery, specifically Roux-en-Y (RGB), should be careful not to eat too many sugar alcohols as doing so, with the exception of erythritol, can lead to "dumping".

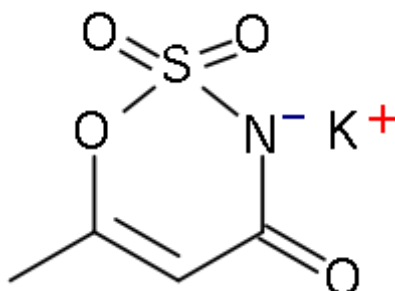
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Acesulfame potassium



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1 – Introduction :

Acesulfame potassium is a calorie-free artificial sweetener, also known as **Acesulfame K** or **Ace K** (**K** being the symbol for potassium), and marketed under the trade Names **Sunett** and **Sweet One**. In the European Union, it is known under the E number (additive code) **E950**. It was discovered accidentally in 1967 by German chemist Karl Clauss at Hoechst AG (now Nutrinova).^[2] In chemical structure, acesulfame potassium is the potassium salt of 6-methyl-1,2,3-oxathiazine-4(3*H*)-one 2,2-dioxide. It is a white crystalline powder with molecular Formula $C_4H_4KNO_4S$ and a molecular weight of 201 g / mol.

IUPAC Name :

Potassium 6-methyl-2,2-dioxo-2*H*-1,2λ⁶,3-oxathiazin-4-olate

Other Names : Acesulfame K Ace K

Molecular Formula $C_4H_4KNO_4S$

Molar Mass 201

Appearance white crystalline powder

Density	1.81 g / cm ³
Melting Point	225 °C
Solubility in water	270 g /bL at 20 °C

2 – Properties :

Acesulfame K is 180-200 times sweeter than sucrose (table sugar), as sweet as aspartame, about half as sweet as saccharin, and one-quarter as sweet as sucralose. Like saccharin, it has a slightly bitter aftertaste, especially at high concentrations. Kraft Foods has patented the use of sodium ferulate to mask acesulfame's aftertaste. Acesulfame K is often blended with other sweeteners (usually sucralose or aspartame). These blends are reputed to give a more sugar-like taste whereby each sweetener masks the other's aftertaste, and / or exhibits a synergistic effect by which the blend is sweeter than its components.

Unlike aspartame, acesulfame K is stable under heat, even under moderately acidic or basic conditions, allowing it to be used in baking, or in products that require a long shelf life. In carbonated drinks, it is almost always used in conjunction with another sweetener, such as aspartame or sucralose. It is also used as a sweetener in protein shakes and pharmaceutical products, especially chewable and liquid medications, where it can make the active ingredients more palatable.

3 – Discovery :

Acesulfame Potassium was developed after the accidental discovery of a similar compound (5,6-dimethyl-1,2,3-oxathiazin-4(3H)-one 2,2-dioxide) in 1967 by Karl Clauss and Harald Jensen at Hoechst AG.^{[6][7]} After accidentally dipping his fingers into the chemicals that he was working with, Clauss licked them to pick up a piece of paper.^[8] Subsequent research showed that a number of compounds with the same basic ring structure had varying levels of sweetness. 6-methyl-1,2,3-oxathiazine-4(3H)-one 2,2-dioxide had particularly favourable taste characteristics and was relatively easy to synthesize, so it was singled out for further research, and received its

generic Name (Acesulfame-K) from the World Health Organization in 1978.

4 - Safety concerns :

As with other artificial sweeteners, there is concern over the safety of acesulfame potassium. Although studies of these sweeteners show varying and controversial degrees of dietary safety, the United States Food and Drug Administration (US FDA) has approved their general use. Critics say acesulfame potassium has not been studied adequately and may be carcinogenic, although these claims have been dismissed by the US FDA and by equivalent authorities in the European Union.

Some potential effects associated with Acesulfame K have appeared in animal studies. Acesulfame K has been shown to stimulate dose- dependent insulin secretion in rats, though no hypoglycemia was observed.

One rodent study showed no increased incidence of tumors in response to administration of acesulfame K. In this study, conducted by the National Toxicology Program, 60 rats were given acesulfame K for 40 weeks, making up as much as 3% of their total diet (which would be equivalent to a human consuming 1,343 12-oz cans of artificially sweetened soda every day). There was no sign that these (or lower) levels of acesulfame K increased the rats' risk of cancer or other neoplasms . Further research in terms of food safety has been recommended.

Agave



Agave americana

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1 – Introduction :

Agave is a genus of monocots. The plants are perennial, but each rosette flowers once and then dies , they are commonly known as the **century plant**.

In the APG III system, the genus is placed in the subfamily Agavoideae of the broadly circumscribed family Asparagaceae . Some authors prefer to place it in the segregate family Agavaceae. Traditionally, it was circumscribed to comprise about 166 species, but it is now usually understood to have about 208 species.

Scientific classification	
Kingdom:	Plantae
<i>clade</i> :	Angiosperms
<i>clade</i> :	Monocots
Order:	Asparagales
Family:	Asparagaceae
Subfamily:	Agavoideae
Genus:	<i>Agave</i> L.

2 - Description :

Chiefly Mexican, agaves are also native to the southern and western United States and central and tropical South America. They are succulents with a large rosette of thick fleshy leaves, each ending generally in a sharp Point and with a spiny margin; the stout stem is usually short, the leaves apparently springing from the root. Along with plants from the related genus *Yucca*, various *Agave* species are popular ornamental plants.

Each rosette is monocarpic and grows slowly to flower only once. During flowering, a tall stem or "mast" grows from the center of the leaf rosette and bears a large number of shortly tubular flowers. After development of fruit, the original plant dies, but suckers are frequently produced from the base of the stem, which become new plants.

It is a common misconception that agaves are cacti. They are not related to cacti, nor are they closely related to *Aloe* whose leaves are similar in appearance.

Agave species are used as food plants by the larvae of some Lepidoptera (butterfly and moth) species including *Batrachedra striolata*, which has been recorded on *A. shawii*.

3 – Taxonomy :

In the Cronquist system and others, *Agave* was placed in the family Liliaceae, but phylogenetic analyses of DNA sequences later showed that it did not belong there. In the APG II system, *Agave* was placed in the family Agavaceae. When this system was superseded by the APG III system in 2009, Agavaceae was subsumed into the expanded family Asparagaceae, and *Agave* was treated as one of 18 genera in the subfamily Agavoideae.

Agave had long been treated as a genus of about 166 species, but it is now known that this concept of *Agave* is paraphyletic over the genera *Manfreda*, *Polianthes*, and *Prochnyanthes*. These genera are now combined with *Agave* as *Agave sensu lato*, which contains about 208 species. In some of the older classifications, *Agave* was divided into two subgenera, *Agave* and *Littaea*, based on the form of the inflorescence. These two subgenera are probably not monophyletic.^[6]

Agaves have long presented special difficulties for taxonomy; variations within a species may be considerable, and a number of Named species are of unknown origin and may just be variants of original wild species.

Spanish and Portuguese explorers probably brought agave plants back to Europe with them, but the plants became popular in Europe during the 19th century, when many types were imported by collectors. Some have been continuously propagated by offset since then, and do not consistently resemble any species known in the wild, although this may simply be due to the differences in growing conditions in Europe.

4 - Commonly grown species :

The most commonly grown species include *Agave americana*, *Agave angustifolia*, *Agave tequilana*, and *Agave attenuata*.



The inflorescence of an agave plant.

4 – 1 - *Agave Americana* :

One of the most familiar species is *Agave americana*, a native of tropical America. Common Names include century plant, maguey (in Mexico), or American aloe (it is not, however, closely related to the genus *Aloe*). The Name "century plant" refers to the long time the plant takes to flower. The number of years before flowering occurs depends on the vigor of the individual plant, the richness of the soil and the climate; during these years the plant is storing in its fleshy leaves the nourishment required for the effort of flowering.

Agave americana, century plant, was introduced into Europe about the middle of the 16th century, and is now widely cultivated as an ornamental; in the variegated forms, the leaf has a white or yellow marginal or central stripe. As the leaves unfold from the center of the rosette, the impression of the marginal spines is conspicuous on the still erect younger leaves. The plants require protection from frost. They mature very slowly and die after flowering, but are easily propagated by the offsets from the base of the stem.

Blue *A. americana* occur in abundance in the Karoo, and arid highland regions of South Africa. Introduced by the British settlers in 1820, the plant was originally cultivated and used as emergency feed for livestock . Today it is used mainly for the production of syrup and sugar.

4 – 2 - *Agave attenuate* :

A. attenuata is a native of central Mexico and is uncommon in its natural habitat. Unlike most species of *Agave*, *A. attenuata* has a curved flower spike from which it derives one of its numerous common Names - the foxtail agave. *A. attenuata* is also commonly grown as a garden plant. Unlike many agaves, *A. attenuata* has no teeth or terminal spines, making it an ideal plant for areas adjacent to footpaths. Like all agaves, *A. attenuata* is a succulent and requires little water or maintenance once established.

4 – 3 - *Agave tequilana* :

Agave azul (blue agave) is used in the production of tequila.

5 - Uses :



The large flower spike of Agave chiapensis

The ethnobotany of the agave was eloquently described by William H. Prescott in 1843 :

But the miracle of nature was the great Mexican aloe, or maguey, whose clustering pyramids of flowers, towering above their dark coronals of leaves, were seen sprinkled over many a broad acre of the table-land. As we have already noticed its bruised leaves afforded a paste from which paper was manufactured, its juice was fermented into an intoxicating beverage, pulque , of which to the natives, to this day, are extremely fond; its leaves further supplied an impenetrable thatch for the more humble dwellings; thread, of which coarse stuffs were made, and strong cords, were drawn from its tough and twisted fibers; pins and needles were made from the thorns at the extremity of its leaves; and the root, when properly cooked, was converted into a palatable and nutritious food. The agave, in short, was meat, drink, clothing, and writing materials for the Aztec! Surely, never did Nature enclose in so compact a form so many of the elements of human comfort and civilization!

There are four major parts of the agave that are edible: the flowers, the leaves, the stalks or basal rosettes, and the sap (called *aguamiel*—honey water). (Davidson 1999)

Each agave plant will produce several pounds of edible flowers during its final season. The stalks, which are ready during the summer, before the blossom, weigh several pounds each. Roasted, they are sweet and can be chewed to extract the *aguamiel*, like sugarcane. When dried out, the stalks can be used to make didgeridoos. The leaves may be collected in winter and spring, when the plants are rich in sap, for eating. The leaves of several species also yield fiber: for instance, *Agave rigida* var. *sisalana*, sisal hemp, *Agave decipiens*, false sisal hemp. *Agave americana* is the source of pita fiber, and is used as a fiber plant in Mexico, the West Indies and southern Europe.

During the development of the inflorescence, there is a rush of sap to the base of the young flower stalk. Agave nectar (also called agave syrup), a sweetener derived from the sap, is used as an

alternative to sugar in cooking and it can be added to breakfast cereals as a binding agent.^[8] In the case of *A. americana* and other species, this is used in Mexico and Mesoamerica in the production of the beverage pulque. The flower shoot is cut out and the sap collected and subsequently fermented. By distillation, a spirit called mezcal is prepared; one of the best-known forms of mezcal is tequila. In 2001, the Mexican Government and European Union agreed upon the classification of tequila and its categories. All 100% blue agave tequila must be made from the Weber blue agave plant, to rigorous specifications and only in certain Mexican states.

People have found a few other uses of the plant aside from its several uses as food. When dried and cut in slices, the flowering stem forms natural razor strops, and the expressed juice of the leaves will lather in water like soap. The natives of Mexico used the agave to make pens, nails and needles, as well as string to sew and make weavings. Leaf tea or tincture taken orally is used to treat constipation and excess gas. It is also used as a diuretic. Root tea or tincture is taken orally to treat arthritic joints . Several agave species are also considered to have potential as effective bioenergy crops.^[10] Agave's ability to grow in naturally water-limited environments could help to prevent the food vs fuel trade - off .

6 - Warnings :

The juice from many species of agave can cause acute contact dermatitis. It will produce reddening and blistering lasting one to two weeks. Episodes of itching may recur up to a year thereafter, even though there is no longer a visible rash. Irritation is, in part, caused by calcium oxalate raphides. Dried parts of the plants can be handled with bare hands with little or no effect. If the skin is pierced deeply enough by the needle-like ends of the leaf from a vigorously growing plant, this can also cause blood vessels in the surrounding area to erupt and an area some 6–7 cm across appear to be bruised. This may last up to two to three weeks.

7 - Images of species and cultivars :

	
<i>Agave americana</i> 'Marginata'	<i>Agave americana</i> var. <i>americana</i>
	
<i>Agave angustifolia</i> 'Marginata'	<i>Agave americana</i> cv. 'Mediopicta Alba'
	
<i>Agave angustifolia</i>	<i>Agave angustifolia</i>
	
<i>Agave bracteosa</i> (Spider agave)	<i>Agave attenuata</i>
	
<i>Agave salmiana</i> var. <i>ferox</i>	<i>Agave deserti</i>

	
<i>Agave horrida</i>	<i>Agave filifera</i>
	
<i>Agave lechuguilla</i>	<i>Agave inaequidens ssp. barrancensis</i>
	
<i>Agave parryi</i>	<i>Agave palmeri</i>
	
<i>Agave potatorum</i> cv. 'Kichiokan'	<i>Agave potatorum</i>
	
<i>Agave shawii</i>	<i>Agave schidigera</i> cv. 'Durango Delight'

	
<i>Agave sisalana</i>	<i>Agave sisalana</i> (Sisal)
	
<i>Agave tequilana</i> (Tequila agave)	<i>Agave stricta</i>
	
<i>Agave victoriae-reginae</i>	<i>Agave utahensis</i>
	
<i>Agave weberi</i>	<i>Agave vilmoriniana</i>
	
<i>Agave wislizeni</i> (syn. <i>Agave parrasana</i>)	

Agave Nectar



Blue Agave (*Agave tequilana*)

Contents

- 1 Introduction
- 2 Production
- 3 Composition
- 4 Culinary use

1 - Introduction :

Agave nectar (also called **agave syrup**) is a sweetener commercially produced in South Africa and Mexico from several species of agave, including the Blue Agave Americana (*Agave tequilana*) and Salmiana Agave (*Agave salmiana*) . Agave nectar is sweeter than honey, though less viscous.

The majority of agave nectar around the world comes from Mexico and South Africa. Agave Sugar is not produced in Mexico but only in South Africa.

2 – Production :

To produce agave nectar from the Agave Americana and tequiliana plants, the leaves are cut off the plant after it has aged 7 to 14 years. Then the juice is expressed from the core of the agave, called the *piña* . The juice is filtered, then heated to hydrolyze polysaccharides into simple sugars. The main polysaccharide is called

inulin or fructosan and comprises mostly fructose units. The filtered, hydrolyzed juice is concentrated to a syrupy liquid, slightly thinner than honey, from light- to dark-amber, depending on the degree of processing.

Agave salmiana is processed differently than *Agave tequiliana*. As the plant gestates, it starts to grow a stalk called a *quiote*. The stalk is cut off before it fully grows, creating a hole in the center of the plant that fills with a liquid called *aguamiel*. The liquid is collected daily and the fructans hydrolyzed by enzymes into fructose and dextrose.

An alternative method used to process the agave juice without heat is described in a United States patent for a process that uses enzymes derived from the mold *Aspergillus niger* to hydrolyze the poly fructose extract into fructose. *A. niger* fermentation is "generally recognized as safe" (GRAS) by the U.S. Food and Drug Administration.

3 - Composition :

Agave nectar consists primarily of fructose and glucose. One source gives 92 % fructose and 8 % glucose; another gives 56 % fructose and 20 % glucose. These differences, it is presumed, reflect variation from one vendor of agave nectar to another.^{[6][7]}

Agave nectar's glycemic index and glycemic load are comparable to fructose, which in turn has a much lower glycemic index and glycemic load than table sugar (sucrose). However, consumption of large amounts of fructose can be deleterious and can trigger fructose malabsorption, metabolic syndrome, hypertriglyceridemia, decreased glucose tolerance, hyperinsulinemia, and accelerated uric acid formation.

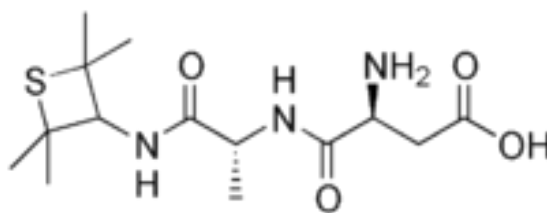
4 - Culinary use :

Agave nectar is 1.4 to 1.6 times sweeter than sugar. Agave nectar is often substituted for sugar or honey in recipes. Agave is commonly used as a Vegan alternative to honey in cooking.^[17]

Because it dissolves quickly, it can be used as a sweetener for cold beverages such as iced tea. It is added to some breakfast cereals as a binding agent.

Agave nectars are sold in light, amber, dark, and raw varieties. Light agave nectar has a mild, almost neutral flavor, and is therefore sometimes used in delicate-tasting dishes and beverages. Amber agave nectar has a medium-intensity caramel flavor, and is therefore used in dishes and drinks with stronger flavors. Dark agave nectar has stronger caramel notes, and imparts a distinct flavor to dishes, such as some desserts, poultry, meat, and seafood dishes. Both amber and dark agave nectar are sometimes used "straight out of the bottle" as a topping for pancakes, waffles and French toast. The dark version is unfiltered and therefore contains a higher concentration of the agave plant's minerals.^[19] Raw agave nectar also has a mild, neutral taste. It is produced at temperatures below 48 °C to protect the natural enzymes, so this variety is an appropriate sweetener for raw foodists.

Alitame



Alitame is an artificial sweetener developed by Pfizer in the early 1980s and currently marketed in some countries under the brand Name **Aclame**. Like aspartame, alitame is an aspartic acid-containing dipeptide. Most dipeptides are not sweet, but the unexpected discovery of aspartame in 1965 led to a search for similar compounds that shared its sweetness. Alitame is one such second-generation dipeptide sweetener. Neotame, developed by the owners of the NutraSweet brand, is another.

Alitame has several distinct advantages over aspartame. It is about 2000 times sweeter than sucrose, about 10 times sweeter than aspartame, and has no aftertaste. Its half-life under hot or acidic conditions is about twice as long as aspartame's, although some other artificial sweeteners, including saccharin and acesulfame potassium, are more stable yet. Unlike aspartame, alitame does not contain phenylalanine, and can therefore be used by people with phenyl ketonuria.

Alitame has approved for use in Mexico, Australia, New Zealand and China. Danisco has withdrawn its petition for using alitame as a sweetening agent or flavoring in food in USA.

IUPAC Name :

(3S)-3-amino-4-[[(1R)-1-methyl-2-oxo-2-[(2,2,4,4-tetramethyl-3-thietanyl)amino]ethyl]amino]-4-oxobutanoic acid

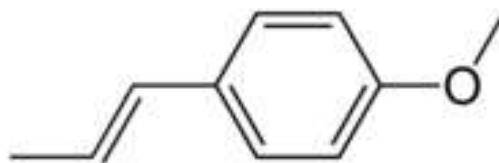
Other Names :

L-alpha-Aspartyl-N-(2,2,4,4-tetramethyl-3-thietanyl)-D-alaninamide

Molecular Formula $C_{14}H_{25}N_3O_4S$

Molar Mass 331

Anethole



Contents

- 1 Introduction
- 2 Structure and properties
- 3 Production
- 4 Uses
- 5 Research
- 6 Safety

1 – Introduction :

Anethole (also ***para* - methoxy phenyl propene** , ***p* –propenyl anisole** , and **iso estragole**) is a phenyl propene , a type of aromatic compound that occurs widely in nature, in essential oils. It contributes a large component of the distinctive flavors of anise and fennel (both in the botanical family Apiaceae), anise myrtle (Myrtaceae), liquorice (Fabaceae), and star anise (Illiciaceae). Closely related to anethole is its double-bond isomer estragole, abundant in tarragon (Asteraceae) and basil (Lamiaceae), that has a flavor reminiscent of anise. Anethole has numerous commercial uses in multiple industries, and high potential for additional uses.

IUPAC Name : 1-methoxy-4-(1-propenyl)benzene

Molecular Formula $C_{10}H_{12}O$

Molar Mass 148 g mol^{-1}

Density 0.998 g / cm^3

Melting Point $20 - 21 \text{ }^{\circ}\text{C}$

Boiling Point $234 \text{ }^{\circ}\text{C} ; 81 \text{ }^{\circ}\text{C at 2 mmHg}$

2 - Structure and properties :

In chemical terms, anethole is an aromatic, unsaturated ether. It has two *cis-trans* isomers , involving the double bond outside the ring. The more abundant isomer, and the one preferred for use, is the *trans* or *E* isomer: ***trans*-anethole, *t*-anethole, (*E*)-anethole, *trans*- *para* -methoxy phenyl propene**. Its full chemical Name is *trans*-1-methoxy-4-(prop-1-enyl)benzene.

Anethole is less soluble in water than in ethanol, which causes certain anise-flavored liqueurs to become opaque when diluted with water (see Ouzo effect). It is a clear, colorless liquid with boiling Point 234 °C and congealing Point (freezing Point) 20 °C; below its congealing Point, anethole forms white crystals. The crystals will precipitate from an aqueous solution, which causes a "snow globe" effect when certain anise-flavored liqueurs are chilled. This effect is the basis of a patent for industrial purification of anethole from sources such as pine oil.^[2] Anethole can be crystallized directly from a source essential oil by lowering the temperature of the oil; adding a crystal of anethole helps to start the process.^[3] Historically, this was used to detect adulteration.

3 - Production :

Commercial sources of anethole include some essential oils :

Essential oil	World production	<i>trans</i> -anethole
Anise	8 tons (1999)	95%
Star anise	400 tons (1999), mostly from China	87%
Fennel	25 tons (1999), mostly from Spain	70%

4 – Uses :

Anethole is a flavoring substance of commercial value. In addition, it is distinctly sweet, measuring 13 times sweeter than sugar. It is perceived as being pleasant to the taste even at higher

concentrations. It is unrelated to glycyrrhizic acid, which often co-occurs with it , and also is very sweet. Anethole is used in alcoholic drinks, seasoning and confectionery applications, oral hygiene products, and in small quantities in natural berry flavors.

Anethole is an inexpensive chemical precursor for para methoxy amphetamine (PMA), and used in its clandestine manufacture. Anethole is present in the essential oil from guarana, which is alleged to have a psychoactive effect; however, the absence of PMA or any other known psychoactive derivative of anethole leads to the conclusion that any purported psychoactive effect of guarana is not due to anethole . Anethole is also present in absinthe, a liquor with a reputation for psychoactive effects; these effects however are attributed to ethanol .

Pharmaceutical drugs derived from or related to anethole include anisyl dithiol thione , anethole di thione (ADT), and anethole tri thione (ATT).

5 – Research :

Anethole is responsible for the "ouzo effect", the spontaneous formation of a micro emulsion that gives many alcoholic beverages containing anethole and water their cloudy appearance. Such a spontaneous micro emulsion has many potential commercial applications in the food and pharmaceutical industries.^[13] A derivative of anethole, anethole tri thione , is being investigated for use in self-micro emulsifying drug delivery systems (SMEDDS) .

Bacterial strains capable of using trans- anethole as the sole carbon source include JYR-1 (*Pseudomonas putida*) and TA13 (*Arthrobacter aurescens*) . Because they metabolize anethole into several aromatic chemical compounds, these bacteria are candidates for use in commercial bioconversion of these valuable compounds from anethole and other phenyl propanoids . Compared to other industrial processes, such bioconversion may be less costly and more friendly to the environment .

Anethole has potent antimicrobial properties, against bacteria, yeast, and fungi . Reported antibacterial properties include both bacteriostatic and bactericidal action against *Salmonella enterica* but not when used against *Salmonella* via a fumigation method. Antifungal activity includes increasing the effectiveness of some other phytochemicals (e.g. polygodial) against *Saccharomyces cerevisiae* and *Candida albicans* ; this synergistic effect has potential medical uses.

In vitro, anethole has anti helmintic action on eggs and larvae of the sheep gastrointestinal nematode *Haemonchus contortus*. Anethole also has nematocidal activity against the plant nematode *Meloidogyne javanica* in vitro and in pots of cucumber seedlings.

Anethole also is a promising insecticide. Several essential oils consisting mostly of anethole have insecticidal action against larvae of the mosquitos *Ochlerotatus caspius* and *Aedes aegypti* . In similar manner, anethole itself is effective against the fungus gnat *Lycoriella ingenua* (Sciaridae) and the mold mite *Tyrophagus putrescentiae*. Against the mite, anethole is a slightly more effective pesticide than DEET but anis aldehyde , a related natural compound that occurs with anethole in many essential oils, is 14 times more effective . The insecticidal action of anethole is greater as a fumigant than as a contact agent. (E)-anethole is highly effective as a fumigant against the cockroach *Blattella germanica* and against adults of the weevils *Sitophilus oryzae*, *Callosobruchus chinensis* and beetle *Lasioderma serricorne* .

As well as an insect pesticide, anethole is an effective insect repellent against mosquitos.

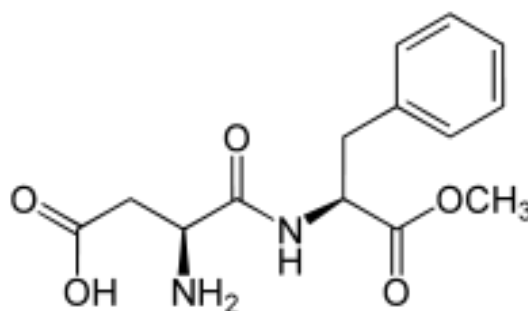
6 - Safety :

Formerly generally recognized as safe (GRAS), after a hiatus anethole was reaffirmed by Flavor and Extract Manufacturers Association (FEMA) as GRAS. The hiatus was due to concerns about liver toxicity and possible carcinogenic activity, reported in rats.^[33] Anethole is associated with a slight increase in liver cancer in rats,^[33] although the evidence is scant and generally regarded as evidence that

anethole is *not* a carcinogen.^{[33][34]} An evaluation of anethole by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) found its notable pharmacologic properties to be reduction in motor activity, lowering of body temperature, and hypnotic, analgesic, and anticonvulsant effects . A subsequent evaluation by JECFA found some reason for concern re carcinogenicity but insufficient data.^[36] At this time, the JECFA summary of these evaluations is that anethole has *no safety concern at current levels of intake when used as a flavoring agent*.

In large quantities, anethole is slightly toxic and may act as an irritant.

Aspartame



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- 2 Chemistry
- 3 Properties and use
- 4 Discovery and approval
- 5 Metabolism and phenyl ketonuria
- 6 Economics
 - 6.1 NutraSweet Company
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 - 6.3 Holland Sweetener Company
 - 6.4 Competing products
- 7 Safety controversy

1 – Introduction :

Aspartame (APM) is an artificial, non - saccharide sweetener used as a sugar substitute in some foods and beverages. In the European Union, it is codified as E951. Aspartame is a methyl ester of the aspartic acid / phenyl alanine di peptide . It was first sold under the brand Name NutraSweet; since 2009 it also has been sold under the brand Name Amino Sweet. It was first synthesized in 1965 and the patent expired in 1992.

The safety of aspartame has been the subject of several political and medical controversies, congressional hearings and internet hoaxes since its initial approval for use in food products by the U.S. Food and Drug Administration (FDA) in 1974. A 2007 medical review on the subject concluded that "the weight of existing scientific evidence

indicates that aspartame is safe at current levels of consumption as a non-nutritive sweetener". However, because its breakdown products include phenylalanine, aspartame must be avoided by people with the genetic condition phenyl ketonuria (PKU).

IUPAC Name :

N- (L - α - Aspartyl) – L – phenyl alanine ,
1- methyl ester

Molecular Formula $C_{14}H_{18}N_2O_5$

Molar Mass 294 g mol^{-1}

Density 1.347 g / cm^3

Melting Point $246 - 247 \text{ }^\circ\text{C}$

Boiling Point decomposes

Solubility in water sparingly soluble

Solubility slightly soluble in ethanol

Acidity (pK_a) 4.5 - 6.0

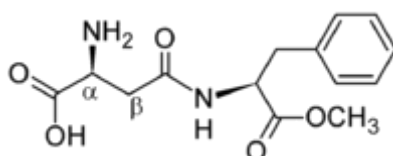
2 - Chemistry :

Aspartame is a methyl ester of the di peptide of the natural amino acids L-aspartic acid and L-phenylalanine. Under strongly acidic or alkaline conditions, aspartame may generate methanol by hydrolysis. Under more severe conditions, the peptide bonds are also hydrolyzed, resulting in the free amino acids.

While known aspects of synthesis are covered by patents, many details are proprietary. Two approaches to synthesis are used commercially. In the chemical synthesis, the two carboxyl groups of aspartic acid are joined into an anhydride, and the amino group is protected by a compound that will prevent further reactions of that group. Phenylalanine is methylated and combined with the *N*-protected aspartic anhydride, then the blocking group is removed from aspartic acid by acid hydrolysis. The drawback of this technique is that a byproduct, the bitter tasting β -form, is produced when the wrong carboxyl group from aspartic acid links to phenyl alanine. A process using an enzyme from *Bacillus thermoproteolyticus* to

catalyze the condensation of the chemically altered amino acids will produce high yields without the β -form byproduct. A variant of this method, which has not been used commercially, uses unmodified aspartic acid, but produces low yields. Methods for directly producing aspartyl – phenyl alanine by enzymatic means, followed by chemical methylation, have also been tried, but not scaled for industrial production.

3 - Properties and use :



Beta-aspartame differs from aspartame based upon which carboxyl group of aspartate binds to the nitrogen of phenyl alanine.

Aspartame, an artificial sweetener, is approximately 200 times sweeter than sucrose, or table sugar. Due to this property, even though aspartame produces four kilocalories of energy per gram when metabolized, the quantity of aspartame needed to produce a sweet taste is so small that its caloric contribution is negligible. The taste of aspartame and other artificial sweeteners differs from that of table sugar in the times of onset and how long the sweetness lasts, though aspartame comes closest to sugar's taste profile among approved artificial sweeteners . The sweetness of aspartame lasts longer than sucrose, so it is often blended with other artificial sweeteners such as acesulfame potassium to produce an overall taste more like sugar. Aspartame can be synthesized from its constituent amino acids, L-phenylalanine and L- aspartate .

Like many other peptides, aspartame may hydrolyze (break down) into its constituent amino acids under conditions of elevated temperature or high pH . This makes aspartame undesirable as a baking sweetener, and prone to degradation in products hosting a high pH, as required for a long shelf life. The stability of aspartame under heating can be improved to some extent by encasing it in fats or in malto dextrin. The stability when dissolved in water depends

markedly on pH. At room temperature, it is most stable at pH 4.3, where its half-life is nearly 300 days. At pH 7, however, its half-life is only a few days. Most soft - drinks have a pH between 3 and 5, where aspartame is reasonably stable. In products that may require a longer shelf life, such as syrups for fountain beverages, aspartame is sometimes blended with a more stable sweetener, such as saccharin.

Aspartame's major decomposition products are its cyclic di peptide (di keto piperazine form) , the de - esterified di peptide (aspartyl- phenyl alanine) , and its constituent components, phenylalanine, aspartic acid , and methanol. At 180°C, aspartame undergoes decomposition to form a di keto piperazine (DKP) derivative.

In products such as powdered beverages, the amine in aspartame can undergo a Maillard reaction with the aldehyde groups present in certain aroma compounds. The ensuing loss of both flavor and sweetness can be prevented by protecting the aldehyde as an acetal.

Descriptive analyses of solutions containing aspartame report a sweet aftertaste as well as bitter and off - flavour aftertastes .

4 - Discovery and approval :

Aspartame was discovered in 1965 by James M. Schlatter, a chemist working for G.D. Searle & Company. Schlatter had synthesized aspartame in the course of producing an antiulcer drug candidate. He accidentally discovered its sweet taste when he licked his finger, which had become contaminated with aspartame, to lift up a piece of paper.

In 1975, prompted by issues regarding Flagyl and Aldactone , a U.S. FDA task force team reviewed 25 studies submitted by the manufacturer, including 11 on aspartame. The team reported “serious deficiencies in Searle’s operations and practices”. The FDA sought to authenticate 15 of the submitted studies against the supporting data. In 1979, the Center for Food Safety and Applied Nutrition (CFSAN) concluded, since many problems with the aspartame studies were

minor and did not affect the conclusions, the studies could be used to assess aspartame's safety.

In 1980, the FDA convened a Public Board of Inquiry (PBOI) consisting of independent advisors charged with examining the purported relationship between aspartame and brain cancer. The PBOI concluded aspartame does not cause brain damage, but it recommended against approving aspartame at that time, citing unanswered questions about cancer in laboratory rats .

Citing data from a Japanese study that had not been available to the members of the PBOI , and after seeking advice from an expert panel that found fault with statistical analyses underlying the PBOI's hesitation, yet argued against approval , FDA commissioner Hayes approved aspartame for use in dry goods . In 1983, the FDA further approved aspartame for use in carbonated beverages, and for use in other beverages, baked goods, and confections in 1993. In 1996, the FDA removed all restrictions from aspartame, allowing it to be used in all foods.

Several European Union countries approved aspartame in the 1980s, with EU-wide approval in 1994. The European Commission Scientific Committee on Food reviewed subsequent safety studies and reaffirmed the approval in 2002. The European Food Safety Authority reported in 2006 that the previously established Acceptable Daily Intake was appropriate, after reviewing yet another set of studies.

5 - Metabolism and phenyl ketonuria :

Upon ingestion, aspartame breaks down into natural residual components, including aspartic acid, phenylalanine, methanol , and further breakdown products including formaldehyde and formic acid, accumulation of the latter being suspected as the major cause of injury in methanol poisoning. Human studies show that formic acid is excreted faster than it is formed after ingestion of aspartate. In some fruit juices, higher concentrations of methanol can be found than the amount produced from aspartame in beverages.

High levels of the naturally-occurring essential amino acid phenylalanine are a health hazard to those born with phenyl ketonuria (PKU), a rare inherited disease that prevents phenylalanine from being properly metabolized. Since individuals with PKU must consider aspartame as an additional source of phenylalanine, foods containing aspartame sold in the United States must state "Phenyl ketonurics : Contains Phenylalanine" on their product labels.

In the UK, foods that contain aspartame are legally required by the country's Food Standards Agency to list the chemical among the product's ingredients and carry the warning "Contains a source of phenylalanine" – this is usually at the foot of the list of ingredients. Manufacturers are also required to print "'with sweetener(s)" on the label close to the main product Name' on foods that contain "sweeteners such as aspartame" or "with sugar and sweetener (s)" on "foods that contain both sugar and sweetener".

In Canada, foods that contain aspartame are legally required by the country to list the chemical among the product's ingredients and include a measure of the amount of aspartame per serving. As well, labels must state that the product contains phenylalanine – this is usually in the order of ingredients, contained in brackets .

6 - Economics :

Equal, NutraSweet, and Canderel are ingredients of approximately 6,000 consumer foods and beverages sold worldwide, including (but not limited to) diet sodas and other soft drinks, instant breakfasts, breath mints, cereals, sugar-free chewing gum, cocoa mixes, frozen desserts, gelatin desserts, juices, laxatives, chewable vitamin supplements, milk drinks, pharmaceutical drugs and supplements, shake mixes, tabletop sweeteners, teas, instant coffees, topping mixes, wine coolers and yogurt. It is provided as a table condiment in some countries. Aspartame is less suitable for baking than other sweeteners, because it breaks down when heated and loses much of its sweetness. Aspartame is also one of the main sugar substitutes used by people with diabetes.

6 – 1 - NutraSweet Company :

In 1984, Monsanto Company bought G.D. Searle, and the aspartame business became a separate Monsanto subsidiary, the NutraSweet Company. On May 25, 2000, Monsanto sold it to J.W. Childs Equity Partners II L.P. European use patents on aspartame expired starting in 1987, and the U.S. patent expired in 1992. Since then, the company has competed for market share with other manufacturers, including Ajinomoto, Merisant and the Holland Sweetener Company.

6 – 2 – Ajinomoto ;

Many aspects of industrial synthesis of aspartame were established by Ajinomoto . In 2004, the market for aspartame, in which Ajinomoto, the world's largest aspartame manufacturer, had a 40 percent share, was 14,000 metric tons a year, and consumption of the product was rising by 2 percent a year . Ajinomoto acquired its aspartame business in 2000 from Monsanto for \$ 67 M .

In 2008, Ajinomoto sued British supermarket chain Asda, part of Wal-Mart, for a malicious falsehood action concerning its aspartame product when the chemical was listed as excluded from the chain's product line, along with other "nasties". In July 2009, a British court found in favour of Asda. In June 2010, an appeals court reversed the decision, allowing Ajinomoto to pursue a case against Asda to protect aspartame's reputation . Asda said that it would continue to use the term "no nasties" on its own-label products,^[37] but the suit was settled in 2011 with ASDA choosing to remove references to aspartame from its packaging .

In November 2009, Ajinomoto announced a new brand Name for its aspartame sweetener — Amino Sweet.

6 – 3 - Holland Sweetener Company :

A joint venture of DSM and Tosoh, the Holland Sweetener Company manufactured aspartame using the enzymatic process developed by Toyo Soda (Tosoh) and sold as the brand Sanecta.

Additionally, they developed a combination aspartame-acesulfame salt was developed under the brand Name Twin sweet. They left the sweetener industry in late 2006, because "global aspartame markets are facing structural oversupply, which has caused world wide strong price erosion over the last five years", making the business "persistently unprofitable".

6 – 4 - Competing products :

Because sucralose, unlike aspartame, retains its sweetness after being heated, and has at least twice the shelf life of aspartame, it has become more popular as an ingredient . This, along with differences in marketing and changing consumer preferences, caused aspartame to lose market share to sucralose . In 2004, aspartame traded at about \$ 30 / kg and sucralose, which is roughly three times sweeter by weight, at around \$ 300 / kg .

7 - Safety controversy :

Aspartame has been the subject of several controversies, hoaxes and health scares since its initial approval by the U.S. Food and Drug Administration (FDA) in 1974. Critics allege that conflicts of interest marred the FDA's approval of aspartame, question the quality of the initial research supporting its safety , and postulate that numerous health risks may be associated with aspartame.

The validity of these claims has been examined and dismissed . In 1987, the U.S. Government Accountability Office concluded the food additive approval process had been followed properly for aspartame . Aspartame has been found to be safe for human consumption by more than ninety countries worldwide , with FDA officials describing aspartame as "one of the most thoroughly tested and studied food additives the agency has ever approved" and its safety as "clear cut". The weight of existing scientific evidence indicates that aspartame is safe at current levels of consumption as a non-nutritive sweetener.

Aspartame Controversy

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1 – Introduction :

The artificial sweetener **aspartame** has been the subject of several **controversies** since its initial approval by the U.S. Food and Drug Administration (FDA) in 1974. The FDA approval of aspartame was highly contested , with critics alleging that the quality of the initial research supporting its safety was inadequate and flawed and that conflicts of interest marred the approval of aspartame . In 1987, the U.S. Government Accountability Office concluded that the food additive approval process had been followed properly for aspartame. In spite of this, critics like anti-aspartame activist Betty Martini have promoted undocumented claims that numerous health risks (such as multiple sclerosis, systemic lupus, methanol toxicity, blindness, spasms, shooting pains, seizures, headaches, depression, anxiety, memory loss, birth defects and death) are associated with the consumption of aspartame in normal doses. These health risk claims have been examined and debunked by numerous scientific research projects, and are also generally dismissed by governments and major health and food safety organizations .

Publicity of this controversy has been spread through an elaborate health scare and "Internet smear campaign" involving hoax e-mails repeating Betty Martini's widely circulated conspiracy theory. Her undocumented claims are still repeated by thousands of self-published Web sites.

Aspartame has been found to be safe for human consumption by more than ninety countries worldwide, with FDA officials describing aspartame as "one of the most thoroughly tested and studied food additives the agency has ever approved" and its safety as "clear cut". The weight of existing scientific evidence indicates that aspartame is safe as a non-nutritive sweetener.

2 - History of approval and controversies over safety :

The controversy over aspartame safety originated in perceived irregularities in the aspartame approval process during the 1970s and early 1980s, including allegations of conflicts of interest and claims that aspartame producer G.D. Searle had withheld and falsified safety data. In 1996, the controversy reached a wider audience with a *60 Minutes* report^[1] that discussed criticisms of the FDA approval process and concerns that aspartame could cause brain tumors in humans. The *60 Minutes* special stated that "aspartame's approval was one of the most contested in FDA history " .

Around the same time, one of many Usenet posts authored by Betty Martini was possibly slightly altered (but still largely identical with originals) and then widely circulated under the pen Name "Nancy Markle", creating the basis for a misleading and unverifiable hoax chain letter that was spread through the Internet.^[9] Numerous websites have spread the email's claims, which were not backed by scientific evidence, about safety issues purportedly linked to aspartame, including Gulf War Syndrome and lupus.

2 – 1 - Government approval ;

Aspartame was originally approved for use in dry foods in 1974 by then FDA Commissioner Alexander Schmidt after review by the FDA's Center for Food Safety and Applied Nutrition. Searle had

submitted 168 studies^{[2]:20} on aspartame, including seven animal studies that were considered crucial by the FDA.^{[2]:21} Soon afterwards, John Olney, a professor of psychiatry and prominent critic of MSG, along with James Turner, a public-interest lawyer and author of an anti-food-additive book, filed a petition for a public hearing, citing safety concerns . Other criticisms (presented in the 1996 *60 Minutes* special) of the Searle studies included assertions of unreported medical treatments that may have affected the study outcomes and discrepancies in the reported data . Schmidt agreed, pending an investigation into alleged improprieties in safety studies for aspartame and several drugs. In December 1975, the FDA placed a stay on the aspartame approval, preventing Searle from marketing aspartame.^{[2]:28} The Searle studies were criticized by the FDA commissioner as "... at best ... sloppy and suffering from "... a pattern of conduct which compromises the scientific integrity of the studies " .

U.S. Attorney Samuel Skinner was requested to "open a grand jury investigation into whether two of Searle's aspartame studies had been falsified or were incomplete". Skinner withdrew from the case when he was considering a job offer from the law firm Sidley & Austin, Searle's Chicago - based law firm, a job he later took. The investigation was delayed and eventually the statute of limitations on the charges against Searle expired^[1] and a grand jury was never convened.

In 1977 and 1978, an FDA task force and a panel of academic pathologists reviewed 15 aspartame studies by Searle, and concluded that, although minor inconsistencies were found, they would not have affected the studies' conclusions. In 1980, a Public Board of Inquiry (PBOI) heard testimony from Olney and disagreed with his claims that aspartame could cause brain damage, including in the developing fetus , The board decided that further study was needed on a postulated connection between aspartame and brain tumors, and revoked approval of aspartame.

In 1981, FDA Commissioner Arthur Hull Hayes sought advice on the issue from a panel of FDA scientists and a lawyer. The panel identified errors underlying the PBOI conclusion that aspartame

might cause brain tumors, and presented arguments both for and against approval. Hayes approved the use of aspartame in dry foods. Hayes further justified his approval with a Japanese brain tumor study, the results of which, the PBOI chairman later said, would have resulted in an "unqualified approval" from the PBOI panel. Several objections followed, but all were denied . In November 1983, a little more than a year after approving aspartame Hayes left the FDA and joined public-relations firm Burson - Marsteller, Searle's public relations agency at the time, as a senior medical adviser.

The actions of Samuel Skinner, in taking a job with a law firm retained by Searle during an investigation into Searle, and Arthur Hull Hayes, in taking a job with Searle's public relations agency following aspartame's approval, fueled conspiracy theories.

Because of the approval controversy, Senator Howard M. Metzenbaum requested an investigation by the U.S. Government Accountability Office (GAO) of aspartame's approval. In 1987, the GAO reported that protocol had been followed and provided a timeline of events in the approval process. At that time, of 67 scientists who responded to a questionnaire, 12 had major concerns about aspartame's safety, 26 were somewhat concerned but generally confident in aspartame safety, and 29 were very confident in aspartame safety.

Food additive safety evaluations by many countries have led to approval of aspartame, citing the general lack of adverse effects following consumption in reasonable quantities. Based on government research reviews and recommendations from advisory bodies such as those listed above, aspartame has been found to be safe for human consumption by more than ninety countries worldwide.

2 – 2 - Alleged conflict of interest prior to 1996 :

In 1976, the FDA notified then-U.S. attorney for Chicago, Sam Skinner, of the ongoing investigation of Searle, and in January 1977, formally requested that a grand jury be convened. In February, 1977, Searle's law firm, Sidley & Austin offered Skinner a job and Skinner recued himself from the case . Mr. Skinner's successor was in place

several months later, and the statute of limitations for the alleged offenses expired in October 1977. Despite complaints and urging from DOJ in Washington, neither the interim U.S. attorney for Chicago, William Conlon, nor Skinner's successor, Thomas Sullivan, convened a grand jury. In December, 1977, Sullivan ordered the case dropped for lack of evidence. Conlon was later hired by Searle's law firm. Concern about conflict of interest in this case inflamed the controversy, and Senator Metzenbaum investigated in 1981 Senate Hearings. In 1989, the U.S. Senate approved the nomination of Sam Skinner to be Secretary of Transportation, noting that both Sullivan and Senator Metzenbaum had concluded that Skinner had not acted improperly.

Ralph G. Walton, a psychologist at Northeastern Ohio Universities College of Medicine, stated in a self-published 1996 analysis of aspartame research that industry-funded studies found no safety concerns while 84 of 92 independent studies did identify safety concerns . This analysis by Walton was submitted to the television show *60 Minutes* and has been extensively discussed on the Internet. An analysis of Walton's claims showed that Walton left out at least 50 peer-reviewed safety studies from his review of the literature and that most of the research he cites as non-industry funded were actually letters to the editors, case reports, review articles or book chapters rather than published studies . In a rebuttal to Walton's statements, the Aspartame Information Service (a service provided by Ajinomoto, a primary producer and supplier of aspartame), reviewed the publications Walton cites as critical of aspartame, arguing that most of them do not involve aspartame or do not draw negative conclusions, are not peer-reviewed, are anecdotal, or are duplicates.

2 – 3 - Internet hoax conspiracy theory :

An elaborate health scare , involving a hoax conspiracy theory disseminated on many Internet websites, attributes a host of deleterious medical effects to aspartame. This theory claims that the FDA approval process of aspartame was tainted and cites as its source an email based upon a supposed talk by a "Nancy Markle" (whose existence has never been confirmed) at a "World

Environmental Conference " . Specifically, the hoax websites allege that aspartame is responsible for multiple sclerosis, systemic lupus, and methanol toxicity, causing "blindness, spasms, shooting pains, seizures, headaches, depression, anxiety, memory loss, birth defects" and death .

The "Markle" email was in large parts identical to many messages posted by Betty Martini to Usenet newsgroups in late 1995 and early 1996 about her claimed talk at a "World Environmental Conference". Although the content was traced back to her, Martini claims that an unknown person combined her original letter with other information and redistributed it as "Nancy Markle". Martini's email has been described as an "Internet smear campaign ... Its contents were entirely false, misleading, and defamatory to various popular products and their manufacturers, with no basis whatever in fact " .

Martini says that there is a conspiracy between the FDA and the producers of aspartame, and her conspiracy theory (repeated by "Markle") has become a canonical example discussed on several Internet conspiracy theory and urban legend websites . Although most of the allegations of this theory contradict the bulk of medical evidence , this misinformation has spread around the world as chain emails since mid-December 1998 , influencing many websites as an urban legend that continues to scare consumers .

The dissemination of the "Nancy Markle" letter was considered so notable that the Media Awareness Network featured one version of it in a tutorial on how to determine the credibility of a web page. The tutorial implied that the "Markle" letter was not credible and stated that it should not be used as an authoritative source of information .

Dean Edell warned very strongly against the "Markle" letter :

Beware The E-Mail Hoax: The Evils Of Nutra sweet (Aspartame)

A highly inaccurate "chain letter" is being circulated via e-mail warning the reader of the health dangers of aspartame

(Nutra sweet) diet drinks. There is so much scientific untruth in it, it's scary. Be careful, because others know how to manipulate you by this. Just because something is beyond your comprehension doesn't mean it is scientific. The e-mail is outrageous enough to state that the Multiple Sclerosis Foundation is suing the FDA for collusion with Monsanto ... Bogus, totally bogus. You've got to be careful of these Internet hoaxes. When you read health information online, be sure to know the source of the information you are reading, okay?

2 – 4 - Government action and voluntary withdrawals :

In 1997, due to public concerns the UK government introduced a new regulation obliging food makers who use sweeteners to state clearly next to the Name of their product the phrase "with sweeteners".

In 2007, the Indonesian government considered banning aspartame . In the Philippines, the small political party Alliance for Rural Concerns introduced House Bill 4747 in 2008 with the aim of having aspartame banned from the food supply . The U.S. state of New Mexico introduced a bill to ban aspartame in 2007 , and Hawaiian legislators signed a 2009 resolution asking the FDA to rescind approval . In March 2009, the California OEHHA identified aspartame as a chemical for consultation by its Carcinogen Identification Committee, in accordance with California state Proposition 65 .

In 2007, the UK supermarket chains Sainsbury's , M&S , and Wal-Mart subsidiary Asda , announced that they would no longer use aspartame in their own label products , In April 2009, Ajinomoto Sweeteners Europe, the makers of Aspartame in Europe, responded to Asda's "no nasties" campaign by filing a complaint of malicious falsehood against Asda in the English courts . In July 2009, Asda initially won the legal case after the trial judge construed the "no nasties" labelling to "not mean that aspartame was potentially harmful or unhealthy". The decision was reversed in June 2010,

upon appeal,^[49] and was settled in 2011 with ASDA removing references to aspartame from its packaging.

In 2009, the South African retailer Woolworths announced it was removing aspartame from its own-brand foods.

In 2010, the British Food Standards Agency launched an investigation into aspartame amid claims that some people experience side - effects after consuming the substance . A significant proportion of volunteers participating in the study are those who have claimed to experience side – effects .

In September 2011 , the European Food Safety Authority (EFSA), which is due to release the findings of its full re - evaluation of aspartame in September 2012 , made all 600 datasets it is using in its full re-evaluation available publicly. This includes previously unpublished scientific data, "including the 112 original studies on aspartame which were submitted to support the request for authorization of aspartame in Europe in the early 1980s " .

3 - Safety and health effects

The safety of aspartame has been studied extensively since its discovery with research that includes animal studies, clinical and epidemiological research, and post - marketing surveillance,^[55] with aspartame being one of the most rigorously tested food ingredients to date . Peer - reviewed comprehensive review articles and independent reviews by governmental regulatory bodies have analyzed the published research on the safety of aspartame and have found aspartame is safe for consumption at current levels . Aspartame has been deemed safe for human consumption by over 100 regulatory agencies in their respective countries , including the UK Food Standards Agency , the European Food Safety Authority (EFSA) and Canada's Health Canada .

3 - 1 - Intake

The acceptable daily intake (ADI) value for aspartame, as well as other food additives studied, is defined as the "amount of a food

additive, expressed on a body weight basis, that can be ingested daily over a lifetime without appreciable health risk ". The Joint FAO / WHO Expert Committee on Food Additives (JECFA) and the European Commission's Scientific Committee on Food has determined this value is 40 mg / kg of body weight for aspartame, while FDA has set its ADI for aspartame at 50 mg / kg.

The primary source for exposure to aspartame in the United States is diet soft drinks, though it can be consumed in other products, such as pharmaceutical preparations, fruit drinks, and chewing gum among others in smaller quantities . A 12 US fluid ounce (355 ml) can of diet soda contains 180 milligrams (0.0063 oz) of aspartame, and for a 75 kg (165 lb) adult, it takes approximately 21 cans of diet soda daily to consume the 3,750 milligrams (0.132 oz) of aspartame that would surpass the FDA's 50 milligrams per kilogram of body weight ADI of aspartame from diet soda alone.

Reviews have analyzed studies which have looked at the consumption of aspartame in countries worldwide, including the United States, countries in Europe and Australia, among others. These reviews have found that the even high levels of intake of aspartame, studied across multiple countries and different methods of measuring aspartame consumption, is well below the ADI for safe consumption of aspartame . Reviews have also found that populations that are believed to be especially high consumers of aspartame such as children and diabetics are below the ADI for safe consumption, even considering very conservative worst-case scenario calculations of consumption .

3 - 2 – Metabolites :

Hypotheses of adverse health effects have focused on the three metabolites of aspartame, which are methanol, phenylalanine and aspartic acid. Aspartame is rapidly hydrolyzed in the small intestines. Even with ingestion of very high doses of aspartame (over 200 mg / kg) , no aspartame is found in the blood due to the rapid breakdown. These metabolites have been studied in a wide range of populations including infants, children, adolescents, and healthy adults. In healthy

adults and children, even enormous doses of aspartame do not lead to plasma levels of metabolites that are a concern for safety. People with the genetic disorder phenyl ketonuria are advised to avoid aspartame as they have a decreased ability to metabolize phenylalanine. Common foods such as milk, meat, and fruits provide far greater amounts of these metabolites in a diet than aspartame.^[57]

The methanol produced by the metabolism of aspartame is absorbed and quickly converted into formaldehyde and then completely converted to formic acid, which, due to its long half life, is considered the primary mechanism of toxicity in methanol poisoning. The methanol from aspartame is unlikely to be a safety concern for several reasons. The amount of methanol in aspartame is less than that found in fruit juices and citrus fruits, and there are other dietary sources for methanol such as fermented beverages. Therefore, the amount of methanol produced from aspartame is likely to be less than that from natural sources. With regards to formaldehyde, it is rapidly converted in the body, and the amounts of formaldehyde from the metabolism of aspartame is trivial when compared to the amounts produced routinely by the human body and from other foods and drugs. At the highest expected human doses of consumption of aspartame, there is no increased blood levels of methanol or formic acid, and ingesting aspartame at the 90th percentile of intake would produce 25 times less methanol than would be considered toxic.

Phenyl alanine is one of the essential amino acids and is required for normal growth and maintenance of life. Concerns about the safety of phenylalanine from aspartame largely centers around hypothetical changes in neurotransmitter levels as well as ratios of neurotransmitters to each other in the blood and brain that could lead to neurological symptoms. Reviews of the literature have found no consistent findings to support such concerns, and while high doses of aspartame consumption may have some biochemical effects, these effects are not seen in toxicity studies to suggest aspartame can adversely affect neuronal function . Like methanol, the typical diet will lead to ingestion of significantly higher amounts of phenylalanine than would be expected from aspartame consumption.

Aspartic acid (aspartate) is one of the most common amino acids in the typical diet but nevertheless has been implicated as a possible source for neurotoxic effects of aspartame. As with methanol and phenylalanine, intake of aspartic acid from aspartame is less than would be expected from other dietary sources. At the 90th percentile of intake, aspartame provides only between 1 % and 2 % of the daily intake of aspartic acid. There has been some speculation that aspartame, in conjunction with other amino acids like glutamate, may lead to excitotoxicity, inflicting damage on brain and nerve cells. However, clinical studies have shown no signs of neurotoxic effects, and studies of metabolism suggests it is not possible to ingest enough aspartic acid and glutamate through food and drink to levels that would be expected to be toxic.

3 - 3 - Cancer

Reviews have found no association between aspartame and cancer. These reviews have looked at numerous carcinogenicity studies in animals, epidemiologic studies in humans, as well as *in vitro* genotoxicity studies. These studies have found no significant evidence that aspartame causes cancer in animals, damages the genome, or causes cancer in humans at doses currently used. This position is supported by multiple regulatory agencies like the FDA^[64] and EFSA as well as scientific bodies such as the National Cancer Institute.

Concern about possible carcinogenic properties of aspartame was originally raised and popularized in the mainstream media by John Olney in 1970s and again in 1996 by suggesting that aspartame may be related to brain tumors. Reviews have found that these concerns were flawed, due to reliance on the ecological fallacy^[65] and the purported mechanism of causing tumors being unlikely to actually cause cancer. Independent agencies such as the FDA and National Cancer Institute have reanalyzed multiple studies based on these worries and found no association between aspartame and brain cancer.

3 - 3 – 1 - Ramazzini studies :

The European Ramazzini Foundation of Oncology and Environmental Sciences (ERF) has released several studies which claim that aspartame can increase several malignancies in rats, concluding that aspartame is a potential carcinogen at normal dietary doses . Although thirteen occupational safety and health experts signed an open letter from CSPI to the FDA expressing that the 2007 ERF study merited a reevaluation of aspartame's safety in humans , these studies have been widely criticized and discounted by the FDA and other food safety agencies :

After reviewing the foundation's claims, the EFSA and the FDA discounted the study results and found no reason to revise their previously established acceptable daily intake levels for aspartame. Reported flaws were numerous and included, but were not limited to, the following: comparing cancer rates of older aspartame - consuming rats to younger control rats; unspecified composition of the "Corticella" diet and method of adding aspartame, leading to possible nutritional deficiencies; unspecified aspartame storage conditions; lack of animal randomization; over crowding and a high incidence of possibly carcinogenic infections; and the U.S. National Toxicology Program's finding that the ERF had misdiagnosed hyperplasias as malignancies.^[8] Reviews by the FDA and EFSA were hampered by the refusal of the Ramazzini Foundation to release all data and pathology slides, but from the materials received, the FDA and EFSA found that the data did not support the researcher's published conclusions. Evaluation of this research by Health Canada and the British government's Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment likewise found methodological problems with the research and did not recommend any further reconsideration of the recommended intake of aspartame in their respective countries. Another carcinogenicity study in rodents published by this foundation in 2010 was evaluated by the EFSA and was found to have multiple significant design flaws and could not be interpreted. The EFSA therefore concluded this study did not provide enough evidence to reconsider previous evaluation of aspartame safety .

A review of the literature concurred with these evaluations, finding many possible flaws in the study's design and conclusions, which are also contradicted by other carcinogenicity studies which found no significant danger. This review therefore concluded this research did not constitute credible evidence for the carcinogenicity of aspartame . Another review criticized the Ramazzini Foundation for relying on 'science by press conference' with its release of results through the media before being published in a proper peer-reviewed journal, thus helping fuel the controversy and publicity about the study in the media .

3 - 4 - Neurological and psychiatric symptoms :

Numerous allegations have been made on the Internet and in consumer magazines purporting neuro toxic effects of aspartame leading to neurological or psychiatric symptoms such as seizures, headaches, and mood changes . Review of the biochemistry of aspartame have found no evidence that the doses consumed would plausibly lead to neuro toxic effects . Comprehensive reviews have not found any evidence for aspartame as a cause for these symptoms . One review did provide a theoretical biochemical background of neurotoxicity and suggested further testing . However, a panel of EFSA experts noted that this review's conclusions were partially based on Internet sources and therefore were not scientifically robust. These experts also concurred with a critique that significant scientific errors were made in the critical review that led to unsubstantiated and misleading interpretations .

3 - 4 – 1 - Headaches :

Headaches are the most common symptom reported by consumers . While one small review noted aspartame is likely one of many dietary triggers of migraines, in a list that includes "cheese, chocolate, citrus fruits, hot dogs, monosodium glutamate, aspartame, fatty foods , ice cream, caffeine withdrawal, and alcoholic drinks, especially red wine and beer" , other reviews have noted conflicting studies about headaches and still more reviews doubt a link . A review of the pediatric literature did not show any significant findings

for safety concerns with regards to neuropsychiatric conditions such as panic attacks, mood changes, hallucinations or with ADHD or seizures.

3 - 4 - Weight change and hunger :

Since the caloric contribution of aspartame is negligible, it has been used as a means for weight loss through its role as a sugar substitute. Although there have been claims that aspartame contributes to weight gain and obesity as well as increases hunger,^[8] comprehensive reviews on this subject have concluded there is little to no data to support the assertion that aspartame adversely affects hunger or obesity .

Barley malt syrup

Barley malt syrup is a sweetener produced from sprouted barley, containing approximately 65 percent maltose, 30 percent complex carbohydrate, 3 % protein. Malt syrup is dark brown, thick and sticky; and possesses a strong distinctive flavor that can only be described as "malty." It is about half as sweet as white sugar. Barley malt syrup is best used in combination with other natural sweeteners.

Birch syrup

1 – Introduction :

Birch syrup is a sweetener made from the sap of birch trees, and used in much the same way as maple syrup. It is used for pancake or waffle syrup, to make candies, as an ingredient in sauces, glazes, and dressings, and as a flavoring in ice cream, beer, wine, and soft drinks. It is condensed from the sap, which has about 0.5 - 2 % percent sugar content, depending on the species of birch, location, weather, and season. The finished syrup is approximately 67 % sugar. Birch sap sugar is about 42–54 % fructose and 45 % glucose, with a small amount of sucrose and trace amounts of galactose . The flavor of birch syrup is distinctive — rich and caramel-like, with a hint of spiciness .

2 - Method :

Making birch syrup is more difficult than making maple syrup, requiring about 80 to 110 liters of sap to produce one liter of syrup (more than twice that needed for maple syrup) . The tapping window for birch is generally shorter than for maple, primarily because birches live in more northerly climates. The trees are typically tapped and their sap collected in the spring (generally mid- to late April, about two to three weeks before the leaves appear on the trees). Birches have a lower trunk and root pressure than maples, so the pipeline or tubing method of sap collection used in large maple sugaring operations is not as useful in birch sap collection.

The sap is reduced in the same way as maple sap, using reverse osmosis machines and evaporators in commercial production. While maple sap may be boiled down without the use of reverse osmosis, birch syrup is difficult to produce this way: the sap is more temperature sensitive than is maple sap because fructose burns at a lower temperature than sucrose, the primary sugar in maple sap. This means that boiling birch sap to produce syrup can much more easily result in a scorched taste.



A birch tree being tapped

2 - Production

Most birch syrup is produced in Russia, Alaska and Yukon from Paper Birch or Alaska Birch sap (*Betula papyrifera* var. *humilis* and *neolaskana*). These trees are found primarily in interior and south central Alaska. The Kenai birch (*Betula papyrifera* var. *kenaica*), which is also used, grows most abundantly on the Kenai peninsula, but is also found in the south central part of the state and hybridizes with *humilis*. The southeast Alaska variety is the Western paper birch, (*Betula papyrifera* var. *commutata*) and has a lower sugar content. One litre of syrup from these trees requires evaporation of approximately 130–150 litres of sap.



Sap dripping from a tapped birch tree

Total production of birch syrup in Alaska is approximately 3,800 liters (1,000 U.S. gallons) per year, with smaller quantities made in other U.S. states and Canada (also from Paper Birch) ,

Russia, Belarus, Ukraine, and Scandinavia (from other species of birch). Because of the higher sap-to-syrup ratio and difficulties in production, birch syrup is more expensive than maple syrup, up to five times the price.

Brazzein

Contents

- 1 Introduction
- 2 Traditional use
- 3 Protein structure
- 4 Sweetness properties
- 5 As a sweetener
- 6 Brazzein controversy

1 – Introduction :

Brazzein is a sweet - tasting protein extracted from the West African fruit of the climbing plant Oubli (*Penta di plandra brazzeana* Baillon) . It was first isolated as an enzyme by University of Wisconsin – Madison in 1994.

Brazzein is found in the extracellular region. The tissue it's found in is the pulp surrounding the seeds.

With pentadin , discovered in 1989, brazzein is the second sweet-tasting protein discovered in this African fruit.

Like the other natural sweet - proteins such as monellin and thaumatin, it is highly sweet.

2 - Traditional use :

The plant grows in Gabon and Cameroon, where the fruit has been consumed by the apes and local people for a long time. The berries of the plant are incredibly sweet. African locals call them "Oubli" (French for "forgot") in their vernacular language because their taste helps nursing infants forget their mother's milk , as once they eat them they forget to come back to the village to see their mother .

3 - Protein structure :

The monomer protein, consisting of 54 amino acid residues, is the smallest of the sweet proteins with a molecular weight of 6.5 kDa. The amino acid sequence of brazzein, adapted from the Swiss-Prot biological database of protein .

The structure of brazzein was determined by proton nuclear magnetic resonance (NMR) at a pH 5.2 and 22 degrees C.. Brazzein has four evenly spaced disulfide bonds and no sulfhydryl groups.

3D analysis of brazzein showed one alpha-helix and three strands of anti-parallel beta sheet. It is not similar to either of the other two sweet-tasting proteins, monellin and thaumatin.

However, a recent 3D study shows that these three proteins possess similar "sweet fingers" believed to elicit the sweet taste.^[9]

Residues 29–33 and 39–43, plus residue 36, as well as the C-terminus were found to be involved in the sweet tasting of the protein. The charge of the protein plays also an important role in its interaction with the sweet taste receptor.

Based on this knowledge a synthesized improved brazzein, called pGlu -1-brazzein, was reported to be twice sweet as the natural counterpart.

4 - Sweetness properties :

On weight basis, brazzein is 500 to 2000 times sweeter than sugar, compared to 10 % sugar and 2 % sugar solution respectively.^[8]

Its sweet perception is more similar to sucrose than that of thaumatin with a clean sweet taste with lingering aftertaste and with a slight delay longer than aspartame in an equi - sweet solution.

Brazzein is stable over a broad pH range from 2.5 to 8^[12] and heat stable at 98°C for 2 hours.

5 - As a sweetener :

Brazzein represents an alternative to available low calorie sweeteners. As a protein it is safe for diabetics and very soluble in water (> 50 mg / mL) .

When blended with other sweeteners, sweeteners such as aspartame and stevia, brazzein reduces side aftertaste and complements their flavor .

Unlike other natural sweeteners, apart from thaumatin, its sweet profile is closer to sucrose. Unlike other sweet-tasting proteins, it can withstand heat which make it suitable for any industrial food manufacture .

Increasing interest of brazzein makes it difficult to source naturally from Gabon, but it can also be synthesized by a solid-phase method , Recombinant proteins were successfully produced via *E. coli* .The Texas companies Prodigene and Nectar Worldwide were among the licensees to use Wisconsin Alumni Research Foundation patents on brazzein, and genetically engineer the enzyme into maize. Brazzein then can be commercially extracted from maize through ordinary milling. Approximately one ton of maize yields 1-2 kilograms of Brazzein. It can also be engineered into plants like wheat to make pre-sweetened grains, e.g. for cereals.

Natur Research Ingredients intends to market brazzein under the *Cweet (1000x)* and *(3000x)* brands by 2009.

6 - Brazzein controversy ;

Despite the fact that the sweet taste of the berries was well known in West Africa, the University claims that the sweet compound (brazzein) is its own invention and admit to no connection with the Gabon . This fact, which involved appropriation of legal rights by means of patents over indigenous biomedical knowledge without compensation to the indigenous groups, is considered an act of Bio piracy by GRAIN and Green Peace.

Brown rice syrup

Brown rice syrup, also known as **rice syrup**, is a sweetener derived by culturing cooked rice with enzymes (usually from dried barley sprouts) to break down the starches, then straining off the liquid and reducing it by cooking until the desired consistency is reached. The final product is 45 % maltose, 3 % glucose, and 52 % malto triose.

Glucose, the most simple of sugars, is used as the reference food in constructing the Glycemic Index, with a glycemic index of 100. It quickly passes through the stomach into the small intestine where it is absorbed into the bloodstream.

Maltose, which has a higher glycemic index of 105, is digested and absorbed as blood glucose even faster.

The more complex Tri saccharide, malto triose , has a glycemic index in the high - 60s about the same as whole, cooked brown rice.

The exact glycemic index for brown rice syrup appears to be unknown, as none of its manufactures have funded the simple blood sugar testing over a 3 hour time frame required to determine it. However, since all three of its components have GIs higher than table sugar, (sucrose) the mix of the three must also have a GI higher than table sugar. Diabetics should manage its consumption accordingly.

Rice syrup has a shelf life of about a year, and once opened, should be stored in a cool, dry place.

Brown rice syrup is produced commercially by cooking brown rice flour or brown rice starch with enzymes. The final carbohydrate mix can be adjusted, depending upon the desired sweetness and application. The syrup is filtered, and excess water is evaporated to thicken it. The product is produced on a commercial scale by several companies in the United States, Europe, and Asia. Brown rice syrup is the sweetener found in some drinks, such as rice milk.

Corn syrup

1 – Introduction ;

Corn syrup is a food syrup, which is made from the starch of maize and contains varying amounts of maltose and higher oligosaccharides, depending on the grade. Corn syrup is used in foods to soften texture, add volume, prevent crystallization of sugar, and enhance flavor. Corn syrup is distinct from high-fructose corn syrup (HFCS), which is created when corn syrup undergoes enzymatic processing, producing a sweeter compound that contains higher levels of fructose.

The more general term glucose syrup is often used synonymously with corn syrup, since glucose syrup is in the US most commonly made from corn starch. Technically, glucose syrup is any liquid starch hydrolysate of mono - , di - , and higher - saccharides and can be made from any source of starch; wheat, tapioca and potatoes are the most common other sources.

2 - Commercial preparation :

Formerly, corn syrup was produced by combining corn starch with dilute hydrochloric acid, and then heating the mixture under pressure. Currently, corn syrup is mainly produced by first adding the enzyme α -amylase to a mixture of corn starch and water. α -amylase is secreted by various species of the bacterium *Bacillus*; the enzyme is isolated from the liquid in which the bacteria are grown. The enzyme breaks the starch into oligosaccharides, which are then broken into glucose molecules by adding the enzyme glucoamylase , known also as " γ -amylase". Glucoamylase is secreted by various species of the fungus *Aspergillus*; the enzyme is isolated from the liquid in which the fungus is grown. The glucose can then be transformed into fructose by passing the glucose through a column that is loaded with the enzyme D - xylose isomerase , an enzyme that is isolated from the growth medium of any of several bacteria.

Corn syrup is produced from number 2 yellow dent corn.^[8] When wet milled, about 2.3 liters of corn are required to yield an average of 947g of starch, to produce 1 kg of glucose or dextrose syrup. A bushel (25 kg) of corn will yield an average 14.3 kg of starch, which in turn will yield about 15.1 kg of syrup. Thus, it takes about 2,300 liters of corn to produce a tone of glucose syrup, or 60 bushels (1524 kg) of corn to produce one short ton.

The viscosity and sweetness of the syrup depends on the extent to which the hydrolysis reaction has been carried out. To distinguish different grades of syrup, they are rated according to their dextrose equivalent (DE).

3 - Uses :

Its major uses in commercially prepared foods are as a thickener, sweetener and humectant (an ingredient that retains moisture and thus maintains a food's freshness).

In the United States, cane sugar quotas raise the price of sugar;^[11] hence, domestically produced corn syrup and high-fructose corn syrup are less expensive alternatives that are often used in American-made processed and Mass - produced foods, candies, soft drinks and fruit drinks to help control cost ,

Glucose syrup was the primary corn sweetener in the United States prior to the expanded use of HFCS production. HFCS is a variant in which other enzymes are used to convert some of the glucose into fructose. The resulting syrup is sweeter and more soluble. Corn syrup is also available as a retail product.

Crystalline fructose

1 – Introduction :

Crystalline fructose is a processed sweetener derived from corn that is almost entirely fructose. It consists of at least 98% pure fructose, any remainder being water and trace minerals. It is used as a sweetener in the likes of beverages and yogurts, where it substitutes for high-fructose corn syrup (HFCS) and table sugar. Crystalline fructose is estimated to be about 20 percent sweeter than table sugar,^[1] and 5% sweeter than HFCS ,

2 - Production :

Crystalline fructose is created from cornstarch, but other starches such as rice and wheat can be used. In this method, corn is first milled to produce cornstarch, then processed to yield corn syrup which is almost entirely glucose. The glucose obtained is reacted with a series of enzymes to convert nearly all the glucose into fructose. The fructose is then allowed to crystallize out, and is finally dried and milled to produce crystalline fructose.

3 - Health effects :

There are studies for and against the health benefits of crystalline fructose.

Crystalline fructose is generally considered safe, but concerns have been raised about health effects, particularly hepato toxicity. As of January 2010, the FDA has not designated crystalline fructose to be generally recognized as safe.

Because crystalline fructose is sweeter than the sugars it replaces, less sugar can be used to produce a desired level of sweetness, resulting in a roughly 5- percent reduction in the amount of calories. Fructose is also an isomer of glucose, carrying the same energetic value when burned.

Any positive health benefit of crystalline fructose consumption is fueled primarily by the fact that fructose does have the same value as glucose when burned. However, fructose is processed by the body differently; fructose's causal relationship to hyperlipidemia, fatty liver disease, cirrhosis, coronary arterial disease and obesity remain a concern for public health analysts.

Curculin

1 – Introduction :

Curculin is a sweet protein that was discovered and isolated in 1990 from the fruit of *Curculigo latifolia* (*Hypoxidaceae*),^[1] a plant from Malaysia. Like miraculin, curculin exhibits taste-modifying activity; however, unlike miraculin, it also exhibits a sweet taste by itself. After consumption of curculin, water and sour solutions taste sweet. The plant is referred to locally as 'Lumbah'.

2 - Protein structure :

The active form of curculin is a hetero dimer consisting of two mono meric units connected through two disulfide bridges. The mature monomers each consist of a sequence of 114 amino acids, weighing 12.5 kDa (curculin 1) and 12.7 kDa (curculin 2), respectively. While each of the two iso forms is capable of forming a homodimer, these do not possess the sweet taste nor the taste-modifying activity of the hetero dimeric form . To avoid confusion, the heterodimeric form is sometimes referred to as "neoculin".

3 - Sweetness properties :

Curculin is considered to be a high - intensity sweetener, with a reported relative sweetness of 430 - 2070 times sweeter than sucrose on a weight basis .

A sweet taste, equivalent to a 6.8 % or 12 % sucrose solution, was observed after holding curculin in the mouth in combination with clear water or acidified water (citric acid), respectively. The sweet taste lasts for 5 minutes with water and 10 minutes with an acidic solution . Sweetness was also observed with other acids such as ascorbic acid (vitamin C) and acetic acid.

The taste-modifying activity of curculin is reduced in the presence of ions with two positive charges (such as Ca^{2+} and Mg^{2+}) in neutral pH solutions, although these ions have no effect in acidic

solutions. In the same way, monovalent ions (such as Na^+ and Cl^-) have no effect in solutions with either neutral or acidic pH .

Although the "sweet-inducing" mechanism is unknown, it is believed that one active site of curculin strongly binds to the taste receptor membranes while a second active site fits into the sweet receptor site. The latter site is thought to be responsible for the induction of sweetness. Presence of Ca^{2+} and/or Mg^{2+} , water and acids tune the binding of the active site of curculin to the receptor site and therefore modify perceived sweetness.

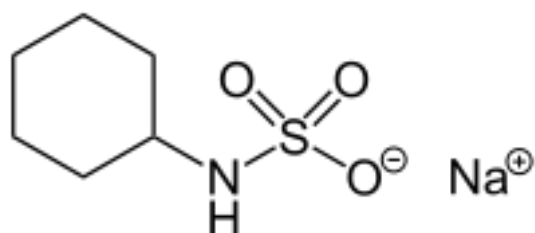
6 - As a sweetener :

Like most proteins, curculin is susceptible to heat. At a temperature of 50 °C the protein starts to degrade and lose its "sweet-tasting" and "taste-modifying" properties, so it is not a good candidate for use in hot or processed foods. However, below this temperature both properties of curculin are unaffected in basic and acidic solutions so it has potential for use in fresh foods and as a table-top sweetener.

Because curculin is not widely found in nature, efforts are underway to produce a recombinant form of the protein. In 1997, curculin was expressed in *E. coli* and yeast, but the recombinant protein did not exhibit "sweet-tasting" or "taste-modifying" activity. However, a 2004 study obtained a recombinant curculin, expressed in *E. coli*, exhibiting "taste-modifying" and "sweet-tasting" properties.

In addition to challenges related to commercial production of the protein, there are many regulatory and legal issues remaining to be resolved before it can be marketed as a sweetener. Curculin currently has no legal status in European Union and United States. However it is approved in Japan as a harmless additive, according to the List of Existing Food Additives established by the Ministry of Health and Welfare (English publication by JETRO).

Cyclamate of Sodium



Contents

- 1 Introduction
- 2 Chemistry
- 3 History
- 4 Status
- 5 Health
- 6 Incidences

1 – Introduction :

Sodium cyclamate (sweetener code 952) is an artificial sweetener. It is 30–50 times sweeter than sugar (depending on concentration; it is not a linear relationship), making it the least potent of the commercially used artificial sweeteners. Some people find it to have an unpleasant aftertaste, but, in general, less so than saccharin or acesulfame potassium. It is often used synergistically with other artificial sweeteners, especially saccharin; the mixture of 10 parts cyclamate to 1 part saccharin is common and masks the off-tastes of both sweeteners. It is less expensive than most sweeteners, including sucralose, and is stable under heating.

IUPAC Name	: Sodium N- cyclo hexyl sulfamate
Molecular Formula	$C_6 H_{12} N Na O_3 S$
Molar Mass	201 g mol^{-1}

2 - Chemistry :

Cyclamate is the sodium or calcium salt of cyclamic acid (cyclo hexane sulfamic acid), which itself is prepared by the sulfonation of

cyclo hexyl amine . This can be accomplished by reacting cyclo hexyl amine with either sulfamic acid or sulfur trioxide.

2 - History :

Cyclamate was discovered in 1937 at the University of Illinois by graduate student Michael Sveda . Sveda was working in the lab on the synthesis of anti-fever medication. He put his cigarette down on the lab bench, and, when he put it back in his mouth, he discovered the sweet taste of cyclamate.

The patent for cyclamate was purchased by DuPont but later sold to Abbott Laboratories, which undertook the necessary studies and submitted a New Drug Application in 1950. Abbott intended to use cyclamate to mask the bitterness of certain drugs such as antibiotics and pentobarbital. In the US in 1958, it was designated GRAS (Generally Recognized as Safe). Cyclamate was marketed in tablet form for use by diabetics as an alternative tabletop sweetener, as well as in a liquid form; one such product was Named 'Sucaryl' and is still available in non-US markets.

Controversy developed when, in 1966, a study reported that some intestinal bacteria could desulfonate cyclamate to produce cyclo hexyl amine, a compound suspected to have some chronic toxicity in animals. Further research resulted in a 1969 study that found the common 10:1 cyclamate : saccharin mixture to increase the incidence of bladder cancer in rats. The released study was showing that eight out of 240 rats fed a mixture of saccharin and cyclamates, at levels of humans ingesting 350 cans of diet soda per day, developed bladder tumors. Other studies implicated cyclo hexyl amine in testicular atrophy in mice . On October 18, 1969, the Food and Drug Administration banned its sale in the United States with citation of the Delaney Amendment after reports that large quantities of cyclamates could cause liver damage, bladder cancer, birth mutations and defects, reduce testosterone or shrivel the testes. In the same month, cyclamate was approved for use in the United Kingdom and is still used in low-calorie drinks; it is still available without restriction in the UK and Europe. As cyclamate is stable in heat, it was and is marketed as

suitable for use in cooking and baking. Commercially, it is available as Sucaryl™. Abbott Laboratories claimed that its own studies were unable to reproduce the 1969 study's results, and, in 1973, Abbott petitioned the FDA to lift the ban on cyclamate. This petition was eventually denied in 1980 by FDA Commissioner Jere Goyan. Abbott Labs, together with the Calorie Control Council (a political lobby representing the diet foods industry), filed a second petition in 1982. Although the FDA has stated that a review of all available evidence does not implicate cyclamate as a carcinogen in mice or rats, cyclamate remains banned from food products in the United States. The petition is now held in abeyance, though not actively considered. It is unclear whether this is at the request of Abbott Labs or because the petition is considered to be insufficient by the FDA.

3 – Status :

Cyclamate is approved as a sweetener in over 55 countries, though it is banned in the United States, Sweeteners produced by Sweet 'N Low and Sugar Twin for Canada contain cyclamate, though not for those deployed in the United States.

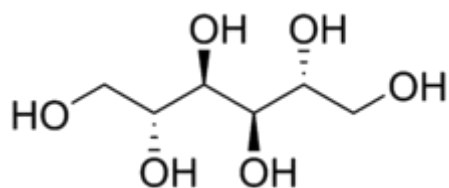
4 – Health :

A 2003 "paper reports the first epidemiological study designed to investigate the possibility of a relationship between cyclamate and cyclo hexyl amine and male fertility in humans." It states that "the results demonstrate no effect of cyclamate or cyclo hexyl amine on male fertility at the present levels of cyclamate consumption."^[8]

5 – Incidences :

In Taipei, Taiwan, a city health survey in 2010 found nearly 30 % of tested dried fruit products failed a health standards test, most having excessive amounts of cyclamate, some at levels 20 times higher than the legal limit. In the Philippines, Magic Sugar, a brand of cyclamate, has been banned. It was placed in coconut juices by local street-side vendors.

D - Mannitol



Contents

- 1 Introduction
- 2 Chemistry
 - 2.1 Similarity to sorbitol
- 3 Obtaining mannitol
 - 3.1 Industrial synthesis
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- 4 Uses
 - 4.1 Medical applications
 - 4.2 In foods
 - 4.3 In analytical chemistry
 - 4.4 In illicit drugs
- 5 Controversy

1 – Introduction :

Mannitol is a white, crystalline organic compound with the Formula (C₆H₈(OH)₆). This polyol is used as an osmotic diuretic agent and a weak renal vasodilator. It was originally isolated from the secretions of the flowering ash, called manna after their resemblance to the Biblical food, and is also referred to as **mannite** and **manna sugar**. In plants, it is used to induce osmotic stress.

Systematic (IUPAC) Name :

(2*R*,3*R*,4*R*,5*R*)-Hexan-1,2,3,4,5,6-hexol

Formula C₆H₁₄O₆

Mol. Mass 182

2 - Chemistry :

Mannitol is a sugar alcohol; that is, it is derived from a sugar by reduction, with a molecular weight of 182.17 g/mol, and a density of 1.52 g / mL . Other sugar alcohols include xylitol and sorbitol. Mannitol and sorbitol are isomers, the only difference being the orientation of the hydroxyl group on carbon 2. Aqueous solutions of mannitol are mildly acidic and sometimes such solutions are treated to lower the pH . D-Mannitol has a solubility of 22g mannitol / 100mL water (25 °C) , and a relative sweetness of 50 (sucrose=100). It melts between 165 and 169 °C , and boils at 295 °C , indicating a greater boiling Point at STP conditions.

2 – 1 - Similarity to sorbitol :

Mannitol and sorbitol are isomers. Both are (C₆H₈(OH)₆). The difference is the second carbon atom in the chain is chiral like, leading to physically different molecules.

3 - Obtaining mannitol :

3 – 1 - Industrial synthesis :

Mannitol is commonly formed via the hydrogenation of fructose, which is formed from either starch or sugar. Although starch is cheaper than sucrose, the transformation of starch is much more complicated. Eventually, it yields a syrup containing about 42 % fructose, 52 % dextrose, and 6 % maltose. Sucrose is simply hydrolyzed into an invert sugar syrup, which contains about 50 % fructose. In both cases, the syrups are chromatographically purified to contain 90 - 95 % fructose. The fructose is then hydrogenated over a nickel catalyst into mixture of isomers sorbitol and mannitol. Yield is typically 50 % : 50 % , although slightly alkaline reaction conditions can slightly increase mannitol yields .

3 – 2 - Biological syntheses :

Mannitol is one of the most abundant energy and carbon storage molecules in nature, produced by a plethora of organisms, including

bacteria, yeasts, fungi, algae, lichens, and many plants.^[6] Fermentation by microorganisms is a possible alternative to traditional industrial synthesis, producing much higher yields of mannitol, with minimal to no side products. A fructose to mannitol metabolic pathway, known as the mannitol cycle in fungi, has been discovered in a type of red algae (*Caloglossa leprieurii*), and it is highly possible that other microorganisms employ similar such pathways. A class of lactic acid bacteria, labeled hetero fermentive because of their multiple fermentation pathways, convert either 3 fructose molecules or 2 fructose and 1 glucose molecule into 2 mannitol molecules, and one molecule each of lactic acid, acetic acid, and carbon dioxide. Feedstock syrups containing medium to large concentrations of fructose (for example, cashew apple juice, containing 55 % fructose: 45 % glucose) can produce yields 200g mannitol / liter feedstock. Further research is being conducted, studying ways to engineer even more efficient mannitol pathways in lactic acid bacteria, and also studying the use of other microorganism, such as yeast and E. coli bacteria in mannitol productions. When food grade strains of any of the aforementioned microorganisms are used, the mannitol and the organism itself are directly applicable to food products, avoiding the need for careful separation of microorganism and mannitol crystals. Although this is a promising method, steps are needed to scale it up to industrially needed quantities.

3 – 3 - Natural product extraction :

As stated above, mannitol is found in a wide variety of natural products, including almost all plants. This allows for direct extraction from natural products, rather than chemical or biological syntheses. In fact, in China, isolation from seaweeds is the most common form of mannitol production. Mannitol concentrations of plant exudates can range from 20 % in seaweeds to 90 % in the plane tree. Traditionally, mannitol is extracted by the Soxhlet extraction, utilizing ethanol, water, and methanol to steam and then hydrolyze the crude material. The mannitol is then recrystallized from the extract, generally resulting in yields of about 18 % of the original natural product. Another up and coming method of extraction is by using supercritical and subcritical fluids. These fluids are at such a stage that there is no

difference between the liquid and gas stages, and are therefore more diffusive than normal fluids. This is considered to make them much more effective Mass transfer agents than normal liquids. The super/sub critical fluid is pumped through the natural product, and the mostly mannitol product is easily separated from the solvent and minute amount of byproduct. Supercritical carbon dioxide extraction of olive leaves has been shown to require less solvent per grams of leaf than a traditional extraction (141.7 g CO₂ vs. 194.4 g ethanol/ 1 g olive leaf). Heated, pressurized, subcritical water is even cheaper, and is shown to have dramatically greater results than traditional extraction. It requires only 4.01 g water / 1 g olive leaf , and gives a yield of 76.75% mannitol. Both super- and sub-critical extractions are cheaper, faster, purer, and more environmentally friendly than the traditional extraction. However, the high required operating temperatures and pressures are cause for hesitancy in the industrial use of this technique.

4 - Uses :

4 – 1 - Medical applications :

Mannitol is used clinically in osmotherapy to reduce acutely raised intracranial pressure until more definitive treatment can be applied, e.g., after head trauma. It is also used to treat patients with oliguric renal failure. It is administered intravenously, and is filtered by the glomeruli of the kidney, but is incapable of being resorbed from the renal tubule, resulting in decreased water and Na⁺ reabsorption via its osmotic effect. Consequently, mannitol increases water and Na⁺ excretion, thereby decreasing extracellular fluid volume.

Mannitol can also be used as a facilitating agent for the transportation of pharmaceuticals directly into the brain. The arteries of the blood - brain barrier are much more selective than normal arteries. Normally, molecules can diffuse into tissues through gaps between the endothelial cells of the blood vessels. However, what enters the brain must be much more rigorously controlled. The endothelial cells of the blood - brain barrier are connected by tight

junctions, and simple diffusion through them is impossible. Rather, active transport is necessary, requiring energy, and only transporting molecules that the arterial endothelial cells have receptor signals for. Mannitol is capable of opening this barrier by temporarily shrinking the endothelial cells, simultaneously stretching the tight junctions between them. An intracarotid injection of high molarity mannitol (1.4-1.6M), causes the contents of the artery to be hyper osmotic to the cell. Water leaves the cell and enters the artery in order to recreate an osmotic equilibrium. This loss of water causes the cells to shrivel and shrink, stretching the tight junctions between the cells.^[9] The newly formed gap reaches its peak width five minutes after mannitol injection, and stays widely open for thirty minutes. During this timespan, drugs injected into the artery can easily diffuse through the gaps between cells directly into the brain. This makes mannitol indispensable for delivering various drugs directly to the brain (e.g., in the treatment of Alzheimer's disease, or in chemotherapy for brain tumors).

Mannitol is commonly used in the circuit prime of a heart lung machine during cardiopulmonary bypass. The presence of mannitol preserves renal function during the times of low blood flow and pressure, while the patient is on bypass. The solution prevents the swelling of endothelial cells in the kidney, which may have otherwise reduced blood flow to this area and resulted in cell damage.

Mannitol is also the basis of Bronchitol which was developed by the Australian pharmaceutical company Pharmaxis as a treatment for cystic fibrosis and bronchiectasis. The mannitol is orally inhaled as a dry powder through what is known as an osmohaler and osmotically draws water into the lungs to thin the thick, sticky mucus characteristic of cystic fibrosis. This is intended to make it easier for the sufferer to cough the mucus up during physiotherapy. The critical characteristic of the mannitol is its particle size distribution. Pharmaxis has also developed Aridol - a diagnostic test for airway hyper responsiveness based on mannitol.

Mannitol is also the first drug of choice for the treatment of acute glaucoma in veterinary medicine. It is administered as a 20 %

solution IV. It dehydrates the vitreous humor and, thus, lowers the intraocular pressure. However, it requires an intact blood-ocular barrier to work. Mannitol can also be used to temporarily encapsulate a sharp object (such as a helix on a lead for an artificial pacemaker) while it is passed through the venous system. Because the mannitol dissolves readily in blood, the sharp Point will become exposed at its destination . Mannitol may be administered in cases of severe Ciguatera poisoning. Severe ciguatoxin, or "tropical fish poisoning" can produce stroke-like symptoms . Mannitol is the primary ingredient of Mannitol Salt Agar, a bacterial growth medium, and is used in others . In oral doses larger than 20 g, mannitol acts as an osmotic laxative, and is sometimes sold as a laxative for children .

4 – 2 - In foods :

Mannitol does not stimulate an increase in blood glucose, and is therefore used as a sweetener for people with diabetes, and in chewing gums. It also has a low glycemic index, making it a low carb food. Although mannitol has a higher heat of solution than most sugar alcohols, its comparatively low solubility reduces the cooling effect usually found in mint candies and gums. However, when mannitol is completely dissolved in a product, it induces a strong cooling effect.^[5] Also, it has a very low hygroscopicity - it does not pick up water from the air until the humidity level is 98 %. This makes mannitol very useful as a coating for hard candies, dried fruits, and chewing gums, and it is often included as an ingredient in candies and chewing gum.^[13] The pleasant taste and mouth feel of mannitol also makes it a popular excipient for chewable tablets.

4 – 3 - In analytical chemistry :

Mannitol can be used to form a complex with boric acid. This increases the acid strength of the boric acid permitting better precision in volumetric analysis of this acid.

4 – 4 - In illicit drugs :

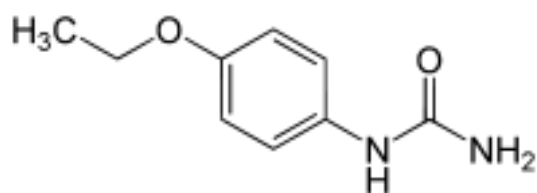
Mannitol is sometimes used as an adulterant or cutting agent for heroin, methamphetamines, cocaine, or other illicit drugs. In popular

culture, when it is used in this manner, it is often referred to as *baby laxative*.

5 – Controversy :

The three studies that initially found that high - dose mannitol was effective in cases of severe head injury have been the subject of a recent investigation . Although several authors are listed with Dr. Julio Cruz, it is unclear whether the authors had knowledge of how the patients were recruited. Further, the Federal University of São Paulo, which Dr. Cruz gave as his affiliation, has never employed him. Currently, therefore, the Cochrane review recommending high-dose mannitol has been withdrawn pending re-evaluation, as there is some evidence that mannitol may worsen cerebral edema .

Dulcin



Dulcin is an artificial sweetener about 250 times sweeter than sugar discovered in 1884 by Joseph Berlinerbau . It was first Mass-produced about seven years later. Despite the fact that it was discovered only five years after saccharin, it never enjoyed the latter compound's market success. Still, it was an important sweetener of the early 20th century and had an advantage over saccharin in that it did not possess a bitter aftertaste.

Early medical tests marked the substance as safe for human consumption, and it was considered ideal for diabetics. However, an FDA study in 1951 raised many questions about its safety resulting in its removal from the market in 1954 after animal testing revealed unspecified carcinogenic properties.

Dulcin is also known by the Names **sucrol** and **valzin**.

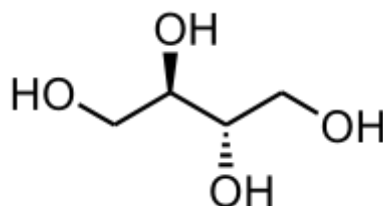
IUPAC Name : (4-Ethoxyphenyl)urea

Other Names : Sucrol ; Valzin

Molecular Formula $C_9 H_{12} N_2 O_2$

Molar Mass 180 g / mol

Erythritol



Contents

- 1 Introduction
- 2 Erythritol and human digestion
- 3 Side effects
- 4 Physical properties
 - 4.1 Heat of solution
 - 4.2 Blending for sugar-like properties
- 5 Erythritol and bacteria

1 – Introduction :

Erythritol ((2*R*,3*S*)-butane-1,2,3,4-tetraol) is a sugar alcohol (or polyol) that has been approved for use as a food additive in the United States and throughout much of the world. It was discovered in 1848 by British chemist John Stenhouse. It occurs naturally in some fruits and fermented foods. At the industrial level, it is produced from glucose by fermentation with a yeast, *Moniliella pollinis*.^[1] It is 60–70% as sweet as table sugar yet it is almost non-caloric, does not affect blood sugar, does not cause tooth decay, and is partially absorbed by the body, excreted in urine and feces. It is less likely to cause gastric side-effects than other sugar alcohols, although a 50g dose caused a significant increase in the number of test subjects reporting nausea and borborygmi. Under U.S. Food and Drug Administration (FDA) labeling requirements, it has a caloric value of 0.2 kilo calories per gram (95 % less than sugar and other carbohydrates), though nutritional labeling varies from country to country. Some countries like Japan and the United States label it as zero - calorie, while European Union regulations currently label it and all other sugar alcohols at 2.4 kcal / g.

IUPAC Name :	(2 <i>R</i> ,3 <i>S</i>)-butane-1,2,3,4- tetraol
Molecular Formula	C ₄ H ₁₀ O ₄
Molar Mass	122 g mol ⁻¹
Density	1.45 g / cm ³
Melting Point	121 °C
Boiling Point	329 - 331 °C

2 - Erythritol and human digestion :

In the body, most of the erythritol is absorbed into the bloodstream in the small intestine, and then for the most part excreted unchanged in the urine. About 10 % enters the colon.^[5] Because 90% of erythritol is absorbed before it enters the large intestine, it does not normally cause laxative effects, as are often experienced after consumption of other sugar alcohols (such as xylitol and maltitol) .

3 - Side effects ;

Doses over 50g can cause a significant increase in nausea and borborygmi , and (rarely) erythritol can cause allergic urticaria.

In general, erythritol is free of side-effects in regular use. Erythritol, when compared with other sugar alcohols, is also much more difficult for intestinal bacteria to digest, so it is less likely to cause gas or bloating than other polyols,^[8] such as maltitol, sorbitol, or lactitol.

4 - Physical properties :

4 – 1 - Heat of solution :

Erythritol has a strong cooling effect (endothermic, or positive heat of solution) when it dissolves in water, which is often combined with the cooling effect of mint flavors but proves distracting with more subtle flavors and textures. The cooling effect is only present when erythritol is not already dissolved in water, a situation that might be experienced in an erythritol - sweetened frosting, chocolate bar, chewing gum, or hard candy. When combined with solid fats,

such as coconut oil, cocoa butter, or cow's butter, the cooling effect tends to accentuate the waxy characteristics of the fat in a generally undesirable manner, This is particularly pronounced in chocolate bars made with erythritol . The cooling effect of erythritol is very similar to that of xylitol and among the strongest cooling effects of all sugar alcohols.

4 – 2 - Blending for sugar - like properties :

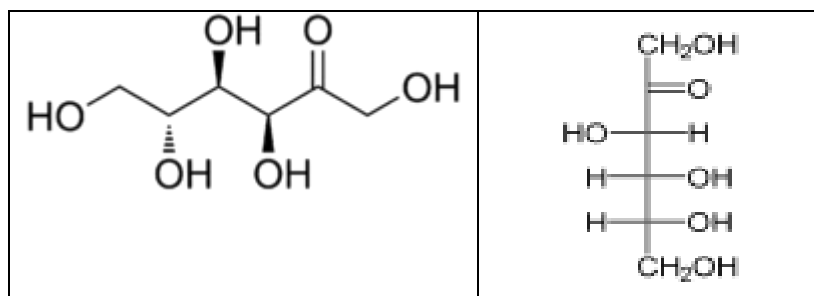
Erythritol is commonly used as a medium in which to deliver high - intensity sweeteners, especially stevia derivatives, serving the dual function of providing both bulk and a flavor similar to that of table sugar. Diet beverages made with this blend, thus, contain erythritol in addition to the main sweetener. Beyond high-intensity sweeteners, erythritol is often paired with other bulky ingredients that exhibit sugar-like characteristics to better mimic the texture and mouthfeel of sucrose. The cooling effect of erythritol is rarely desired, hence other ingredients are chosen to dilute or negate that effect. Erythritol also has a propensity to crystallize and is not as soluble as sucrose, so ingredients may also be chosen to help negate this disadvantage. Furthermore, erythritol is non - hygroscopic, meaning it does not attract moisture, which can lead to the drying out of products, in particular baked goods, if another hygroscopic ingredient is not used in the Formulation.

Inulin is oftentimes combined with erythritol due to inulin's offering a complementary negative heat of solution (exothermic, or warming effect when dissolved, which helps cancel erythritol's cooling effect) and non-crystallizing properties. However, inulin has a propensity to cause gas and bloating in those having consumed it in moderate to large quantities, in particular in individuals unaccustomed to it. Other sugar alcohols are sometimes used with erythritol, in particular isomalt due to its minimally positive heat of solution, and glycerin, which has a negative heat of solution, moderate hygroscopicity , and non - crystallizing liquid form.

5 – Erythritol and bacteria :

Erythritol has been certified as tooth-friendly.^[11] The sugar alcohol cannot be metabolized by oral bacteria, and so does not contribute to tooth decay. It is interesting to note that erythritol exhibits some, but not all, of xylitol 's tendency to "starve" harmful bacteria. Unlike xylitol, erythritol is actually absorbed into the bloodstream after consumption but before excretion . However, it is not clear at present if the effect of starving harmful bacteria occurs systemically.

Fructose



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1 – Introduction :

Fructose, or fruit sugar, is a simple mono saccharide found in many plants. It is one of the three dietary mono saccharides, along with glucose and galactose, that are absorbed directly into the bloodstream during digestion. Fructose was discovered by French chemist Augustin - Pierre Dubrunfaut in 1847. Pure, dry fructose is a very sweet, white, odorless, crystalline solid and is the most water-soluble of all the sugars . From plant sources, fructose is found in honey, tree and vine fruits, flowers, berries and most root vegetables. In plants, fructose may be present as the monosaccharide and/or as a component of sucrose. Sucrose is a disaccharide with a molecule of glucose and a molecule of fructose bonded together with a glycosidic linkage. Most modern fruits and vegetables have been bred to have much higher sugar content than the wild plants they are descended from.

Commercially, fructose is usually derived from sugar cane, sugar beets and corn and there are 3 commercially important forms. Crystalline fructose is the monosaccharide, dried and ground, and of high purity. High - fructose corn syrup (HFCS) is a mixture of glucose and fructose as mono saccharides. Sucrose is the third form. All forms of fructose, including fruits and juices, are commonly added to foods and drinks for palatability, taste enhancement and improved browning of some foods, such as baked goods . About 240,000 tons of crystalline fructose are produced annually.

IUPAC Name : Fructose

Other Names : fruit sugar, levulose ,
D - fructo furanose , D - fructose ,
D - arabino - hexulose

Molecular Formula	$C_6H_{12}O_6$
Molar Mass	180 g / mol
Density	1.694 g / cm ³
Melting Point	103 °C

2 - Chemical properties :

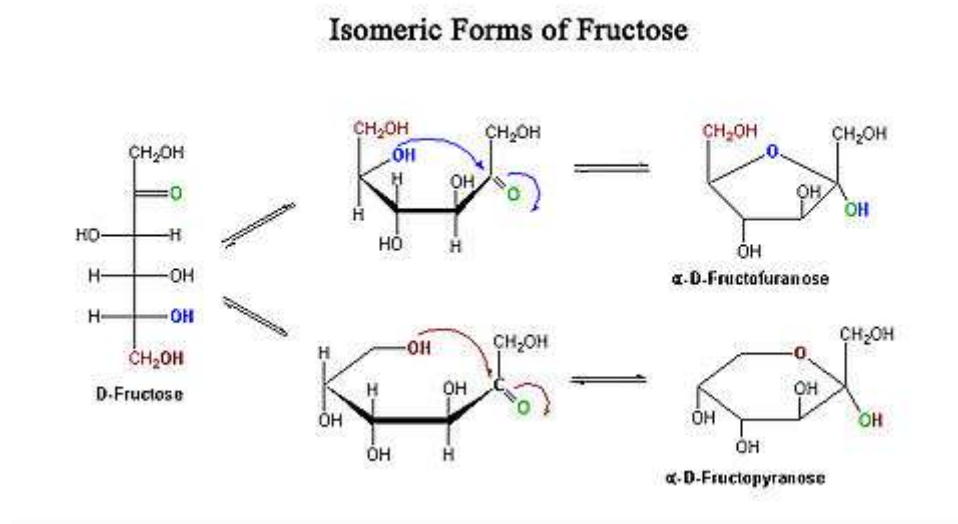
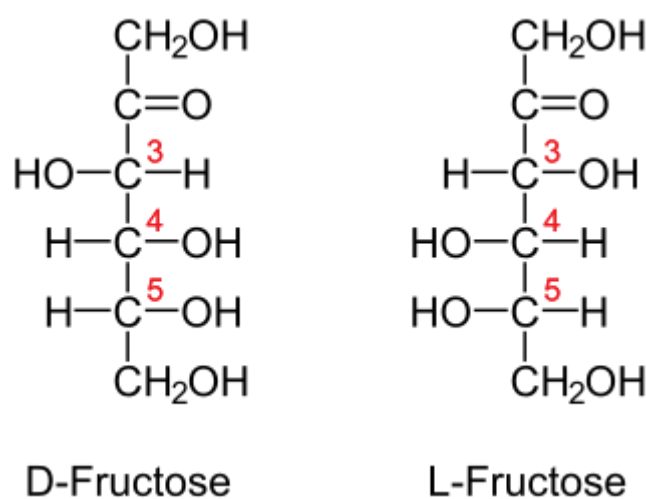


Figure 1: Relationship between the acyclic and the cyclic (hemiketal) isomers of fructose.



D- and L-isomers of fructose (open-chain form)

Fructose is a 6 - carbon poly hydroxy ketone. It is an isomer of glucose, i.e. both have the same molecular Formula ($C_6H_{12}O_6$) but

they differ structurally. Crystalline fructose adopts a cyclic six-membered structure owing to the stability of its hemiketal and internal hydrogen-bonding. This form is formally called D-fructo pyranose. In solution, fructose exists as an equilibrium mixture of 70% fructo pyranose and about 22 % fructo furanose, as well as small amounts of three other forms, including the acyclic structure.

2 – 1 – Reactions :

2 – 1 – 1 - Fructose and fermentation :

Fructose may be anaerobically fermented by yeast or bacteria. Yeast enzymes convert sugar (glucose, or fructose) to ethanol and carbon dioxide. The carbon dioxide released during fermentation will remain dissolved in water where it will reach equilibrium with carbonic acid unless the fermentation chamber is left open to the air. The dissolved carbon dioxide and carbonic acid produce the carbonation in bottle fermented beverages.

2 – 1 – 2 - Fructose and Maillard reaction :

Fructose undergoes the Maillard reaction, non-enzymatic browning, with amino acids. Because fructose exists to a greater extent in the open-chain form than does glucose, the initial stages of the Maillard reaction occurs more rapidly than with glucose. Therefore, fructose potentially may contribute to changes in food palatability, as well as other nutritional effects, such as excessive browning, volume and tenderness reduction during cake preparation, and formation of mutagenic compounds.

2 – 1 – 3 – Dehydration :

Fructose readily dehydrates to give hydroxymethylfurfural ("HMF"). This process may in the future be part of a low-cost, carbon-neutral system to produce replacements for petrol and diesel from plantations.

3 - Physical and functional properties :

3 – 1 - Relative sweetness :

The primary reason that fructose is used commercially in foods and beverages, besides its low cost, is its high relative sweetness. It is the sweetest of all naturally occurring carbohydrates. Fructose is generally regarded as being 1.73 times as sweet as sucrose.^{[11][12]} However, it is the 5-ring form of fructose that is sweeter; the 6-ring form tastes about the same as usual table sugar. Warming fructose leads to formation of the 6-ring form.^[13]

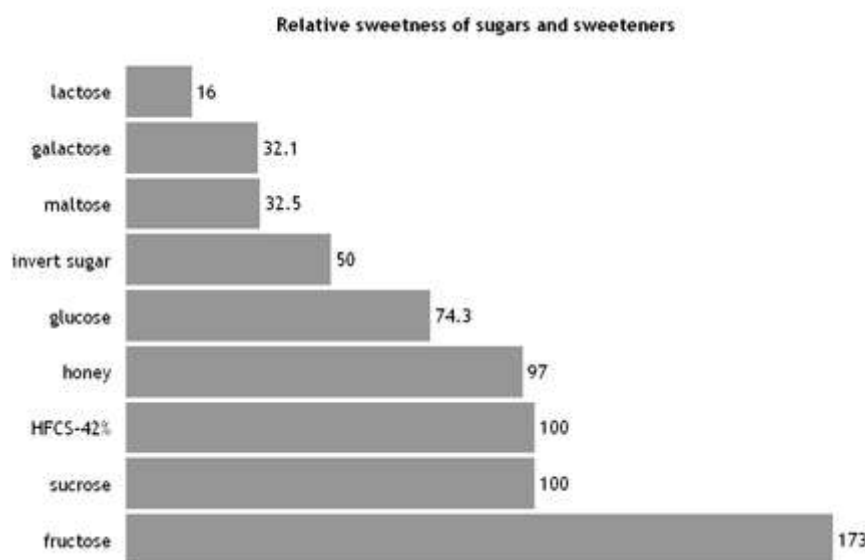


Figure 2: *Relative sweetness of sugars and sweeteners.*

The sweetness of fructose is perceived earlier than that of sucrose or dextrose, and the taste sensation reaches a peak (higher than sucrose) and diminishes more quickly than sucrose. Fructose can also enhance other flavors in the system.

3 – 1 – 1 - Sweetness synergy :

Fructose exhibits a sweetness synergy effect when used in combination with other sweeteners. The relative sweetness of fructose blended with sucrose, aspartame, or saccharin is perceived to be greater than the sweetness calculated from individual components.^[14]

3 – 1 – 2 - Fructose solubility and crystallization :

Fructose has higher solubility than other sugars as well as other sugar alcohols. Fructose is therefore difficult to crystallize from an

aqueous solution.^[11] Sugar mixes containing fructose, such as candies, are softer than those containing other sugars because of the greater solubility of fructose.^[15]

3 – 1 – 3 - Fructose hygroscopicity and humectancy :

Fructose is quicker to absorb moisture and slower to release it to the environment than sucrose, dextrose, or other nutritive sweeteners.^[14] Fructose is an excellent humectant and retains moisture for a long period of time even at low relative humidity (RH). Therefore, fructose can contribute to improved quality, better texture, and longer shelf life to the food products in which it is used.^[11]

3 – 1 – 4 - Freezing Point :

Fructose has a greater effect on freezing Point depression than disaccharides or oligosaccharides, which may protect the integrity of cell walls of fruit by reducing ice crystal formation. However, this characteristic may be undesirable in soft-serve or hard-frozen dairy desserts.

3 – 1 – 5 - Fructose and starch functionality in food systems :

Fructose increases starch viscosity more rapidly and achieves a higher final viscosity than sucrose because fructose lowers the temperature required during gelatinizing of starch, causing a greater final viscosity.

Many artificial sweeteners are not suitable for home-baking, but, with a little adjustment, many traditional recipes can be prepared using fructose .

4 - Food sources :

Natural sources of fructose include fruits, vegetables (including sugar cane), and honey. Fructose is often further concentrated from these sources. The highest dietary sources of fructose, besides pure crystalline fructose, are foods containing table sugar (sucrose), high-fructose corn syrup, agave nectar, honey, molasses, maple syrup, and fruit juices, as these have the highest percentages of fructose

(including fructose in sucrose) per serving compared to other common foods and ingredients. Fructose exists in foods either as a free mono saccharide, or bound to glucose as sucrose, a disaccharide. Fructose, glucose, and sucrose may all be present in a food; however, different foods will have varying levels of each of these three sugars.

The sugar contents of common fruits and vegetables are presented in Table 1. In general, in foods that contain free fructose, the ratio of fructose to glucose is approximately 1:1; that is, foods with fructose usually contain about an equal amount of free glucose. A value that is above 1 indicates a higher proportion of fructose to glucose, and below 1, a lower proportion. Some fruits have larger proportions of fructose to glucose compared to others. For example, apples and pears contain more than twice as much free fructose as glucose, while for apricots the proportion is less than half as much fructose as glucose.

Apple and pear juices are of particular interest to pediatricians because the high concentrations of free fructose in these juices can cause diarrhea in children. The cells (enterocytes) that line children's small intestines have less affinity for fructose absorption than for glucose and sucrose . Unabsorbed fructose creates higher osmolarity in the small intestine, which draws water into the gastrointestinal tract, resulting in osmotic diarrhea. This phenomenon is discussed in greater detail in the Health Effects section.

Table 1 also shows the amount of sucrose found in common fruits and vegetables. Sugarcane and sugar beet have a high concentration of sucrose, and are used for commercial preparation of pure sucrose. Extracted cane or beet juice is clarified, removing impurities; and concentrated by removing excess water. The end product is 99.9 % pure sucrose. Sucrose-containing sugars include common table white granulated sugar and powdered sugar, as well as brown sugar.

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

Food Item	Total Carbohydrate	Total Sugars	Free Fructose	Free Glucose	Sucrose	Fructose/ Glucose Ratio	Sucrose as a % of Total Sugars
<i>Fruits</i>							
Apple	13.8	10.4	5.9	2.4	2.1	2.0	19.9
Apricot	11.1	9.2	0.9	2.4	5.9	0.7	63.5
Banana	22.8	12.2	4.9	5.0	2.4	1.0	20.0
Fig, dried	63.9	47.9	22.9	24.8	0.07	0.93	0.001
Grapes	18.1	15.5	8.1	7.2	0.2	1.1	1.0
Peach	9.5	8.4	1.5	2.0	4.8	0.9	56.7
Pear	15.5	9.8	6.2	2.8	0.8	2.1	8.0
Pineapple	13.1	9.9	2.1	1.7	6.0	1.1	60.8
Plum	11.4	9.9	3.1	5.1	1.6	0.66	0.16
<i>Vegetables</i>							
Beet, Red	9.6	6.8	0.1	0.1	6.5	1.0	96.2
Carrot	9.6	4.7	0.6	0.6	3.6	1.0	70.0
Corn, Sweet	19.0	3.2	0.5	0.5	2.1	1.0	64.0
Red Pepper, Sweet	6.0	4.2	2.3	1.9	0.0	1.2	0.0
Onion, Sweet	7.6	5.0	2.0	2.3	0.7	0.9	14.3
Sweet Potato	20.1	4.2	0.7	1.0	2.5	0.9	60.3
Yam	27.9	0.5	tr	tr	tr	na	tr
Sugar Cane		13 - 18	0.2 – 1.0	0.2 – 1.0	11 - 16	1.0	100
Sugar Beet		17 - 18	0.1 – 0.5	0.1 – 0.5	16 - 17	1.0	100

Data obtained at [2]. All data with a unit of g (gram) are based on 100 g of a food item. The fructose / glucose ratio is calculated by dividing the sum of free fructose plus half sucrose by the sum of free glucose plus half sucrose.

Fructose is also found in the synthetically manufactured sweetener, high-fructose corn syrup (HFCS). Hydrolyzed corn starch is used as the raw material for production of HFCS. Through the enzymatic treatment, glucose molecules are converted into fructose. There are three types of HFCS, each with a different proportion of fructose: HFCS-42, HFCS-55, and HFCS-90. The number for each HFCS corresponds to the percentage of synthesized fructose present in the syrup. HFCS-90 has the highest concentration of fructose, and is typically used to manufacture HFCS-55; HFCS-55 is used as sweetener in soft drinks, while HFCS-42 is used in many processed foods and baked goods.

4 – 1 - Carbohydrate content of commercial sweeteners :

Sugar	Fructose	Glucose	Sucrose (Fructose –Glucose)	Other Sugars
Granulated Sugar	0	0	100	0
Brown Sugar	1	1	97	1
HFCS-42	42	53	0	5
HFCS-55	55	41	0	4
HFCS-90	90	5	0	5
Honey	50	44	1	5
Maple Syrup	1	4	95	0
Molasses	23	21	53	3
Corn Syrup	0	35	0	0

Data obtained from Kretchmer, N. & Hollenbeck, CB (1991). Sugars and Sweeteners, Boca Raton, FL: CRC Press, Inc.^[20] for HFCS, and USDA for fruits and vegetables and the other refined sugars.

Cane and beet sugars have been used as the major sweetener in food manufacturing for centuries. However, with the development of HFCS, a significant shift occurred in the type of sweetener consumption. As seen in Figure 3, this change happened in the 1970s. Contrary to the popular belief, however, with the increase of HFCS consumption, the total fructose intake has not dramatically changed. Granulated sugar is 99.9 % pure sucrose, which means that it has equal ratio of fructose to glucose. The most commonly used forms of

HFCS, HFCS-42 and HFCS-55, have a roughly equal ratio of fructose to glucose, with minor differences. HFCS has simply replaced sucrose as a sweetener. Therefore, despite the changes in the sweetener consumption, the ratio of glucose to fructose intake has remained relatively constant.

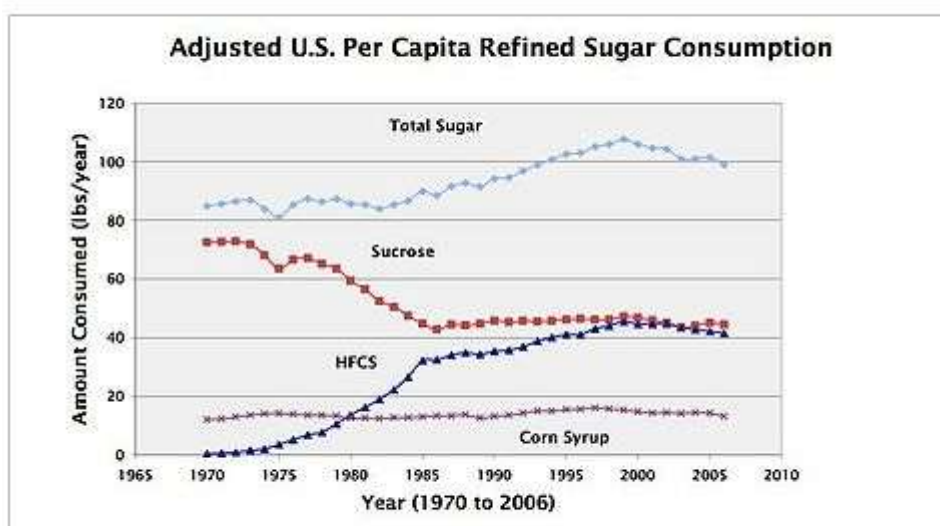


Figure 3 :

Adjusted consumption of refined sugar per capita in the U.S.

5 - Fructose digestion and absorption in humans :

Fructose exists in foods as either a monosaccharide (free fructose) or as a unit of a disaccharide (sucrose). Free fructose is absorbed directly by the intestine; however, when fructose is consumed in the form of sucrose, digestion occurs entirely in the upper small intestine. As sucrose comes into contact with the membrane of the small intestine, the enzyme sucrase catalyzes the cleavage of sucrose to yield one glucose unit and one fructose unit. Fructose is absorbed in the small intestine, then enters the hepatic portal vein and is directed toward the liver.

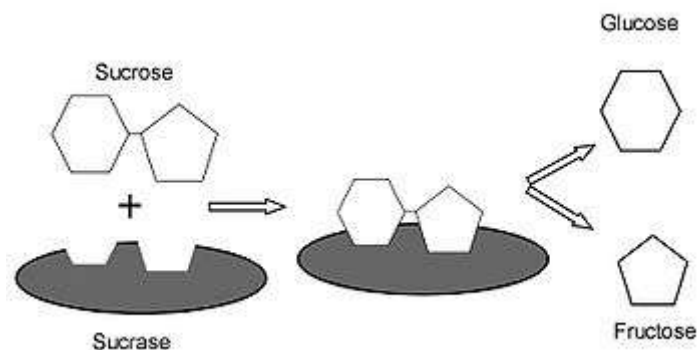


Figure 4: Hydrolysis of sucrose to glucose and fructose by sucrase.

The mechanism of fructose absorption in the small intestine is not completely understood. Some evidence suggests active transport, because fructose uptake has been shown to occur against a concentration gradient. However, the majority of research supports the claim that fructose absorption occurs on the mucosal membrane via facilitated transport involving GLUT5 transport proteins. Since the concentration of fructose is higher in the lumen, fructose is able to flow down a concentration gradient into the enterocytes, assisted by transport proteins. Fructose may be transported out of the enterocyte across the basolateral membrane by either GLUT2 or GLUT5, although the GLUT2 transporter has a greater capacity for transporting fructose and therefore the majority of fructose is transported out of the enterocyte through GLUT2.

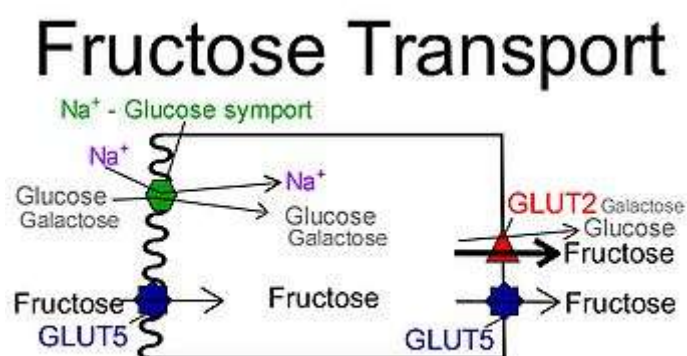


Figure 5: Intestinal sugar transport proteins.

5 – 1 - Capacity and rate of absorption ;

The absorption capacity for fructose in monosaccharide form ranges from less than 5 g to 50 g and adapts with changes in dietary fructose intake. Studies show the greatest absorption rate occurs when glucose and fructose are administered in equal quantities . When fructose is ingested as part of the disaccharide sucrose, absorption capacity is much higher because fructose exists in a 1:1 ratio with glucose. It appears that the GLUT5 transfer rate may be saturated at low levels, and absorption is increased through joint absorption with glucose. One proposed mechanism for this phenomenon is a glucose-dependent cotransport of fructose. In addition, fructose transfer activity increases with dietary fructose intake. The presence of fructose in the lumen causes increased mRNA transcription of GLUT5, leading to increased transport proteins. High-fructose diets^[vague] have been shown to increase abundance of transport proteins within 3 days of intake .

5 – 2 – Malabsorption :

Several studies have measured the intestinal absorption of fructose using hydrogen breath test. These studies indicate that fructose is not completely absorbed in the small intestine. When fructose is not absorbed in the small intestine, it is transported into the large intestine, where it is fermented by the colonic flora. Hydrogen is produced during the fermentation process and dissolves into the blood of the portal vein. This hydrogen is transported to the lungs, where it is exchanged across the lungs and is measurable by the hydrogen breath test. The colonic flora also produces carbon dioxide, short-chain fatty acids, organic acids, and trace gases in the presence of unabsorbed fructose.^[31] The presence of gases and organic acids in the large intestine causes gastrointestinal symptoms such as bloating, diarrhea, flatulence, and gastrointestinal pain. Exercise immediately after consumption can exacerbate these symptoms by decreasing transit time in the small intestine, resulting in a greater amount of fructose being emptied into the large intestine.

6 - Fructose metabolism :

All three dietary mono saccharides are transported into the liver by the GLUT 2 transporter . Fructose and galactose are phosphorylated in the liver by fructokinase ($K_m = 0.5 \text{ mM}$) and galactokinase ($K_m = 0.8 \text{ mM}$). By contrast, glucose tends to pass through the liver (K_m of hepatic glucokinase = 10 mM) and can be metabolised anywhere in the body. Uptake of fructose by the liver is not regulated by insulin. However, insulin is capable of increasing the abundance and functional activity of GLUT5 in skeletal muscle cells.

6 – 1 – Fructolysis :

The initial catabolism of fructose is sometimes referred to as fructolysis, in analogy with glycolysis, the catabolism of glucose. In fructolysis, the enzyme fructokinase initially produces fructose 1-phosphate, which is split by aldolase B to produce the trioses dihydroxy acetone phosphate and glyceraldehyde . Unlike glycolysis, in fructolysis the triose glyceraldehyde lacks a phosphate group. A third enzyme, triokinase, is therefore required to phosphorylate glyceraldehyde, producing glyceraldehyde-3-phosphate. The resulting trioses are identical to those obtained in glycolysis and can enter the gluconeogenic pathway for glucose or glycogen synthesis, or be further catabolized through the lower glycolytic pathway to pyruvate.

6 – 2 – Metabolism of fructose to DHAP and glyceraldehyde :

The first step in the metabolism of fructose is the phosphorylation of fructose to fructose 1-phosphate by fructokinase , thus trapping fructose for metabolism in the liver. Fructose 1-phosphate then undergoes hydrolysis by aldolase B to form DHAP and glyceraldehydes; DHAP can either be isomerized to glyceraldehyde 3-phosphate by triosephosphate isomerase or undergo reduction to glycerol 3-phosphate by glycerol 3-phosphate dehydrogenase. The glyceraldehyde produced may also be converted to glyceraldehyde 3-phosphate by glyceraldehyde kinase or converted to glycerol 3-phosphate by glyceraldehyde 3-phosphate dehydrogenase. The metabolism of fructose at this Point yields

intermediates in the gluconeogenic and fructolytic pathways leading to glycogen synthesis as well as fatty acid and triglyceride synthesis.

6 – 3 – Synthesis of glycogen from DHAP and glyceraldehyde 3 phosphate :

The resultant glyceraldehyde formed by aldolase B then undergoes phosphorylation to glyceraldehyde 3-phosphate. Increased concentrations of DHAP and glyceraldehyde 3-phosphate in the liver drive the gluconeogenic pathway toward glucose and subsequent glycogen synthesis . It appears that fructose is a better substrate for glycogen synthesis than glucose and that glycogen replenishment takes precedence over triglyceride formation. Once liver glycogen is replenished, the intermediates of fructose metabolism are primarily directed toward triglyceride synthesis.

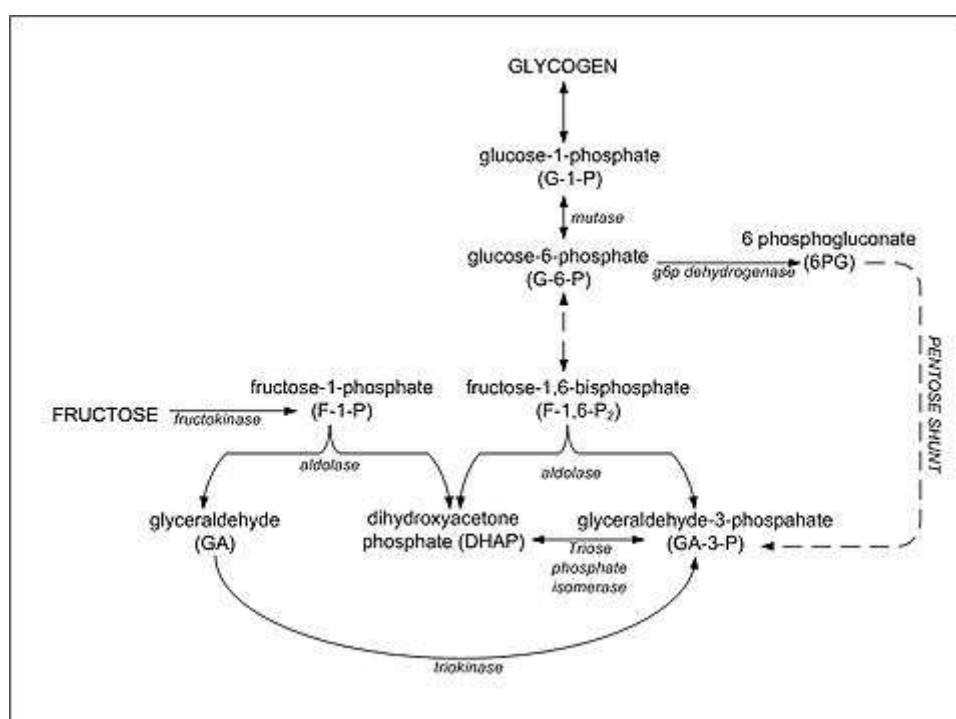


Figure 6: Metabolic conversion of fructose to glycogen in the liver.

6 – 4 – Synthesis of triglyceride from DHAP and glyceraldehyde 3 phosphate :

Carbons from dietary fructose are found in both the free fatty acid and glycerol moieties of plasma triglycerides. High fructose

consumption can lead to excess pyruvate production, causing a buildup of Krebs cycle intermediates. Accumulated citrate can be transported from the mitochondria into the cytosol of hepatocytes, converted to acetyl CoA by citrate lyase and directed toward fatty acid synthesis. Additionally, DHAP can be converted to glycerol 3-phosphate as previously mentioned, providing the glycerol backbone for the triglyceride molecule. Triglycerides are incorporated into very low density lipoproteins (VLDL), which are released from the liver destined toward peripheral tissues for storage in both fat and muscle cells.

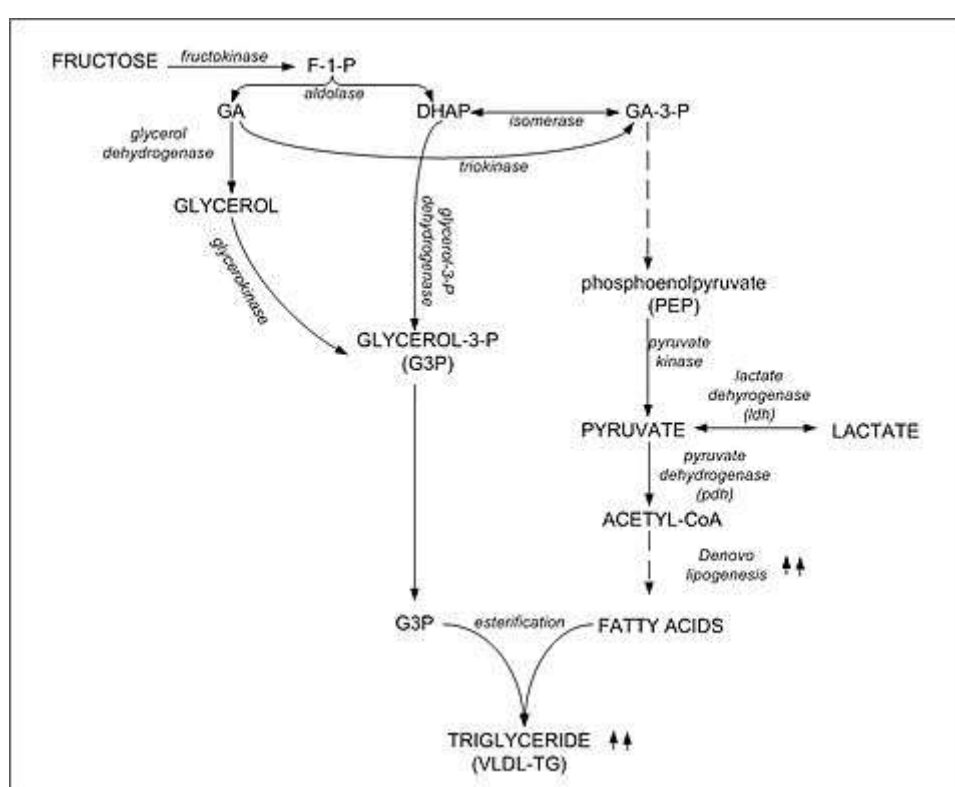


Figure 7: Metabolic conversion of fructose to triglyceride in the liver.

7 - Health effects :

7 – 1 – Digestive problems :

Fructose absorption occurs in the small intestine via the GLUT-5^[38] (fructose only) transporter, and the GLUT2 transporter, for which it competes with glucose and galactose. Over consumption of fructose, inhibition of GLUT2 by other phytochemicals, such as flavonoids,^[39] or other issues, may result in unabsorbed fructose being

carried into the large intestine where, like any sugar, it may provide nutrients for the existing gut flora which produce gas. It may also cause water retention in the intestine. These effects may lead to bloating, excessive flatulence, loose stools, and even diarrhea depending on the amounts eaten and other factors. For people with celiac disease, irritable bowel syndrome, or other fructose absorption issues, fructose malabsorption may be a major health concern.

7 – 2 – Metabolic syndrome :

Excess fructose consumption has been hypothesized to be a cause of insulin resistance, obesity , elevated LDL cholesterol and triglycerides, leading to metabolic syndrome. Fructose consumption has been shown to be correlated with obesity, especially central obesity which is thought to be the most dangerous kind of obesity. A study in mice showed that a high fructose intake increases adiposity.

Although all simple sugars have nearly identical chemical Formulae, each has distinct chemical properties. This can be illustrated with pure fructose. A journal article reports that, "...fructose given alone increased the blood glucose almost as much as a similar amount of glucose (78 % of the glucose-alone area)".

One study concluded that fructose "produced significantly higher fasting plasma tri acyl glycerol values than did the glucose diet in men" and "...if plasma tri acyl glycerols are a risk factor for cardiovascular disease, then diets high in fructose may be undesirable". Bantle et al. "noted the same effects in a study of 14 healthy volunteers who sequentially ate a high-fructose diet and one almost devoid of the sugar " .

Fructose is a reducing sugar, as are all mono saccharides. The spontaneous chemical reaction of simple sugar molecules binding to proteins, known as glycation, is thought to be a significant cause of damage in diabetics. Fructose appears to be equivalent to glucose in this regard and so does not seem to be a better answer for diabetes for this reason alone, save for the smaller quantities required to achieve equivalent sweetness in some foods . This may be an important contribution to senescence and many age-related chronic diseases.

7 – 3 – Compared to sucrose :

Studies that have compared high-fructose corn syrup (an ingredient in nearly all soft drinks sold in the US) to sucrose (common table sugar) find that most measured physiological effects are equivalent. For instance, Melanson et al. (2006), studied the effects of HFCS and sucrose sweetened drinks on blood glucose, insulin, leptin, and ghrelin levels. They found no significant differences in any of these parameters . This is not surprising, since sucrose is a disaccharide that digests to 50 % fructose and 50 % glucose, whereas the high - fructose corn syrup most commonly used on soft drinks is 55 % fructose and 45 % glucose. The difference between the two lies in the fact that HFCS contains little sucrose, the fructose and glucose being independent moieties.

Fructose is often recommended for diabetics because it does not trigger the production of insulin by pancreatic β cells, probably because β cells have low levels of GLUT5 . Fructose has a very low glycemic index of 19 ± 2 , compared with 100 for glucose and 68 ± 5 for sucrose . Fructose is also seventy-three percent sweeter than sucrose at room temperature, so diabetics can use less of it. Studies show that fructose consumed before a meal may even lessen the glycemic response of the meal . Its sweetness changes at higher temperatures, so its effects in recipes are not equivalent to those of sucrose (i.e., table sugar) .

7 – 4 – Liver disease :

"The medical profession thinks fructose is better for diabetics than sugar," says Meira Field, PhD, a research chemist at United States Department of Agriculture, "but every cell in the body can metabolize glucose. However, all fructose must be metabolized in the liver. The livers of the rats on the high fructose diet looked like the livers of alcoholics, plugged with fat and cirrhotic " . While a few other tissues (e.g., sperm cells and some intestinal cells) do use fructose directly, fructose is almost entirely metabolized in the liver.

"When fructose reaches the liver," says Dr. William J. Whelan, a biochemist at the University of Miami School of Medicine, "the

liver goes bananas and stops everything else to metabolize the fructose." Eating fructose instead of glucose results in lower circulating insulin and leptin levels, and higher ghrelin levels after the meal. Since leptin and insulin decrease appetite and ghrelin increases appetite, some researchers suspect that eating large amounts of fructose increases the likelihood of weight gain.

Excessive fructose consumption is also believed to contribute to the development of non-alcoholic fatty liver disease.

7 – 5 – Gout :

A 2008 British Medical Journal (BMJ) study linked the level of fructose consumption to incidence of gout. (The authors noted, "We found that the risk of incident gout associated with fructose or fructose rich foods was substantial.") Cases of gout have risen in recent years, despite commonly being thought of as a Victorian disease, and it is suspected that the fructose found in soft drinks (e.g., carbonated beverages) and other sweetened drinks is the reason for this.

In order for the liver to process fructose, it must be phosphorylated by removal of phosphates from adenosine triphosphate (ATP). The ATP gets converted to adenosine mono phosphate (AMP), then to inositol mono phosphate (IMP), and finally to uric acid , the agent in gout.

7 – 6 – Glycemic index :

Fructose has the lowest glycemic index (GI = 19) of all the natural sugars and used to be recommended for use by diabetics due to its small effect on blood glucose levels. In comparison, ordinary table sugar (sucrose which is half fructose) has a GI of 65 and honey (usually about 40 % fructose content) has a GI of 55. Due to the potential that excessive consumption of fructose may be a factor in some diseases, including metabolic syndrome and insulin resistance, products containing high contents of fructose may be discouraged.

Fructo Oligo Saccharide

Contents

- 1 Introduction
- 2 Chemistry
- 3 Food sources
- 4 Health benefits
- 5 Side - effects
- 6 Regulation
 - 6.1 US FDA regulation
 - 6.2 NZ NZFSA regulation
 - 6.3 EU regulation
 - 6.4 Canadian regulations

1 – Introduction :

Fructo oligo saccharides (FOS) also some times called **oligo fructose** or **oligo fructan** , are oligo saccharide fructans, used as an alternative sweetener. FOS exhibits sweetness levels between 30 and 50 percent of sugar in commercially-prepared syrups . It occurs naturally, and its commercial use emerged in the 1980s in response to consumer demand for healthier and calorie-reduced foods.

2 – Chemistry :

Two different classes of fructo oligo saccharide (FOS) mixtures are produced commercially, based on inulin degradation or trans fructosylation processes.

FOS can be produced by degradation of inulin, or polyfructose, a polymer of D-fructose residues linked by $\beta(2\rightarrow1)$ bonds with a terminal $\alpha(1\rightarrow2)$ linked D-glucose. The degree of polymerization of inulin ranges from 10 to 60. Inulin can be degraded enzymatically or chemically to a mixture of oligosaccharides with the general structure $\text{Glu}(\text{Fru})_n$ (GF_n) and Fru_m (F_m), with n and m ranging from 1 to 7. This process also occurs to some extent in nature, and these oligosaccharides can be found in a large number of plants, especially in Jerusalem artichoke and chicory. The main components of

commercial products are kestose (GF2), nystose (GF3), fructosylnystose (GF4), bifurcose (GF3), inulobiose (F2), inulotriose (F3), and inulotetraose (F4).

The second class of FOS is prepared by the transfructosylation action of a β -fructosidase of *Aspergillus niger* on sucrose. The resulting mixture has the general Formula of GF_n, with n ranging from 1 to 5. Contrary to the inulin-derived FOS, not only is there $\beta(1\rightarrow2)$ binding but other linkages do occur, however, in limited numbers.

Because of the configuration of their osidic bonds, fructo oligo saccharides resist hydrolysis by salivary and intestinal digestive enzymes. In the colon they are fermented by anaerobic bacteria. In other words, they have a lower caloric value, while contributing to the dietary fiber fraction of the diet. Fructo oligo saccharides are more soluble than inulins and are, therefore, sometimes used as an additive to yogurt and other (dairy) products. Fructo oligo saccharides are used specially in combination with high-intensity artificial sweeteners, whose sweetness profile and aftertaste it improves.

3 - Food sources :

FOS is extracted from fruits and vegetables such as bananas, onions, chicory root, garlic, asparagus, barley, wheat, jícama, and leeks. Some grains and cereals, such as wheat, also contain FOS.^[3] The Jerusalem artichoke and its relative yacón have been found to have the highest concentrations of FOS of cultured plants.^[citation needed]

4 - Health benefits :

FOS has been a popular dietary supplement in Japan for many years, even before 1990, when the Japanese government installed a "Functionalized Food Study Committee" of 22 experts to start to regulate "special nutrition foods or functional foods" that contain the categories of fortified foods (e.g., vitamin-fortified wheat flour),^[4] and is now becoming increasingly popular in Western cultures for its prebiotic effects. FOS serves as a substrate for microflora in the large intestine, increasing the overall gastrointestinal tract (GI Tract) health.

It has also been touted as a supplement for preventing yeast infections.

Several studies have found that FOS and inulin promote calcium absorption in both the animal and the human gut.^{[5][6]} The intestinal microflora in the lower gut can ferment FOS, which results in a reduced pH. Calcium is more soluble in acid, and, therefore, more of it comes out of food and is available to move from the gut into the bloodstream.

FOS can be considered a small dietary fiber with (like all types of fibre) low caloric value. The fermentation of FOS results in the production of gases and acids. The latter provide some energy to the body.

5 - Side – effects :

All inulin-type prebiotics, including FOS, are generally thought to stimulate the growth of *Bifidobacteria* species. *Bifidobacteria* are considered "friendly" bacteria. This effect has not been uniformly found in all studies, both for *Bifidobacteria* and for other gut organisms . FOS are also fermented by numerous bacterial species in the intestine, including *Klebsiella*, *E. coli* and many *Clostridium* species, which are considered less-friendly bacteria in the gut. These species are responsible mainly for the gas formation (hydrogen and carbon dioxide), which results after ingestion of FOS. Most people can eat 5-10 grams of FOS without gaseous discomfort, whereas others have problems with 1 gram. The estimated optimal dose for adults is around 5-10 gram/day.

6 - Regulation :

6 – 1 - US FDA regulation :

FOS is classified as generally recognized as safe (GRAS).

6 – 2 - NZ NZFSA regulation :

The Food Safety Authority warned parents of babies that a major European Baby-Formula brand made in New Zealand does not

comply with local regulations, (because it contains fructo-oligosaccharides (FOS)) and urged them to stop using it .

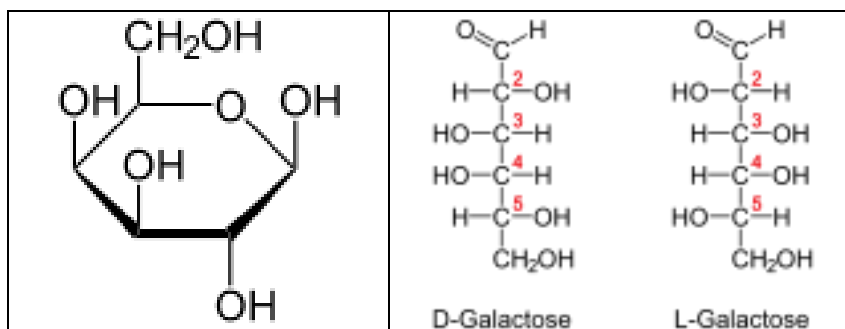
6 – 1 - EU regulation :

FOS use has been approved in the European Union; allowing addition of FOS in **restricted** amounts to baby Formula (for babies up to six months) and follow- on Formula (for babies between six and 12 months). Infant and follow- on Formula products containing FOS have been sold in the EU since 1999.

6 – 4 - Canadian regulations :

FOS is currently not approved for use in baby Formula.^[12]

Galactose



Contents

- 1 Introduction
- 2 Structure and isomerism
- 3 Relationship to lactose
- 4 Galactose metabolism
- 5 Sources
- 6 Clinical significance

1 – Introduction :

Galactose (from Greek *galaktos* "milk"), some times abbreviated **Gal** , is a type of sugar that is less sweet than glucose. It is a C- 4 epimer of glucose.

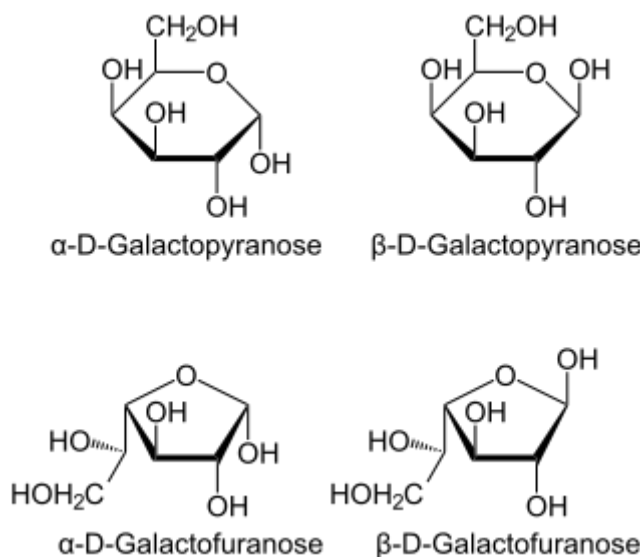
Galactan is a polymer of the sugar galactose found in hemicellulose. Galactan can be converted to galactose by hydrolysis.

Molecular Formula	$C_6 H_{12} O_6$
Molar Mass	180 g mol^{-1}
Density	1.723 g / cm^3
Melting Point	$167 \text{ }^\circ\text{C}$
Solubility in water	683.0 g / L

2 - Structure and isomerism :

Galactose exists in both open-chain and cyclic form. The open-chain form has a carbonyl at the end of the chain.

Four isomers are cyclic, two of them with a pyranose (six-membered) ring, two with a furanose (five-membered) ring. Galactofuranose occurs in bacteria, fungi and protozoa .



Cyclic forms of galactose

3 - Relationship to lactose :

Galactose is a mono saccharide . When combined with glucose (mono saccharide , through a dehydration reaction, the result is the disaccharide lactose. The hydrolysis of lactose to glucose and galactose is catalyzed by the enzymes lactase and β -galactosidase. The latter is produced by the *lac* operon in *Escherichia coli*.

Lactose is found primarily in milk and milk products. Galactose metabolism, which converts galactose into glucose, is carried out by the three principal enzymes in a mechanism known as the Leloir pathway. The enzymes are listed in the order of the metabolic pathway: galactokinase (GALK), galactose-1-phosphate uridylyltransferase (GALT), and UDP-galactose-4'-epimerase (GALE).

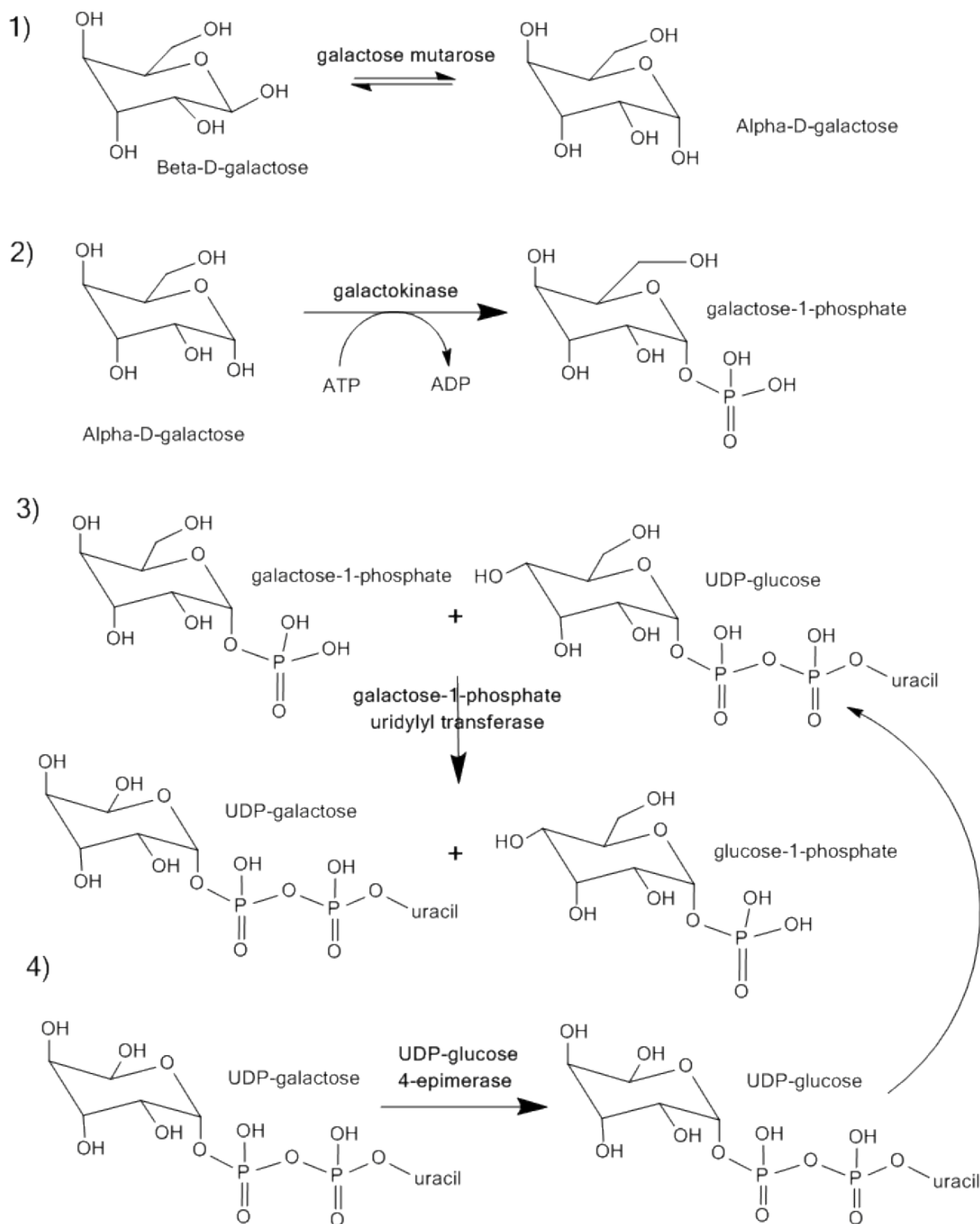
In the human body, glucose is changed into galactose via hexoneogenesis to enable the mammary glands to secrete lactose. However, most galactose in breast milk is synthesized from galactose taken up from the blood, and only 35 ± 6 % is made by *de novo*

synthesis . Glycerol also contributes some to the mammary galactose production.

4 - Galactose metabolism :

Glucose is the primary metabolic fuel for humans. It is more stable than galactose and is less susceptible to the formation of nonspecific glycoconjugates, molecules with at least one sugar attached to a protein or lipid. Many speculate that it is for this reason that a pathway for rapid conversion from galactose to glucose has been highly conserved among many species .

The main pathway of galactose metabolism is the Leloir pathway; humans and other species, however, have been noted to contain several alternate pathways, such as the De Ley Doudoroff pathway. The Leloir pathway consists of the latter stage of a two-part process that converts β -D-galactose to UDP-glucose. The initial stage is the conversion of β -D-galactose to α -D-galactose by the enzyme, mutarotase (GALM). The Leloir pathway then carries out the conversion of α -D-galactose to UDP-glucose via three principle enzymes. Galactokinase (GALK) phosphorylates α -D-galactose to galactose-1-phosphate, or Gal-1-P. Galactose-1-phosphate uridyltransferase (GALT) then transfers a UMP group from UDP-glucose to Gal-1-P to form UDP-galactose. Finally, UDP galactose-4'-epimerase (GALE) interconverts UDP-galactose and UDP-glucose, thereby completing the pathway .



5 – Sources :

Galactose is found in dairy products, sugar beets, and other gums and mucilages. It is also synthesized by the body, where it forms part of glycolipids and glycoproteins in several tissues.

6 - Clinical significance :

Chronic systemic exposure of mice, rats, and *Drosophila* to D-galactose causes the acceleration of senescence and has been used as an aging model . Two studies have suggested a possible link between galactose in milk and ovarian cancer . Other studies show no correlation , even in the presence of defective galactose metabolism . More recently, pooled analysis done by the Harvard School of Public Health showed no specific correlation between lactose-containing foods and ovarian cancer, and showed statistically insignificant increases in risk for consumption of lactose at ≥ 30 g / d . More research is necessary to ascertain possible risks.

Some ongoing studies suggest galactose may have a role in treatment of focal segmental glomerulosclerosis (a kidney disease resulting in kidney failure and proteinuria) . This effect is likely to be a result of binding of galactose to FSGS factor.

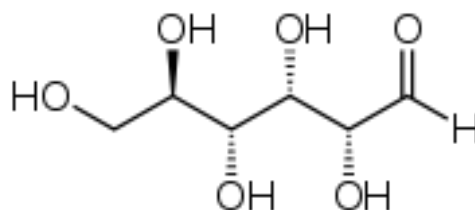
Galactose is a component of the antigens present on blood cells that determine blood type within the ABO blood group system .

Glucin

Glucin is the Name of an artificial sweetening agent similar to saccharin that was used in the early 20th century . The substance is a sodium salt derived from coal tar. It is composed of a mixture of mono- and di-sulfonic acids with a chemical Formula of $C_{19}H_{16}N_4$. It typically appears as a light brown powder, easily soluble in water. It is insoluble in ether and chloroform. Glucin is about three hundred times sweeter than cane sugar.

The use of glucin as a food additive is prohibited in much of the United States due to concerns about its health effects.

Glucose



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- 1 Introduction
- 2 Function
 - 2.1 Analyte in medical blood test
 - 2.2 As an energy source
 - 2.3 Glucose in glycolysis
 - 2.4 As a precursor
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- 3 Structure and nomenclature
 - 3.1 Open - chain form
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- 4 Physical properties
 - 4.1 Solutions
 - 4.2 Solid state
 - 4.3 Optical activity
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- 6 Sources and absorption
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1 – Introduction :

Glucose ($C_6H_{12}O_6$, also known as **D-glucose**, **dextrose**, or **grape sugar**) is a simple sugar (mono saccharide) and an important carbohydrate in biology. Cells use it as the primary source of energy^[1] and a metabolic intermediate. Glucose is one of the main products of photosynthesis and starts cellular respiration.

Glucose exists in several different structures, but all of these structures can be divided into two families of mirror-images (stereo isomers). Only one set of these isomers exists in nature, those derived from the "right-handed form" of glucose, denoted D-glucose. D-glucose is often referred to as dextrose. The term dextrose is derived from *dextrorotatory glucose*. Solutions of dextrose rotate polarized light to the right. Starch and cellulose are polymers derived from the dehydration of D-glucose. The other stereoisomer, called L-glucose, is hardly found in nature.

The Name "glucose" comes from the Greek word *glukus* (γλυκύς), meaning "sweet". The suffix "-ose" denotes a sugar. The Name "dextrose" and the 'D-' prefix come from Latin *dexter* ("right"), referring to the handedness of the molecules.

Preferred IUPAC Name : D- glucose	
Systematic Name :	
(2R,3S,4R,5R)-2,3,4,5,6-Penta hydroxy hexanal	
Other Names :	
Blood sugar	
Dextrose	
Corn sugar	
D-Glucose	
Grape sugar	
Gmelin Reference	83256
Molecular Formula	C ₆ H ₁₂ O ₆
Molar Mass	180 g / mol
Density	1.54 g / cm ³
Melting Point	α-D-glucose: 146 °C
	β-D-glucose: 150 °C
Solubility in water	91 g/100 mL

2 – Function :



Glucose metabolism and various forms of it in the process.

- *Glucose-containing compounds and isomeric forms are digested and taken up by the body in the intestines, including starch, glycogen, disaccharides and mono saccharides.*
- *Glucose is stored in mainly the liver and muscles as glycogen.*
- *It is distributed and utilized in tissues as free glucose.*

Scientists can speculate on the reasons that glucose, and not another monosaccharide such as fructose, is so widely used in organisms. One reason might be that glucose has a lower tendency, relative to other hexose sugars, to react non-specifically with the amino groups of proteins. This reaction (glycation) reduces or destroys the function of many enzymes. The low rate of glycation is due to glucose's preference for the less reactive cyclic isomer. Nevertheless, many of the long-term complications of diabetes (e.g., blindness, renal failure, and peripheral neuropathy) are probably due to the glycation of proteins or lipids . In contrast, enzyme-regulated addition of glucose to proteins by glycosylation is often essential to their function .

2 – 1 - Analyte in medical blood test :

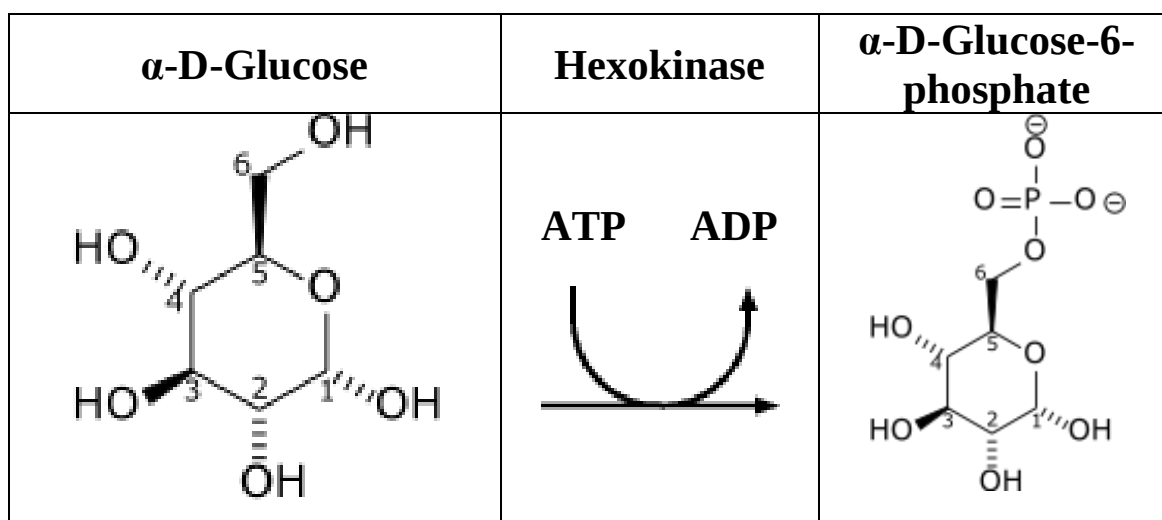
Glucose is a common medical analyte measured in blood samples. Eating or fasting prior to taking a blood sample has an effect on the result. Higher than usual glucose levels may be a sign of prediabetes or diabetes mellitus.

2 – 2 - As an energy source :

Glucose is a ubiquitous fuel in biology. It is used as an energy source in most organisms, from bacteria to humans. Use of glucose may be by either aerobic respiration, anaerobic respiration, or fermentation. Glucose is the human body's key source of energy, through aerobic respiration, providing approximately 3.75 kilocalories (16 kilojoules) of food energy per gram.^[4] Breakdown of carbohydrates (e.g. starch) yields mono- and disaccharides, most of which is glucose. Through glycolysis and later in the reactions of the citric acid cycle (TCAC), glucose is oxidized to eventually form CO₂ and water, yielding energy sources, mostly in the form of ATP. The insulin reaction, and other mechanisms, regulate the concentration of glucose in the blood. A high fasting blood sugar level is an indication of prediabetic and diabetic conditions.

Glucose is a primary source of energy for the brain, and hence its availability influences psychological processes. When glucose is low, psychological processes requiring mental effort (e.g., self-control, effortful decision-making) are impaired.

2 – 3 - Glucose in glycolysis :



Use of glucose as an energy source in cells is via aerobic or anaerobic respiration. Both of these start with the early steps of the glycolysis metabolic pathway. The first step of this is the phosphorylation of glucose by hexokinase to prepare it for later

breakdown to provide energy. The major reason for the immediate phosphorylation of glucose by a hexokinase is to prevent diffusion out of the cell. The phosphorylation adds a charged phosphate group so the glucose 6-phosphate cannot easily cross the cell membrane. Irreversible first steps of a metabolic pathway are common for regulatory purposes.

In anaerobic respiration one glucose molecule produces a net gain of 2 ATP molecules (4 ATP molecules are produced during glycolysis but 2 are required by enzymes used during the process).^[9] In aerobic respiration a molecule of glucose is much more profitable in that a net worth of 32 ATP molecules are generated (34 gross with 2 being required in the process).

2 – 4 - As a precursor :

Glucose is critical in the production of proteins and in lipid metabolism. In plants and most animals, it is also a precursor for vitamin C (ascorbic acid) production. It is modified for use in these processes by the glycolysis pathway . Glucose is used as a precursor for the synthesis of several important substances. Starch, cellulose, and glycogen ("animal starch") are common glucose polymers (polysaccharides). Lactose, the predominant sugar in milk, is a glucose-galactose disaccharide. In sucrose, another disaccharide, glucose is joined to fructose. These synthesis processes also rely on the phosphorylation of glucose through the first step of glycolysis.

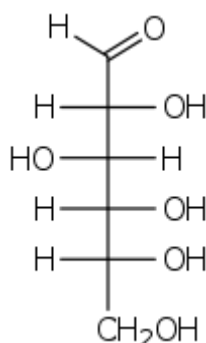
2 – 4 - 1 - Industrial use :

In industry, glucose is used as a precursor to make vitamin C in the Reichstein process, to make citric acid, gluconic acid, bio-ethanol, poly lactic acid, sorbitol.

3 - Structure and nomenclature :

Glucose is a monosaccharide with Formula $C_6H_{12}O_6$ or $H-(C=O)-(CHOH)_5-H$, whose five hydroxyl (OH) groups are arranged in a specific way along its six - carbon backbone.

3 – 1 - Open - chain form :



D-glucose in Fischer projection

In its fleeting open-chain form, the glucose molecule has an open (as opposed to cyclic) and unbranched backbone of six carbon atoms, C-1 through C-6; where C-1 is part of an aldehyde group $\text{H}(\text{C}=\text{O})-$, and each of the other five carbons bears one hydroxyl group $-\text{OH}$. The remaining bonds of the backbone carbons are satisfied by hydrogen atoms $-\text{H}$. Therefore glucose is an hexose and an aldose, or an aldohexose.

Each of the four carbons C-2 through C-5 is chiral, meaning that its four bonds connect to four different substituents. (Carbon C-2, for example, connects to $-(\text{C}=\text{O})\text{H}$, $-\text{OH}$, $-\text{H}$, and $-(\text{CHOH})_4\text{H}$.) In D-glucose, these four parts must be in a specific three-dimensional arrangement. Namely, when the molecule is drawn in the Fischer projection, the hydroxyls on C-2, C-4, and C-5 must be on the right side, while that on C-3 must be on the left side.

The positions of those four hydroxyls are exactly reversed in the Fischer diagram of L-Glucose. D- and L-glucose are two of the 16 possible aldohexoses; the other 14 are allose, altrose, mannose, gulose, idose, galactose, and talose, each with two isomers, 'D-' and 'L-'.

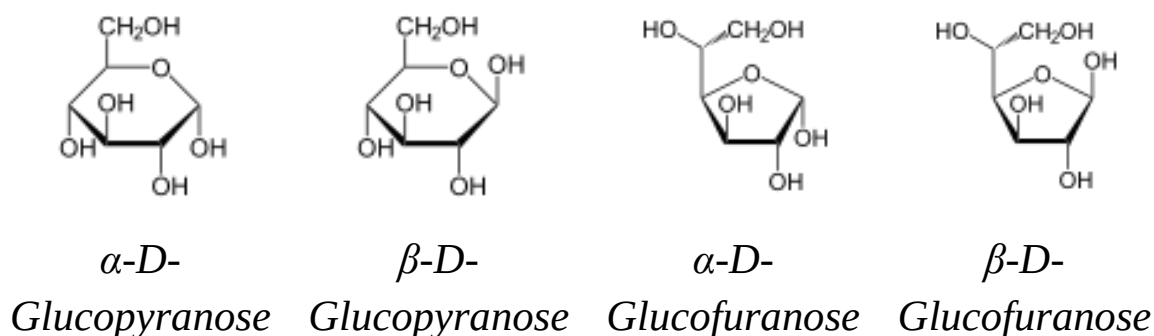
3 – 2 - Cyclic forms

In solutions, the open-chain form of glucose (either 'D-' or 'L-') exists in equilibrium with several cyclic isomers, each containing a ring of carbons closed by one oxygen atom. In aqueous solution,

however, glucose exists as pyranose for more than 99%. The open-chain form is limited to about 0.25 % and furanose exists in negligible amounts. The terms "glucose" and "D-glucose" are generally used for these cyclic forms as well. The ring arises from the open-chain form by a nucleophilic addition reaction between the aldehyde group - (C=O)H at C-1 and the hydroxyl group -OH at C-4 or C-5, yielding a hemiacetal group -C(OH)H-O-.

The reaction between C-1 and C-5 creates a molecule with a six-membered ring, called pyranose, after the cyclic ether pyran, the simplest molecule with the same carbon-oxygen ring. The (much rarer) reaction between C-1 and C-4 creates a molecule with a five-membered ring, called furanose, after the cyclic ether furan. In either case, each carbon in the ring has one hydrogen and one hydroxyl attached, except for the last carbon (C-4 or C-5) where the hydroxyl is replaced by the remainder of the open molecule (which is -(CHOH)₂-H or -(CHOH)-H, respectively).

The ring-closing reaction makes carbon C-1 chiral, too, since its four bonds lead to -H, to -OH, to carbon C-2, and to the ring oxygen. These four parts of the molecule may be arranged around C-1 (the anomeric carbon) in two distinct ways, designated by the prefixes ' α -' and ' β -. When a glucopyranose molecule is drawn in the Haworth projection, the designation ' α -' means that the hydroxyl group attached to C-1 and the -CH₂OH group at C-5 lies on opposite sides of the ring's plane (a *trans* arrangement), while ' β -' means that they are on the same side of the plane (a *cis* arrangement). Therefore, the open isomer D-glucose gives rise to four distinct cyclic isomers: α -D-glucopyranose, β -D-glucopyranose, α -D-glucofuranose, and β -D-glucofuranose; which are all chiral.



The other open-chain isomer L-glucose similarly gives rise to four distinct cyclic forms of L-glucose, each the mirror image of the corresponding D-glucose.

The rings are not planar but twisted in three dimensions. The glucopyranose ring (α or β) can assume several non-planar shapes, analogous to the 'chair' and 'boat' conformations of cyclo hexane. Similarly, the glucofuranose ring may assume several shapes, analogous to the 'envelope' conformations of cyclo pentane.

The glucopyranose forms of glucose predominate in solution, and are the only forms observed in the solid state. They are crystalline colorless solids, highly soluble in water and acetic acid, poorly soluble in methanol and ethanol. They melt at 146 °C (α) and 150 °C (β), and decompose at higher temperatures into carbon and water.

3 – 3 - Rotational isomers :

Each glucose isomer is subject to rotational isomerism. Within the cyclic form of glucose, rotation may occur around the O6-C6-C5-O5 torsion angle, termed the ω -angle, to form three staggered rotamer conformations called *gauche-gauche* (gg), *gauche-trans* (gt) and *trans-gauche* (tg). For methyl α -D-glucopyranose at equilibrium the ratio of molecules in each rotamer conformation is reported as 57:38:5 gg:gt:tg.^[11] This tendency for the ω -angle to prefer to adopt a *gauche* conformation is attributed to the gauche effect.

4 - Physical properties :

4 - 1 - Solutions :

All forms of glucose are colorless and easily soluble in water, acetic acid, and several other solvents. They are only sparingly soluble in methanol and ethanol.

The open-chain form is thermodynamically unstable, and it spontaneously tautomerizes to the cyclic forms. (Although the ring closure reaction could in theory create four- or three-atom rings, these would be highly strained and are not observed.) In solutions at room

temperature, the four cyclic isomers interconvert over a timescale of hours, in a process called mutarotation . Starting from any proportions , the mixture converges stable ratio of $\alpha:\beta$ 36:64. The ratio would be $\alpha:\beta$ 11:89 if it were not for the influence of the anomeric effect. Mutarotation is considerably slower at temperatures close to 0 °C.

Mutarotation consists of a temporary reversal of the ring-forming reaction, resulting in the open-chain form, followed by a re-forming of the ring. The ring closure step may use a different -OH group than the one recreated by the opening step (thus switching between pyranose and furanose forms), and/or the new hemiacetal group created on C-1 may have the same or opposite handedness as the original one (thus switching between the α and β forms). Thus, even though the open-chain form is barely detectable in solution, it is an essential component of the equilibrium.

4 - 2 - Solid state :

Depending on conditions, three major solid forms of glucose can be crystallized from water solutions: α - gluco pyranose , β -gluco pyranose , and β -gluco pyranose hydrate.

4 - 3 - Optical activity :

Whether in water or in the solid form, D-glucose is dextrorotatory, meaning that it will rotate the direction of polarized light clockwise. The effect is due to the chirality of the molecules, and indeed the mirror-image isomer, L-glucose, is levorotatory (rotates polarized light counterclockwise) by the same amount. The strength of the effect is different for each of the five tautomers.

Note that the D- prefix does not refer directly to the optical properties of the compound. It indicates that the C-2 chiral center has the same handedness as that of D-glutaraldehyde (which was so labeled because *it* is dextrorotatory). The fact that D-glucose is dextrorotatory is a combined effect of its four chiral centers, not just of C-2; and indeed some of the other D-aldo hexoses are levorotatory.

5 - Production :

5 - 1 - Biosynthesis :

In plants and some prokaryotes, glucose is a product of photosynthesis. In animals and fungi, glucose results from the breakdown of glycogen, a process known as glycogenolysis. In plants the breakdown substrate is starch.

In animals, glucose is synthesized in the liver and kidneys from non-carbohydrate intermediates, such as pyruvate and glycerol, by a process known as gluconeogenesis.

In some deep-sea bacteria glucose is produced by chemosynthesis.

5 - 2 - Commercial :

Glucose is produced commercially via the enzymatic hydrolysis of starch. Many crops can be used as the source of starch. Maize, rice, wheat, cassava, corn husk and sago are all used in various parts of the world. In the United States, cornstarch (from maize) is used almost exclusively. Most commercial glucose occurs as a component of invert sugar, an approximately 1:1 mixture of glucose and fructose. In principle, cellulose could be hydrolyzed to glucose, but this process is not yet commercially practical .

6 - Sources and absorption :

Most dietary carbohydrates contain glucose, either as their only building block, as in starch and glycogen, or together with another monosaccharide, as in sucrose and lactose.

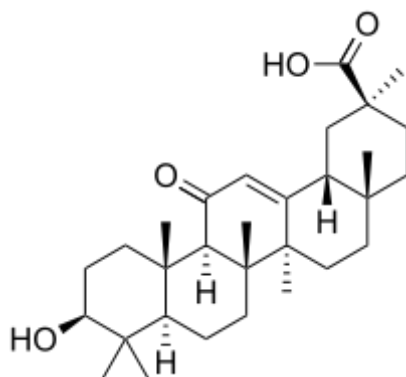
In the lumen of the duodenum and small intestine, the glucose oligo- and polysaccharides are broken down to mono saccharides by the pancreatic and intestinal glycosidases. Other polysaccharides cannot be processed by the human intestine and require assistance by intestinal flora if they are to be broken down; the most notable exceptions are sucrose (fructose-glucose) and lactose (galactose-glucose). Glucose is then transported across the apical membrane of

the enterocytes by SLC5A1, and later across their basal membrane by SLC2A2.^[15] Some of the glucose is directly utilized as an energy source by brain cells, intestinal cells and red blood cells, while the rest reaches the liver, adipose tissue and muscle cells, where it is absorbed and stored as glycogen (under the influence of insulin). Liver cell glycogen can be converted to glucose and returned to the blood when insulin is low or absent; muscle cell glycogen is not returned to the blood because of a lack of enzymes. In fat cells, glucose is used to power reactions that synthesize some fat types and have other purposes. Glycogen is the body's 'glucose energy storage' mechanism because it is much more 'space efficient' and less reactive than glucose itself.

7 – History :

Because glucose is a basic necessity of many organisms, a correct understanding of its chemical makeup and structure contributed greatly to a general advancement in organic chemistry. This understanding occurred largely as a result of the investigations of Emil Fischer, a German chemist who received the 1902 Nobel Prize in Chemistry as a result of his findings.^[16] The synthesis of glucose established the structure of organic material and consequently formed the first definitive validation of Jacobus Henricus van't Hoff's theories of chemical kinetics and the arrangements of chemical bonds in carbon-bearing molecules. Between 1891 and 1894, Fischer established the stereo chemical configuration of all the known sugars and correctly predicted the possible isomers, applying van't Hoff's theory of asymmetrical carbon atoms.

Glycyrrhetic acid



1 – Introduction :

Glycyrrhetic acid is a penta cyclic triterpenoid derivative of the beta - amyrin type obtained from the hydrolysis of glycyrrhizic acid, which was obtained from the herb liquorice. It is used in flavoring and it masks the bitter taste of drugs like aloe and quinine. It is effective in the treatment of peptic ulcer and also has expectorant (anti tussive) properties. It has some additional pharmacological properties including antiviral, antifungal, anti protozoal, and antibacterial activities.

IUPAC Name :

(2*S*,4*aS*,6*aS*,6*bR*,8*aR*,10*S*,12*aS*,12*bR*,14*bR*)-10-hydroxy-2,4*a*,6*a*,6*b*,9,9,12*a*-heptamethyl-13-oxo-1,2,3,4,4*a*,5,6,6*a*,6*b*,7,8,8*a*,9,10,11,12,12*a*,12*b*,13,14*b*-icosahydronicene-2-carboxylic acid

Other Names :

Enoxolone ; Glycyrrhetin ; Uralenic acid ;

Glycyrrhetinate ; Arthrodont ;

3β-Hydroxy-11- oxoolean-12-en-30-olic acid

Molecular Formula

$C_{30} H_{46} O_4$

Molar Mass

471 g mol⁻¹

2 - Mechanism of action :

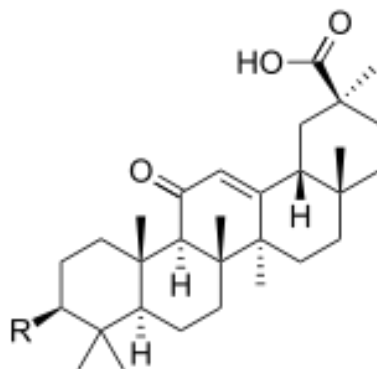
Glycyrrhetic acid inhibits the enzymes (15-hydroxy prostaglandin dehydrogenase and delta-13-prostaglandin) that metabolize the prostaglandins PGE-2 and PGF-2 α to their respective 15-keto-13,14-dihydro metabolites which are inactive. This causes an increased level of prostaglandins in the digestive system. Prostaglandins inhibit gastric secretion but stimulate pancreatic secretion and mucous secretion in the intestines and markedly increase intestinal motility. They also cause cell proliferation in the stomach. The effect on gastric acid secretion, promotion of mucous secretion and cell proliferation shows why licorice has potential in treating peptic ulcer.

PGF-2 α stimulates activity of the uterus during pregnancy and can cause abortion, therefore, licorice should not be taken during pregnancy.

The structure of glycyrrhetic acid is similar to that of cortisone. Both molecules are flat and similar at position 3 and 11. This might be the basis for licorice's anti-inflammatory action.

3- β -D-(mono glucuronyl)-18- β -glycyrrhetic acid, a metabolite of glycyrrhetic acid, inhibits the conversion of *active* cortisol to *inactive* cortisone in the kidneys. This occurs via inhibition of the enzyme by inhibiting the enzyme 11- β -hydroxysteroid dehydrogenase. As a result, cortisol levels are high within the collecting duct of the kidney. Cortisol has intrinsic mineralocorticoid properties (that is, it acts like aldosterone and increases sodium reabsorption) that work on ENaC channels in the collecting duct. Hypertension develops due to this mechanism of sodium retention. People often have high blood pressure with a low renin and low aldosterone blood level. The increased amounts of cortisol binds to the unprotected, unspecific mineralocorticoid receptors and induce sodium and fluid retention, hypokalaemia, high blood pressure and inhibition of the rennin – angiotensin - aldosterone system. Therefore licorice should not be given to patients with a known history of hypertension.

3 - Derivatives :



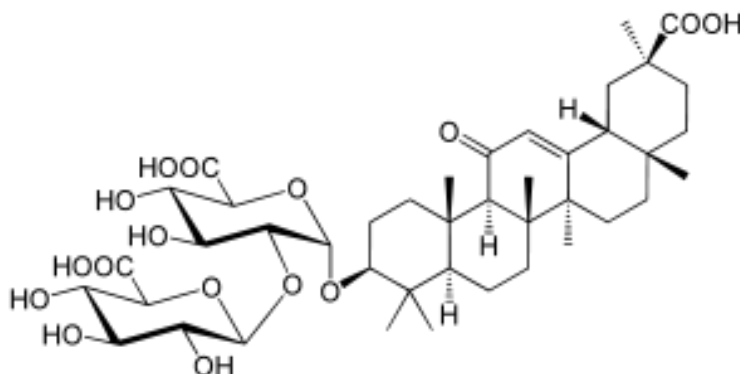
*Glycyrrhetic acid derivatives,
where R is a variable functional group*

In glycyrrhetic acid, the functional group (**R**) is a hydroxyl group. Research in 2005 demonstrated that with a proper functional group a very effective glycyrrhetic artificial sweetener can be obtained . When **R** is an anionic $\text{NHCO}(\text{CH}_2)\text{CO}_2\text{K}$ side chain, the sweetening effect is found to 1200 times that of sugar (human sensory panel data). A shorter or longer spacer reduces the sweetening effect. One explanation is that the taste bud cell receptor has 1.3 nanometers (13 angstroms) available for docking with the sweetener molecule. In addition the sweetener molecule requires three proton donor positions of which two reside at the extremities to be able to interact efficiently with the receptor cavity.

A synthetic analog, carbenoxolone, was developed in Britain. Both glycyrrhetic acid and carbenoxolone have a modulatory effect on neural signaling through gap junction channels.

Acetoxolone, the acetyl derivative of glycyrrhetic acid, is a drug used in the treatment of peptic ulcer and gastro esophageal reflux disease.

Glycyrrhizin



1 – Introduction :

Glycyrrhizin is the main sweet-tasting compound from liquorice root. It is 30 – 50 times as sweet as sucrose (table sugar). Pure glycyrrhizin is odorless.

In chemical terms, glycyrrhizin is a triterpenoid saponin glycoside of glycyrrhizic (or glycyrrhizinic) acid.^[2] Upon hydrolysis, the glycoside loses its sweet taste and is converted to the aglycone glycyrrhetic acid plus two molecules of glucuronic acid. The acid form is not particularly water-soluble, but its ammonium salt is soluble in water at pH greater than 4.5.

Although sweet, the taste sensation of glycyrrhizin is different from that of sugar. The sweetness of glycyrrhizin has a slower onset than sugar has, and lingers in the mouth for some time. Unlike the artificial sweetener aspartame, glycyrrhizin maintains its sweetness under heating.

In the United States, glycyrrhizin is classified as "generally recognized as safe" as a flavoring agent, although not as a sweetener. Glycyrrhizin is used as a flavoring in some candies, pharmaceuticals, and tobacco products.

The European Union suggests people should not consume any more than 100 mg of glycyrrhizic acid a day . equivalent to approximately 50 g of liquorice sweets .

In Japan, where concern over the safety of artificial sweeteners during the 1970s led to a shift towards plant-derived sugar substitutes, glycyrrhizin is a commonly used sweetener, often used in combination with another plant-based sweetener, stevia. However, the Japanese government has asked its citizens to limit their consumption to 200 milligrams per day .

2 Health effects :

The most widely reported side-effects of glycyrrhizin use are hypertension and edema (water retention). These effects are related to the inhibition of cortisol metabolism within the kidney, and the subsequent stimulation of the mineralocorticoid receptors . Thus, consumption of black licorice can mimic disorders of excess aldosterone.

Glycyrrhizin and other licorice root products have been used for numerous medical purposes, in particular, treatment of peptic ulcers and as an expectorant. The triterpene derivative of hydrolyzed glycyrrhizin glycyrrhetinic acid is itself effective in treatment of peptic ulcer . According to MedlinePlus and the *Natural Medicines Comprehensive Database*, licorice is "possibly effective" for dyspepsia in combination with other herbs, but there is "insufficient evidence" to rate its effectiveness for other conditions. Regarding stomach ulcers, specifically, there is "some evidence...that specially prepared licorice will speed the healing of stomach ulcers" .

An un-blinded study of 82 patients from the early 1980s, published in the *British Medical Journal*, reported that Caved-S had a therapeutic effect is similar to that of cimetidine in the treatment of gastric ulcers.

Although licorice may produce anti - inflammatory effects, it is uncertain as to whether that is due to glycyrrhizin, glycyrrhetinic acid, or some other licorice derivative.

Researchers have recently demonstrated doses of licorice root extract, delivering the constituent glycyrrhizin in amounts similar to

that contained in standard medical doses of the root, rapidly and significantly lowered levels of circulating testosterone in males.^[8]

Glycyrrhizin inhibits liver cell injury caused by many chemicals and is used in the treatment of chronic hepatitis and cirrhosis in Japan. It also inhibits the growth of several DNA and RNA viruses, inactivating herpes simplex virus particles irreversibly.

Hernandulcin



The lippia dulcis plant, which naturally produces hernandulcin.

1 – Introduction :

Hernandulcin is an intensely sweet chemical compound gained from the chiefly Mexican and South American plant *Lippia dulcis*.

Molecular formula	$C_{15}H_{24}O_2$
Molar mass	236 g / mol

2- History and origin:

In the 1570s, Spanish physician Francisco Hernández described a remarkably sweet plant known to the Aztecs as Tzonpelic xihuitl, meaning "sweet herb". This reference, accompanied by an accurate description and illustration of the plant, led pharmacologists in 1985 to a previously unrecognised, intensely sweet chemical that can provide sweetness without tooth decay. A. Douglas Kinghorn, a graduate of the University of Illinois Medical Centre in Chicago took samples of the sweet compound from the leaves and flowers of the *Lippia dulcis* plant, in Guanajuato. The researchers noted the chemical structure of the colourless oil, and named it hernandulcin after Francisco Hernandez. By slightly modifying the compound, they identified the two chemical groups which caused the sweet taste - the carbonyl group, and the hydroxyl group.

3 - Structure:

Hernandulcin is a sesquiterpene with the molecular formula $C_{15}H_{24}O_2$. By slightly modifying the compound, researchers have identified the two chemical groups which caused the sweet taste - the carbonyl group, and the hydroxyl group. The structure of hernandulcin is very simple, and after a panel of volunteers tasted hernandulcin, it was determined that it was 1,000 times sweeter than sugar. Hernandulcin also has a bitter aftertaste, and does not cause tooth decay, which would make it a good candidate for a mouthwash.

High - fructose corn syrup



High - fructose corn syrup railroad tanker

Contents:

- 1 Introduction
- 2 Use as a replacement for sugar
- 3 Comparison to other sugars
 - 3.1 Cane and beet sugar
 - 3.2 Honey
- 4 Production
- 5 Sweetener consumption patterns
 - 5.1 In the United States
 - 5.2 International markets
- 6 Health effects
- 7 Apiculture
- 8 Public relations
 - 8.1 Labeling as "natural"
 - 8.2 HFCS advertisements
 - 8.3 Helpful to the sugar industry

1 – Introduction :

High - fructose corn syrup (HFCS) – called **iso glucose**, **maize syrup**, or **glucose-fructose syrup** in the UK, and **glucose / fructose** in Canada – comprises any of a group of corn syrups that has undergone enzymatic processing to convert its glucose into fructose and has then been mixed with pure corn syrup (100 % glucose) to produce a desired sweetness. In the United States, HFCS is typically

used as a sugar substitute and is ubiquitous in processed foods and beverages, including soft drinks, yogurt, industrial bread, cookies, salad dressing, and tomato soup.

The most widely used varieties of high-fructose corn syrup are: HFCS 55 (mostly used in soft drinks), approximately 55% fructose and 45% glucose; and HFCS 42 (used in many foods and baked goods), approximately 42 % fructose and 58 % glucose. HFCS – 90 , approximately 90 % fructose and 10 % glucose, is used in small quantities for specialty applications, but primarily is used to blend with HFCS 42 to make HFCS 55.

The process by which HFCS is produced was first developed by Richard Off. Marshall and Earl P. Kooi in 1957.^[8] The industrial production process was refined by Dr. Y. Takasaki at Agency of Industrial Science and Technology of Ministry of International Trade and Industry of Japan in 1965–1970. HFCS was rapidly introduced to many processed foods and soft drinks in the U.S. from about 1975 .

Per relative sweetness, HFCS 55 is comparable to table sugar , a di saccharide of fructose and glucose. That makes it useful to food manufacturers as a substitute for sucrose in soft drinks and processed foods. HFCS 90 is sweeter than sucrose; HFCS 42 is less sweet than sucrose.

High-Fructose Corn Syrup	
Nutritional value per 100 g	
Energy	1,176 kJ , (281 kcal)
Carbohydrates	76 g
Dietary fiber	0 g
Fat	0 g
Protein	0 g
Water	24 g
Riboflavin (Vit. B2)	0.019 mg (1%)
Niacin (Vit. B3)	0 mg (0%)

Pantothenic acid (B5)	0.011 mg (0%)
Vitamin B6	0.024 mg (2%)
Folate (Vit. B9)	0 µg (0%)
Vitamin C	0 mg (0%)
Calcium	6 mg (1%)
Iron	0.42 mg (3%)
Magnesium	2 mg (1%)
Phosphorus	4 mg (1%)
Potassium	0 mg (0%)
Sodium	2 mg (0%)
Zinc	0.22 mg (2%)

2 - Use as a replacement for sugar:

Since its introduction, HFCS has begun to replace sugar in various processed foods in the United States. The main reasons for this switch are:

- HFCS is some what cheaper in the United States as a result of a combination of corn subsidies and sugar tariffs / quotas. Since the mid 1990s, the United States federal government has subsidized corn growers by \$40 billion.
- HFCS is easier to blend and transport because it is a liquid.

3 - Comparison to other sugars:

3 – 1 - Cane and beet sugar:

Cane sugar and beet sugar are both relatively pure sucrose. While the glucose and fructose, which are the two components of HFCS, are monosaccharides, sucrose is a disaccharide composed of glucose and fructose linked together with a relatively weak glycosidic bond. A molecule of sucrose (with a chemical formula of $C_{12}H_{22}O_{11}$) can be broken down into a molecule of glucose ($C_6H_{12}O_6$) plus a molecule of fructose (also $C_6H_{12}O_6$ — an isomer of glucose) in a

weakly acidic environment. Sucrose is broken down during digestion into fructose and glucose through hydrolysis by the enzyme sucrase, by which the body regulates the rate of sucrose breakdown. Without this regulation mechanism, the body has less control over the rate of sugar absorption into the bloodstream.

The fact that sucrose is composed of glucose and fructose units chemically bonded complicates the comparison between cane sugar and HFCS. Sucrose, glucose and fructose are unique, distinct molecules. Sucrose is broken down into its constituent mono saccharides – namely, fructose and glucose – in weakly acidic environments by a process called inversion.^[16] This same process occurs in the stomach and in the small intestine during the digestion of sucrose into fructose and glucose. People with sucrase deficiency cannot digest (break down) sucrose and thus exhibit sucrose intolerance.

Sucrose has approximately 4 kcal of energy per gram, while HFCS has approximately 3 kcal per gram. This is because HFCS contains roughly 25% water.

3 – 2 - Honey:

Honey is a mixture of different types of sugars, water, and small amounts of other compounds. Honey typically has a fructose/glucose ratio similar to HFCS 55, as well as containing some sucrose and other sugars. Like HFCS, honey contains water and has approximately 3 kcal per gram. Because of its similar sugar profile and lower price, HFCS has been used illegally to "stretch" honey. As a result, checks for adulteration no longer test for sugar but instead test for minute quantities of proteins that can be used to differentiate between HFCS and honey.

4 – Production:

High-fructose corn syrup is produced by milling corn to produce corn starch, then processing that starch to yield corn syrup, which is almost entirely glucose, and then adding enzymes that change most of the glucose into fructose. The resulting syrup (after enzyme

conversion) contains approximately 90 % fructose and is HFCS 90. To make the other common forms of HFCS (HFCS 55 and HFCS 42) the HFCS 90 is mixed with 100% glucose corn syrup in the appropriate ratios to form the desired HFCS. The enzyme process that changes the 100 % glucose corn syrup into HFCS 90 is as follows:

1. Cornstarch is treated with alpha-amylase to produce shorter chains of sugars called oligosaccharides.
2. Glucoamylase - which is produced by *Aspergillus*, a fungus, in a fermentation vat — breaks the sugar chains down even further to yield the simple sugar glucose.
3. Xylose isomerase (aka glucose isomerase) converts glucose to a mixture of about 42 % fructose and 50 – 52 % glucose with some other sugars mixed in.

While inexpensive alpha - amylase and glucoamylase are added directly to the slurry and used only once, the more costly glucose-isomerase is packed into columns and the sugar mixture is then passed over it, allowing it to be used repeatedly until it loses its activity. This 42 – 43 % fructose glucose mixture is then subjected to a liquid chromatography step, where the fructose is enriched to about 90 %. The 90 % fructose is then back-blended with 42 % fructose to achieve a 55 % fructose final product. Most manufacturers use carbon absorption for impurity removal. Numerous filtration, ion-exchange and evaporation steps are also part of the overall process.

The units of measurement for sugars including HFCS are degrees Brix (symbol °Bx). Brix is a measurement of the mass ratio of dissolved sugars to water in a liquid. A 25 °Bx solution has 25 grams of sugar per 100 grams of solution (25% w/w). Or, to put it another way, there are 25 grams of sugar and 75 grams of water in the 100 grams of solution. The Brix measurement was introduced by Antoine Brix.

When an infrared Brix sensor is used, it measures the vibrational frequency of the high-fructose corn syrup molecules, giving Brix degrees measurement. This will not be the same measurement as Brix degrees using a density or refractive index measurement, because it

will specifically measure dissolved sugar concentration instead of all dissolved solids. When a refractometer is used, it is correct to report the result as "refractometric dried substance" (RDS). One might speak of a liquid as being 20 °Bx RDS. This is a measure of percent by weight of *total* dried solids and, although not technically the same as Brix degrees determined through an infrared method, renders an accurate measurement of sucrose content, since the majority of dried solids are in fact sucrose. The advent of in-line infrared Brix measurement sensors have made measuring the amount of dissolved HFCS in products economical using a direct measurement. It also gives the possibility of a direct volume/volume measurement.

Recently, an isotopic method for quantifying sweeteners derived from corn and sugar cane was developed by which permits measurement of corn syrup- and cane sugar-derived sweeteners in humans, thus allowing dietary assessment of the intake of these substances relative to total intake.

5 - Sweetener consumption patterns:

5 – 1 - In the United States:

US sweetener consumption, 1966 - 2004. It is apparent from this graph that overall sweetener consumption, and in particular glucose-fructose mixtures, has increased since the introduction of HFCS. Thus, the amount of fructose consumed in the United States has increased since the early 1980s. This would be true whether the added sweetener was HFCS, table sugar, or any other glucose-fructose mixture. However, because HFCS has slightly more fructose than does table sugar, the proportion of fructose as a component of overall sweetener intake in the United States has also increased, which would not be true if the increase in overall intake was table sugar.

A system of sugar tariffs and sugar quotas imposed in 1977 in the United States significantly increased the cost of imported sugar and U.S. producers sought cheaper sources. High-fructose corn syrup, derived from corn, is more economical because the domestic U.S. and Canadian prices of sugar are twice the global price and the price of #2 corn is kept low through government subsidies paid to growers.

HFCS became an attractive substitute, and is preferred over cane sugar among the vast majority of American food and beverage manufacturers. Soft drink makers such as Coca-Cola and Pepsi use sugar in other nations, but switched to HFCS in the U.S. in 1984.^[23] Large corporations, such as Archer Daniels Midland, lobby for the continuation of government corn subsidies.

Other countries, including Mexico, typically use sugar in soft drinks. Some Americans seek out Mexican Coca - Cola in ethnic groceries, because they prefer the taste compared to Coke made with HFCS. Kosher for Passover Coca - Cola sold in the U.S. around the Jewish holiday also uses sucrose rather than HFCS and is also highly sought after by people who prefer the original taste.

The average American consumed approximately 28.4 kg of HFCS in 2005, versus 26.7 kg of sucrose. In countries where HFCS is not used or rarely used, sucrose consumption per person may be higher than in the USA; sucrose consumption per person from various locations is shown below (2002) :

- USA: 32.4 kg
- EU: 40.1 kg
- Brazil: 59.7 kg
- Australia: 56.2 kg

Of course, in terms of total sugars consumed, the figures from countries where HFCS is not used should be compared to the sum of the sucrose and HFCS figures from countries where HFCS consumption is significant.

5 – 2 - International markets:

In the European Union (EU), HFCS, known as isoglucose or glucose-fructose syrup:, is subject to a production quota. In 2005, this quota was set at 303,000 tons; in comparison, the EU produced an average of 18.6 million tons of sugar annually between 1999 and 2001. Therefore, wide scale replacement of sugar has not occurred in the EU. In Japan, HFCS consumption accounts for one quarter of total sweetener consumption.

6 - Health effects:

Critics of HFCS point out a correlation between increased usage of HFCS in foods and obesity rates in the United States over three decades. Some allege that HFCS is in itself more detrimental to health than sucrose ; others claim that the low cost of HFCS encourages overconsumption of sugars. The Corn Refiners Association has launched an aggressive advertising campaign to counter these criticisms, claiming that high-fructose corn syrup "is natural" and "has the same natural sweeteners as table sugar". Both sides point to studies in peer reviewed journals that allegedly support their point of view. Elliot *et al.* implicate increased consumption of fructose (due primarily to the increased consumption of sugars but also partly due to the slightly higher fructose content of HFCS as compared to sucrose) in obesity and insulin resistance. Chi-Tang Ho *et al.* found that soft drinks sweetened with HFCS are up to 10 times richer in harmful carbonyl compounds, such as methylglyoxal, than a diet soft drink control, and claimed that sucrose does not have the same tendency to produce these compounds. Carbonyl compounds are elevated in people with diabetes and are blamed for causing diabetic complications such as foot ulcers and eye and nerve damage.

A study in mice suggests that consumption of a fructose solution (not HFCS) increases obesity when compared with a sucrose solution. Large quantities of fructose stimulate the liver to produce tri glycerides, promotes glycation of proteins and induces insulin resistance.

A 2008 study in humans analyzed the circulating levels of glucose, insulin, leptin, ghrelin, and triacylglycerol during a 24 hour period after consuming drinks containing HFCS or sucrose. The researchers concluded that the consumption of HFCS or sucrose did not yield differing metabolic effects.

In a 2007 study, rats were fed a diet high in fat and HFCS and kept relatively sedentary for 16 weeks in an attempt to emulate the diet and lifestyle of many Americans. The rats were not forced to eat, but were able to eat as much as they wanted; they consumed a large

amount of food, and the researcher, Dr. Tetri stated that there is evidence that fructose suppresses the sensation of fullness. Within four weeks, the rats showed early signs of fatty liver disease and type II diabetes. An equivalent diet using sucrose instead of HFCS was not tested. Shapiro *et al.* fed rats a high - fructose diet for six months and compared them to rats that had been fed a fructose - free diet. Although the rats that had consumed high levels of fructose showed no change in weight, when compared to the rats that had consumed a fructose-free diet, levels of leptin in the blood of rats fed a high-fructose diet indicated the development of leptin resistance. When the rats were switched to a high - fat diet, the leptin - resistant rats, those fed a high-fructose diet, gained more weight than those who had not developed the resistance and had been fed a fructose - free diet.

Several studies funded by Tate & Lyle, a large corn refiner, the American Beverage Institute and the Corn Refiners Association,^{[42][43]} have defended HFCS. Forshee *et al.* concluded "that HFCS does not appear to contribute to overweight and obesity any differently than do other energy sources."^[44] Melanson *et al.* (2006), studied the effects of HFCS and sucrose sweetened drinks on blood glucose, insulin, leptin, and ghrelin levels. They found no significant differences in any of these parameters. Monsivais *et al.* (2007) compared the effects of isocaloric servings of colas sweetened with HFCS 42, HFCS 55, sucrose, and aspartame on satiety and subsequent energy intake.^[46] They found that all of the drinks with caloric sweeteners produced similar satiety responses, and had the same effects on subsequent energy intake.

One much - publicized 2004 study found an association between obesity and high HFCS consumption, especially from soft drinks.^[47] However, this study provided only correlative data. One of the study coauthors, Dr. Barry M. Popkin, is quoted in the *New York Times* as saying, "I don't think there should be a perception that high-fructose corn syrup has caused obesity until we know more." In the same article, Walter Willett, chair of the nutrition department of the Harvard School of Public Health, is quoted as saying, "There's no substantial evidence to support the idea that high-fructose corn syrup is somehow responsible for obesity If there was no high-fructose

corn syrup, I don't think we would see a change in anything important." Willett also recommends drinking water over soft drinks containing sugars or high - fructose corn syrup.

A pilot study reported that some high-fructose corn syrup manufactured in the U.S. in 2005 contained trace amounts of mercury. The mercury appeared to come from sodium hydroxide and hydrochloric acid, two chemicals used in the manufacture of high-fructose corn syrup. The caustic soda used by HFCS may be produced in industrial chlorine chlor - alkali plants using the mercury cell Castner - Kellner process, and may contain traces of mercury if this specific process is utilized. Mercury concentrations in the samples testing positive ranged from 0.012 µg / g to 0.570 µg / g (micrograms per gram). Nine of the twenty samples tested did contain measurable amounts of mercury.

7 - Apiculture

In the United States, high - fructose corn syrup has become a sucrose replacement for honey bees. In 2009, a study by Leblanc *et al.* found that at temperatures above 45 °C HFCS rapidly begins to form hydroxymethylfurfural, which is toxic to the honeybees being fed HFCS.

8 - Public relations:

8 – 1 - Labeling as "natural":

In May 2006, the Center for Science in the Public Interest (CSPI) threatened to file a lawsuit against Cadbury Schweppes for labeling 7 Up as "All Natural" or "100 % Natural", despite the presence of high-fructose corn syrup. Although the U.S. Food and Drug Administration (FDA) has no general definition of "natural", CSPI claims that HFCS is not a “natural” ingredient due to the high level of processing and the use of at least one genetically modified (GMO) enzyme required to produce it. On January 12, 2007, Cadbury Schweppes agreed to stop calling 7 Up "All Natural". They now label it "100 % Natural Flavors".

8 – 2 - HFCS advertisements:

In September 2008, the Corn Refiners Association launched a series of United States television advertisements that claim that HFCS "is made from corn", "is natural" (changed from previously-stated "doesn't have artificial ingredients"), "has the same calories as sugar or honey", "is nutritionally the same as sugar", and "is fine in moderation", in an attempt keep consumers from boycotting HFCS. The ads feature actors portraying roles in upbeat domestic situations with sugary foods, with one actor disparaging a food's HFCS content but being unable to explain why, and another actor rebuking the comments with these claims. Finally, the ads each plug the Corn Refiners Association website. As HFCS is a controversial topic, parodies and criticisms of the ads have appeared on YouTube.

8 – 3 - Helpful to the sugar industry:

A March 21, 2009 *New York Times* article said that some food companies and restaurants were using sugar in their product as a selling point, in order to attract customers who prefer not to consume high - fructose corn syrup. As one example, the article cited Jason's Deli, a chain of delis with 200 restaurants in 27 states. The chain had replaced high - fructose corn syrup with sugar in everything except a few soft drinks. Daniel Helfman, a spokesman for the deli chain, was quoted as saying, "Part of this is a huge rebellion against HFCS... but part of it is taste."

Pepsi Co recently put forth a "throwback" version of Mountain Dew and Pepsi - Cola. The reasoning for this second line is unknown now, but there is speculation that Pepsi could be attempting to make up some revenue or to capitalize on a new revenue stream as a result of the backlash against HFCS .This "Throw back" is a version of Pepsi and Mountain Dew in which the HFCS is replaced with sugar.

Honey

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Jars of honey and honeycomb



Honey in honey combs

1 – Introduction :

Honey is a sweet food made by some insects using nectar from flowers. The variety produced by honey bees (the genus *Apis*) is the one most commonly referred to and is the type of honey collected by beekeepers and consumed by humans. Honey produced by other bees and insects has distinctly different properties.

Honey bees form nectar into honey by a process of regurgitation and store it as a food source in wax honeycombs inside the beehive. Beekeeping practices encourage overproduction of honey so that the excess can be taken without endangering the bee colony.

Honey gets its sweetness from the monosaccharides fructose and glucose and has approximately the same relative sweetness as that of granulated sugar (74 % of the sweetness of sucrose, a disaccharide). It

has attractive chemical properties for baking, and a distinctive flavor which leads some people to prefer it over sugar and other sweeteners. Most micro - organisms do not grow in honey because of its low water activity of 0.6. However, honey sometimes contains dormant endospores of the bacterium *Clostridium botulinum*, which can be dangerous to infants as the endospores can transform into toxin-producing bacteria in the infant's immature intestinal tract, leading to illness and even death (see Potential health hazards below).

Honey has a long history as a comestible and is used in various foods and beverages as a sweetener and flavoring. It also has a role in religion and symbolism. Flavors of honey vary based on the nectar source, and various types and grades of honey are available. It is also used in various medicinal traditions to treat ailments. The study of pollens and spores in raw honey (melissopalynology) can determine floral sources of honey. Because bees carry an electrostatic charge, and can attract other particles, the same techniques of melissopalynology can be used in area environmental studies of radioactive particles, dust, or particulate pollution.

2 - Formation:



A honey bee on calyx of goldenrod

Honey is created by bees as a food source. In cold weather or when food sources are scarce, bees use their stored honey as their source of energy.^[8] By contriving for bee swarms to nest in artificial

hives, people have been able to semi-domesticate the insects, and harvest excess honey. In the hive there are three types of bee: a single female queen bee, a seasonally variable number of male drone bees to fertilize new queens, and some 20,000 to 40,000 female worker bees. The worker bees raise larvae and collect the nectar that will become honey in the hive. Leaving the hive, they collect sugar-rich flower nectar and return. In the process, they release Nasonov pheromones. These pheromones lead other bees to rich nectar sites by "smell". Honeybees also release Nasonov pheromones at the entrance to the hive, which enables returning bees to return to the proper hive.

In the hive the bees use their "honey stomachs" to ingest and regurgitate the nectar a number of times until it is partially digested. The bees work together as a group with the regurgitation and digestion until the product reaches a desired quality. It is then stored in honey comb cells. After the final regurgitation, the honeycomb is left unsealed. However, the nectar is still high in both water content and natural yeasts which, unchecked, would cause the sugars in the nectar to ferment. The process continues as bees inside the hive fan their wings, creating a strong draft across the honeycomb which enhances evaporation of much of the water from the nectar.^[8] This reduction in water content raises the sugar concentration and prevents fermentation. Ripe honey, as removed from the hive by a beekeeper, has a long shelf life and will not ferment if properly sealed.

3 - In history, culture, and folklore:

Honey use and production has a long and varied history. In many cultures, honey has associations that go beyond its use as a food. Honey is frequently a talisman and symbol of sweetness.

3 – 1 - Ancient times:

Honey collection is an ancient activity. Eva Crane's *The Archaeology of Beekeeping* states that humans began hunting for honey at least 10,000 years ago. She evidences this with a cave painting in Valencia, Spain. The painting is a Mesolithic rock painting, showing two female honey - hunters collecting honey and honeycomb from a wild bee hive. The two women are depicted in the

nude, carrying baskets, and using a long wobbly ladder in order to reach the wild nest.

In Ancient Egypt, honey was used to sweeten cakes and biscuits, and was used in many other dishes. Ancient Egyptian and Middle-Eastern peoples also used honey for embalming the dead. In the Roman Empire, honey was possibly used instead of gold to pay taxes. Pliny the Elder devotes considerable space in his book *Naturalis Historia* to the bee and honey, and its many uses. The fertility god of Egypt, Min, was offered honey.

In some parts of post - classical Greece, like Rhodes, it was formerly the custom for a bride to dip her fingers in honey and make the sign of the cross before entering her new home.

Honey was also cultivated in ancient Mesoamerica. The Maya used honey from the stingless bee for culinary purposes, and continue to do so today. The Maya also regard the bee as sacred.

Some cultures believed honey had many practical health uses. It was used as an ointment for rashes and burns, and used to help soothe sore throats when no other medicinal practices were available.

3 – 2 - Religious significance:

In Hinduism, honey (Madhu) is one of the five elixirs of immortality (Panchamrita). Honey is used widely as an offering to God. In temples, honey is poured over the deities in a ritual called Madhu abhisheka. The vedas and other ancient literature mention the use of honey as a great medicinal and health food.

In Jewish tradition, honey is a symbol for the new year, Rosh Hashana. At the traditional meal for that holiday, apple slices are dipped in honey and eaten to bring a sweet new year. Some Rosh Hashana greetings show honey and an apple, symbolizing the feast. In some congregations, small straws of honey are given out to usher in the new year.

In Islam, there is an entire Surah in the Qur'an called al – Nahl (the Honey Bee) . According to hadith, Prophet Muhammad strongly recommended honey for healing purposes. Not only does the Qur'an promote honey as a nutritious and healthy food, it also describes that it is the female bee who creates honey within her stomach. Below is the English translation of those specific verses.

And your Lord inspired the bees, saying: "Take you habitations in the mountains and in the trees and in what they erect. (68) Then, eat of all fruits, and follow the ways of your Lord made easy (for you)." There comes forth from their bellies, a drink of varying colour wherein is healing for men. Verily, in this is indeed a sign for people who think.

In Buddhism, honey plays an important role in the festival of Madhu Purnima, celebrated in India and Bangladesh. The day commemorates Buddha's making peace among his disciples by retreating into the wilderness. The legend has it that while he was there, a monkey brought him honey to eat. On Madhu Purnima, Buddhists remember this act by giving honey to monks. The monkey's gift is frequently depicted in Buddhist art.

The Hebrew Bible contains many references to honey. In The Book of Judges, Samson found a swarm of bees and honey in the carcass of a lion (14:8). The Book of Exodus famously describes the Promised Land as a "land flowing with milk and honey" (33:3). However, the claim has been advanced that the original Hebrew (*devash*) actually refers to the sweet syrup produced from the juice of the date.

In the Christian New Testament, Matthew 3:4, John the Baptist is said to have lived for a long period of time in the wilderness on a diet consisting of locusts and wild honey.

3 – 3 - In Western culture:

The word "honey", along with variations like "honey bun" and the abbreviation "hon", has become a term of endearment in most of the English - speaking world. In some places it is used for loved ones;

in others, such as the American South, it is used when addressing casual acquaintances or even strangers.

Also, in many children's books bears are depicted as eating honey, (e.g. Winnie the Pooh) even though most bears actually eat a wide variety of foods, and bears seen at beehives are usually more interested in bee larvae than honey. In some European languages even the word for 'bear' (e.g. in Russian 'medvéd', in Czech 'medvěd', in Hungarian medve, in Croatian 'medvjed') is coined from the noun which means 'honey' and the verb which means 'to eat'. Honey is sometimes sold in bear-shaped jars or squeeze bottles.

4 - Modern uses:



A jar of honey with honey dipper

4 – 1 - As a food and in cooking:

The main uses of honey are in cooking, baking, as a spread on breads, and as an addition to various beverages such as tea and as a sweetener in some commercial beverages. According to international food regulations, "honey stipulates a pure product that does not allow for the addition of any other substance...this includes, but is not limited to, water or other sweeteners".

Honey is the main ingredient in the alcoholic beverage mead, which is also known as "honey wine" or "honey beer" (although it is

neither wine nor beer). Historically, the ferment for mead was honey's naturally-occurring yeast. Honey is also used as an adjunct in beer. Its glycemic index ranges from 31 to 78, depending on the variety.

5 - Nutrition :

Honey: Nutritional value per 100 g (3.5 oz)	
Energy	1,272 kJ , (304 kcal)
Carbohydrates	82.4 g
Sugars	82.12 g
Dietary fiber	0.2 g
Fat	0 g
Protein	0.3 g
Water	17.10 g
Riboflavin (Vit. B2)	0.038 mg (3%)
Niacin (Vit. B3)	0.121 mg (1%)
Pantothenic acid (B5)	0.068 mg (1%)
Vitamin B6	0.024 mg (2%)
Folate (Vit. B9)	2 µg (1%)
Vitamin C	0.5 mg (1%)
Calcium	6 mg (1%)
Iron	0.42 mg (3%)
Magnesium	2 mg (1%)
Phosphorus	4 mg (1%)
Potassium	52 mg (1%)
Sodium	4 mg (0%)
Zinc	0.22 mg (2%)

Honey is a mixture of sugars and other compounds. With respect to carbohydrates, honey is mainly fructose (about 38.5%) and glucose (about 31.0 %), making it similar to the synthetically

produced inverted sugar syrup which is approximately 48 % fructose, 47 % glucose, and 5 % sucrose. Honey's remaining carbohydrates include maltose, sucrose, and other complex carbohydrates. Honey contains trace amounts of several vitamins and minerals.^[22] As with all nutritive sweeteners, honey is mostly sugars and is not a significant source of vitamins or minerals. Honey also contains tiny amounts of several compounds thought to function as antioxidants, including chrysin, pinobanksin, vitamin C, catalase, and pinocembrin. The specific composition of any batch of honey depends on the flowers available to the bees that produced the honey.

Typical honey analysis:

- Fructose: 38.2%
- Glucose: 31.3%
- Sucrose: 1.3%
- Maltose: 7.1%
- Water: 17.2%
- Higher sugars: 1.5%
- Ash: 0.2%
- Other/undetermined: 3.2%

Honey has a density of about 1.36 kilo grams per liter (36 % denser than water).

Isotope ratio mass spectrometry can be used to detect addition of corn syrup or sugar cane sugars by the carbon isotopic signature. Addition of sugars originating from corn or sugar cane (C4 plants, unlike the plants used by bees which are predominantly C3 plants) skews the isotopic ratio of sugars present in honey, but does not influence the isotopic ratio of proteins; in an unadulterated honey the carbon isotopic ratios of sugars and proteins should match. As low as 7 % level of addition can be detected.

6 - Classification:

Honey is classified by its floral source, and there are also divisions according to the packaging and processing used. There are also regional honeys.

6 – 1 - Floral source:

Generally, honey is classified by the floral source of the nectar from which it was made. Honey can be from specific types of flower nectars, from indeterminate origin, or can be blended after collection.

6 – 1 – 1 - Blended:

Most commercially available honey is blended, meaning that it is a mixture of two or more honeys differing in floral source, color, flavor, density or geographic origin.

6 – 1 – 2 - Poly floral:

Poly floral honey, also known as wild flower honey, is derived from the nectar of many types of flowers. The taste may vary from year to year, and the aroma and the flavor can be more or less intense, depending on which bloomings are prevalent.

6 – 1 – 3 - Mono floral:

Mono floral honey is made primarily from the nectar of one type of flower. Different mono floral honeys have a distinctive flavor and color because of differences between their principal nectar sources.^[33] In order to produce mono floral honey beekeepers keep beehives in an area where the bees have access to only one type of flower. In practice, because of the difficulties in containing bees, a small proportion of any honey will be from additional nectar from other flower types. Typical examples of North American monofloral honeys are clover, orange blossom, sage, tupelo, buckwheat, and sourwood. Some typical European examples include thyme, thistle, heather, acacia, dandelion, sunflower, honeysuckle, and varieties from lime and chestnut trees. In North Africa, such as Egypt, examples include clover, cotton, and citrus, mainly orange blossoms.

6 – 1 – 4 - Honeydew honey:

Instead of taking nectar, bees can take honeydew, the sweet secretions of aphids or other plant sap - sucking insects. Honeydew honey is very dark brown in color, with a rich fragrance of stewed

fruit or fig jam and is not as sweet as nectar honeys. Germany's Black Forest is a well known source of honeydew - based honeys, as well as some regions in Bulgaria. In Greece, pine honey (a type of honeydew honey) constitutes 60 - 65 % of the annual honey production. Honeydew honey is popular in some areas, but in other areas beekeepers have difficulty selling the stronger flavored product.

The production of honeydew honey has some complications and dangers. The honey has a much larger proportion of indigestibles than light floral honeys, which can cause dysentery to the bees, resulting in the death of colonies in areas with cold winters. Good beekeeping management requires the removal of honeydew prior to winter in colder areas. Bees collecting this resource also have to be fed protein supplements, as honeydew lacks the protein - rich pollen accompaniment gathered from flowers.

6 – 2 - Classification by packaging and processing:



Honey comb

Generally, honey is bottled in its familiar liquid form. However, honey is sold in other forms, and can be subjected to a variety of processing methods.

6 – 2 – 1 - Comb honey:

- **Comb honey** is honey meant to be consumed still in the honeybees' wax comb. Comb honey traditionally is collected by using standard wooden frames in honey supers. The frames are collected and the comb cut out in chunks before packaging. As an

alternative to this labor intensive method, plastic rings or cartridges can be used that do not require manual cutting of the comb, and speed packaging. Comb honey harvested in the traditional manner is also referred to as "Cut-Comb honey"

- **Chunk honey** is honey packed in widemouth containers consisting of one or more pieces of comb honey immersed in extracted liquid honey.

6 – 2 – 2 - Organic:

- **Certified Organic Honey** is honey or honey combs produced, processed, and packaged in accordance with national regulations, and certified as such by some government body or an independent organic farming certification organization. In the United Kingdom, the standard covers not only the origin of bees, but also the siting of the apiaries. These must be on land that is certified as organic, and within a radius of 4 miles from the apiary site, nectar and pollen sources must consist essentially of organic crops or uncultivated areas. Certified organic honey is less common than other honey because some non-organic beekeepers "routinely use sulfa compounds and antibiotics to control bee diseases, carbolic acid to remove honey from the hive, and calcium cyanide to kill colonies before extracting the honey, not to mention that conventional honeybees gather nectar from plants that have been sprayed with pesticides."

6 – 2 – 2 - Varieties of processing:

- **Crystallized honey** is honey in which some of the glucose content has spontaneously crystallized from solution as the monohydrate. Also called "granulated honey."

- **Pasteurized honey** is honey that has been heated in a pasteurization process. Pasteurization in honey reduces the moisture level, destroys yeast cells, and liquefies crystals in the honey. While this process sterilizes the honey and improves shelf-life, it has some disadvantages. Excessive heat - exposure also results in product deterioration, as it increases the level of hydroxymethylfurfural (HMF) and reduces enzyme (e.g. diastase)

activity. The heat also affects appearance, taste, and fragrance. Heat processing can also darken the natural honey color (browning).

- **Raw honey** is honey as it exists in the beehive or as obtained by extraction, settling or straining without adding heat (although some honey that has been "minimally processed" is often labeled as raw honey).^[40] Raw honey contains some pollen and may contain small particles of wax. Local raw honey is sought after by allergy sufferers as the pollen impurities are thought to lessen the sensitivity to hay fever (see Medical Applications below).

- **Strained honey** is honey which has been passed through a mesh material to remove particulate material (pieces of wax, propolis, other defects) without removing pollen, minerals or valuable enzymes.

- **Ultra filtered honey** is honey processed by very fine filtration under high pressure to remove all extraneous solids and pollen grains. The process typically heats honey to 150–170 °F (approx 65-77 °C) to more easily pass through the fine filter. Ultrafiltered honey is very clear and has a longer shelf life, because it crystallizes more slowly because of the high temperatures breaking down any sugar seed crystals, making it preferred by the supermarket trade. The heating process degrades certain qualities of the honey similar to the aforementioned pasteurization process.

- **Ultra sonicated honey** is honey that has been processed by ultrasonication, a non-thermal processing alternative for honey. When honey is exposed to ultrasonication, most of the yeast cells are destroyed. Yeast cells that survive sonication generally lose their ability to grow. This reduces the rate of honey fermentation substantially. Ultrasonication also eliminates existing crystals and inhibits further crystallization in honey. Ultrasonically aided liquefaction can work at substantially lower temperatures of approximately 35 °C (95 °F) and can reduce liquefaction time to less than 30 seconds.

- **Whipped honey**, also called creamed honey, spun honey, churned honey, candied honey, and honey fondant, is honey that has been processed to control crystallization. Whipped honey

contains a large number of small crystals in the honey. The small crystals prevent the formation of larger crystals that can occur in unprocessed honey. The processing also produces a honey with a smooth spreadable consistency.

- **Dried honey**, has the moisture extracted from liquid honey to create a completely solid, non-sticky honey. This process may or may not include the use of drying and anti-binding agents. Dried honey is commonly used to garnish desserts.

7 - Preservation



Sealed frame of honey

Because of its unique composition and the complex processing of nectar by the bees which changes its chemical properties, honey is suitable for long term storage and is easily assimilated even after long preservation. History knows examples of honey preservation for decades, and even centuries. The main goal is to prevent the fermentation of the honey. Honey should also be protected from oxidation. The ideal example is the natural process of bees sealing of the honey in honeycomb cells with wax caps. The best honey is in the uncut honey combs. After being removed from the comb, honey is very vulnerable, and the main losses of quality take place during preservation and distribution.

A number of special prerequisites are, however, necessary to achieve the conservation. These include sealing the product in vessels of chosen material, kept in a favorable environment of specific

humidity, temperature, etc. Honey should not be preserved in metal containers, because the acids in the honey may promote oxidation of the vessel. This leads to increased content of heavy metals in honey, decreases the amount of nutrients, and may lead to stomach discomfort or even poisoning. Traditionally honey was stored in ceramic or wooden containers, however glass is now the favored material. While ceramic vessels are still a viable option, honey stored in wooden containers may be discolored or take on flavors imparted from the vessel.

Traditionally honey was preserved in deep cellars, but not together with wine or other products.^[44] As honey has a strong tendency to absorb outside smells and moisture, it is advisable to keep it in clean, hermetically sealed vessels. For the same reasons, it is not advisable to preserve honey uncovered in a refrigerator, especially together with other foods and products.

It is also advisable to keep it in opaque vessels, or stored in a dark place. Optimal preservation temperature is 4 to 10 °C. Honey should be stored in a dark, dry place, preventing it from absorbing any moisture. If excessive moisture is absorbed by the honey, it can ferment. When conventional preservation methods are applied, it is not recommended to preserve the honey for longer than 2 (maximum 3) years.

Excessive heat can have detrimental effects on the nutritional value of honey. Heating up to 37°C causes loss of nearly 200 components, part of which are antibacterial. Heating up to 40°C destroys invertase, an important enzyme. Heating up to 50°C turns the honey into caramel (the most valuable honey sugars become analogous to sugar). Generally any larger temperature fluctuation (10°C is ideal for preservation of ripe honey) causes decay.

Acacia honey is known to be more resistant to crystallization.

8 - Distinguishing quality honey:

8 – 1 - Honey grading:

In the US, honey grading is performed voluntarily based upon USDA standards. The quality of honey is graded based upon a number of factors including: soluble solids, water content, flavor, aroma, clarity, absence of defects, and color. The honey grade scale is:

- Grade A - Good
- Grade B - Reasonably Good
- Grade C - Fairly Good
- Substandard - Poor, Failing

8 – 2 - Indicators of quality:

High quality honey can be distinguished by fragrance, taste, and consistency. Ripe, freshly collected, high quality honey at 20 °C should flow from a knife in a straight stream, without breaking into separate drops. After falling down, the honey should form a bead. The honey when poured should form small, temporary layers that disappear fairly quickly, indicating high viscosity. If not, it indicates excessive water content (over 20 %) of the product. Honey with excessive water content is not suitable for long - term preservation.

In jars, fresh honey should appear as a pure, consistent fluid and should not set in layers. Within a few weeks to a few months of extraction, many varieties of honey crystallize into a cream-coloured solid. Some varieties of honey, including tupelo, acacia, and sage, crystallize less regularly.^[53] Honey may be heated during bottling at temperatures of 104 – 120°F to delay or inhibit crystallization without degrading the honey. Although, lack of crystallization is not proof of excessive heating or pasteurization. If transparent and reluctant to thicken, this may indicate that the bees were fed with sugar syrup or even sugar itself, which is bad for the bees and leads to inferior honey. A fluffy film on the surface of the honey (like a white foam), or marble - coloured or white-spotted crystallization on a containers sides, is formed by air bubbles trapped during the bottling process . This is a characteristic of unpasteurized honey.

A 2008 Italian study determined that nuclear magnetic resonance spectroscopy can be used to distinguish between different honey types, and can be used to pinpoint the area where it was produced. Researchers were able to identify differences in acacia and polyfloral honeys by the differing proportions of fructose and sucrose, as well as differing levels of aromatic amino acids phenylalanine and tyrosine. This ability allows greater ease of selecting compatible stocks.

8 – 2 – 1 - Vegans and honey:

During early vegan movements in the 1940s, The Vegan Society in England defined veganism as "the practice of living on the products of the plant kingdom to the exclusion of flesh, fish, fowl, eggs, honey, animal milk and its derivatives, and encourages the use of alternatives for all commodities derived wholly or in part from animals." Vegans do not eat honey as it is considered an animal product. There is active debate in the vegan community on the status of honey as an animal product and its appropriateness for human consumption, though it is regarded as non - vegan on food labels, and most vegans consider honey a non-vegan product.

Vegans will usually eat agave nectar or rice nectar instead of honey, which some consider superior due to its low glycemic index (GI), longer shelf life, similar taste, and quality as it stays smooth and doesn't crystallise like honey does.

8 – 3 - In medicine:

For at least 2700 years, honey has been used by humans to treat a variety of ailments through topical application, but only recently have the antiseptic and antibacterial properties of honey been chemically explained.

Wound gels that contain antibacterial raw honey and have regulatory approval for wound care are now available to help conventional medicine in the battle against drug resistant strains of bacteria MRSA. As an antimicrobial agent honey may have the potential for treating a variety of ailments. One New Zealand

researcher says a particular type of honey may be useful in treating MRSA infections. Antibacterial properties of honey are the result of the low water activity causing osmosis, hydrogen peroxide effect,^[63] and high acidity.

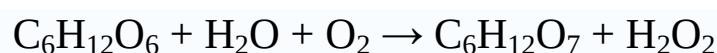
Honey appears to be effective in killing drug-resistant biofilms which are implicated in chronic rhinosinusitis.

8 - 3 – 1 – Osmotic effect:

Honey is primarily a saturated mixture of two mono saccharides. This mixture has a low water activity; most of the water molecules are associated with the sugars and few remain available for micro organisms, so it is a poor environment for their growth. If water is mixed with honey, it loses its low water activity, and therefore no longer possesses this antimicrobial property.

8 -3 -2 - Hydrogen peroxide:

Hydrogen peroxide in honey is activated by dilution. However, unlike medical hydrogen peroxide, commonly 3 % by volume, it is present in a concentration of only 1 mmol/L in honey. Honey chelates and deactivates the free ion, which starts the formation of oxygen free radicals produced by hydrogen peroxide and the antioxidant constituents in honey help clean up oxygen free radicals present.



When used topically (as, for example, a wound dressing), hydrogen peroxide is produced by dilution with body fluids. As a result, hydrogen peroxide is released slowly and acts as an antiseptic.

8 -3 -2 -1 - In diabetic ulcers:

Topical honey has been used successfully in a comprehensive treatment of diabetic ulcers when the patient cannot use other topical antibiotics.

8 - 3 – 3 - Acidity:

The pH of honey is commonly between 3.2 and 4.5. This relatively acidic pH level prevents the growth of many bacteria.

8 - 3 – 4 - Nutraceutical effects:

Anti oxidants in honey have even been implicated in reducing the damage done to the colon in colitis . Such claims are consistent with its use in many traditions of folk medicine.

8 - 3 – 5 - For throats:

Honey has also been used for centuries as a treatment for sore throats and coughs, and according to recent research may in fact be as effective as many common cough medicines. It is important to remember however that this is an initial study with a small sample size.

Mixed with lemon juice and consumed slowly, honey coats the throat, alleviating discomfort. The antibacterial and antiseptic properties of honey aid in healing sore throats and laryngitis.

8 - 3 – 6 - Other medical applications:

Some studies suggest that the topical use of honey may reduce odors, swelling, and scarring when used to treat wounds; it may also prevent the dressing from sticking to the healing wound. Honey has been shown to be an effective treatment for conjunctivitis in rats.

Though widely believed to alleviate allergies, commercial honey has been shown to be no more effective than placebos in controlled studies of ocular allergies. However, a recent study has shown pollen collected by bees to exert an anti allergenic effect, mediated by an inhibition of IgE immunoglobulin binding to mast cells. This inhibited mast cell degranulation and thus reduced allergic reaction.

Honey mixed with water and vinegar was also used as a vermifuge. The concoction was called Oxymellin.

A review in the Cochrane Library suggests that honey could reduce the time it takes for a burn to heal - up to four days sooner in some cases. The review included 19 studies with 2,554 participants. Although the honey treatment healed moderate burns faster than traditional dressings did, the author recommends viewing the findings with caution, since a single researcher performed all of the burn studies.

8 – 4 - Potential health hazards:

Because of the natural presence of botulinum endospores in honey, children under one year of age should not be given honey. The more developed digestive systems of older children and adults generally destroy the spores. Infants, however, can contract botulism from honey.

Infantile botulism shows geographical variation. In the UK, there have only been six cases reported between 1976 and 2006 , yet the USA has much higher rates 1.9 per 100,000 live births, 47.2% of which are in California. Although honey has been implicated as a risk factor for infection, it is household dust that is the major source of spores. Therefore the risk honey poses to infant health is small, if uncertain.

Honey produced from the flowers of rhododendrons, mountain laurels, sheep laurel, and azaleas may cause honey intoxication. Symptoms include dizziness, weakness, excessive perspiration, nausea, and vomiting. Less commonly, low blood pressure, shock, heart rhythm irregularities, and convulsions may occur, with rare cases resulting in death. Honey intoxication is more likely when using "natural" unprocessed honey and honey from farmers who may have a small number of hives. Commercial processing, with pooling of honey from numerous sources, generally dilutes any toxins.

Toxic honey may also result when bees are in close proximity to tutu bushes (*Coriaria arborea*) and the vine hopper insect (*Scolypopa australis*). Both are found throughout New Zealand. Bees gather honeydew produced by the vine hopper insects feeding on the tutu plant. This introduces the poison tutin into honey. Only a few areas in

New Zealand (Coromandel Peninsula, Eastern Bay of Plenty and the Marlborough Sound) frequently produce toxic honey. Symptoms of tutin poisoning include vomiting, delirium, giddiness, increased excitability, stupor, coma, and violent convulsions. To reduce the risk of tutin poisoning, humans should not eat honey taken from feral hives in the risk areas of New Zealand. Since December 2001, New Zealand beekeepers have been required to reduce the risk of producing toxic honey by closely monitoring tutu, vine hopper, and foraging conditions within 3 km of their apiary.

9 - Honey producing countries:

In 2005, China, Argentina, Turkey and the United States were the top producers of natural honey, reports the Food and Agriculture Organization of the United Nations (FAO).

The largest volume of honey in Europe is produced in Turkey (ranked 3rd world wide) and in Ukraine (ranked 5th worldwide).^[84]

Mexico is also an important producer of honey, providing about ten percent of the world's supply. Much of this (about one-third) comes from the Yucatán Peninsula. Honey production began there when the *Apis mellifera* and the *A. mellifer ligustica* were introduced there early in the 20th century. Most of Mexico's Yucatán producers are small, family operations who use original traditional techniques, moving hives to take advantage of the various tropical and sub-tropical flowers. The honey-producing cycle depends on the rainy season. The first and best harvest takes place in the dry season between February and May. Many species flower at this time. After the rainy season begins, there are still plenty of flowers but the bees have a difficult time traveling for nectar and producing the honey because of the weather conditions. Bees may not make enough for sale and what may be produced is of lower - quality.

Honey is also one of the gourmet products of the French island of Corsica. Corsican honey is certified as to its origin (Appellation d'origine contrôlée) just as French wines, like Champagne, are.

Inverted sugar syrup

Contents:

- 1 Introduction
- 2 Chemical reaction of the inversion
- 3 Inverting sugar
- 4 Shelf life
- 5 Examples

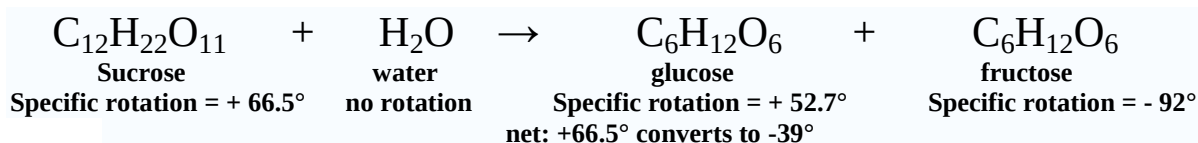
1 - Introduction:

Inverted or **invert sugar syrup** is a mixture of glucose and fructose. It is obtained by splitting sucrose into its two components. Compared with its precursor sucrose, inverted sugar is sweeter and its products tend to stay moist and are less prone to crystallisation. Inverted sugar is therefore valued by bakers, who refer to the syrup as 'trimoline' or 'invert syrup'.

In technical terms, sucrose is a disaccharide, a molecule derived from two monosaccharides, fructose and glucose. The splitting of sucrose is a hydrolysis reaction. The hydrolysis can be induced simply by heating an aqueous solution of sucrose, but more commonly, catalysts are added to accelerate the conversion. The biological catalysts are sucrases (in animals) and invertases (in plants), glycoside hydrolase enzymes. Acid, such as occurs in lemon juice or cream of tartar, also accelerates the conversion of sucrose to invert.

2 - Chemical reaction of the inversion:

The term 'inverted' is derived from the method of measuring the concentration of sugar syrup using a polarimeter. Plane polarized light, when passed through a sample of pure sucrose solution, is rotated to the right (optical rotation). As the solution is converted to a mixture of sucrose, fructose and glucose, the amount of rotation is reduced until (in a fully converted solution) the direction of rotation has changed (inverted) from right to left.



Hydrolysis is a chemical reaction in which a molecule breaks down by the addition of water. Hydrolysis of sucrose yields glucose and fructose about 85 %, the reaction temperature can be maintained at 50 - 60 °C.

3 - Inverting sugar:

Inverted sugar syrup can be easily made by adding roughly one gram of citric acid or ascorbic acid, per kilo gram of sugar. Cream of tartar (one gram per kilo gram) or fresh lemon juice (10 milli litres per kilogram) may also be used.

The mixture is boiled for 20 minutes, and will convert enough of the sucrose to effectively prevent crystallization, with out giving a noticeably sour taste. Invert sugar syrup may also be produced with out the use of acids or enzymes by thermal means alone: two parts granulated sucrose and one part water simmered for five to seven minutes will convert a modest portion to invert sugar.

All inverted sugar syrups are created from hydrolysing sucrose to glucose (dextrose) and fructose by heating a sucrose solution, then relying on time alone, with the catalytic properties of an acid or enzymes used to speed the reaction. Commercially prepared acid catalysed solutions are neutralised when the desired level of inversion is reached.

All constituent sugars (sucrose, glucose and fructose) support fermentation, so invert sugar solutions may be fermented as readily as sucrose solutions.

4 - Shelf life:

Invert sugar has a lower water activity than that of sucrose, so it provides more powerful preserving qualities (a longer shelf life) to products that use it.

The shelf life of partial inverts is approximately six months, depending on storage and climatic conditions. Crystallised invert sugar solutions may be restored to their liquid state by gently heating.

5 – Examples:

- Toffee
- Honey is a mixture (principally) of glucose and fructose, giving it similar properties to invert syrup. This gives it the ability to remain liquid for long periods of time.
- Jam, when made, produces invert sugar during extensive heating under the action of the acid in the fruit.
- Golden syrup is a syrup of approximately 56 % invert syrup , 44 % sucrose.
- Fondant filling for chocolates is unique in that the conversion enzyme is added, but not activated before the filling is enrobed with chocolate. The very viscous (and thus formable) filling then becomes less viscous with time, giving the creamy consistency desired.
- Quaker Granola Bars contain inverted sugar.
- York Peppermint Patties contain inverted sugar.
- Junior Mints contain inverted sugar.
- Jones Soda sweeten their soda with inverted cane sugar.
- Jujubes contain inverted sugar.
- Sour Patch Kids contain inverted sugar.
- Caramello candy bars contain inverted sugar.
- Swedish Fish contain inverted sugar.
- Sour Patch contain inverted sugar.
- Sugar Babies contain inverted sugar.
- Cadbury eggs contain inverted sugar.
- Wheat Thins contain inverted sugar.
- Cigarettes use inverted sugar as a 'casing' to add flavour.

Isomalt

1 - Introduction :

Isomalt is a sugar substitute, a type of sugar alcohol, which is primarily used for its sugar-like physical properties. It has only a small impact on blood sugar levels and does not promote tooth decay. It has 2 kcal / g , half the calories of sugars. However, like most sugar alcohols, it carries a risk of gastric distress, including flatulence and diarrhea, when consumed in large quantities. Isomalt is advised to not be consumed in quantities larger than about 50g per day for adults and 25g for children. The reason that isomalt may prove upsetting to the stomach is because the body treats it as a dietary fiber instead of as a simple carbohydrate. Therefore, like most fibers, it can increase bowel movements and it passes through the bowel in virtually undigested form. Like other dietary fibers, regular consumption of isomalt might eventually lead one to become desensitized to it, decreasing the risk of stomach upset. Isomalt is typically blended with a high intensity sweetener such as sucralose, so that the mixture has approximately the sweetness of sugar.

Isomalt is a disaccharide composed of the two sugars glucose and mannitol. It is an odourless, white, crystalline substance containing about 5 % water of crystallisation. Isomalt has a minimal cooling effect (positive heat of solution), lower than many other sugar alcohols, particularly xylitol and erythritol. Isomalt is unusual as it is a natural sugar alcohol that is produced from beets. An interesting use of isomalt is found in the product DiabetiSweet, a sugar substitute sold for baking use and composed of a blend of isomalt and acesulfame potassium, but it has a bitter taste (due to the acesulfame potassium) and lacks the caramelizing properties of sugar.

Isomalt is manufactured in a two-stage process in which sugar is first transformed into isomaltulose, a reducing disaccharide (6-O- α -D-glucopyranosido-D-fructose). The isomaltulose is then hydrogenated, using a Raney metal catalytic converter. The final product—**isomalt**—is an equimolar composition of 6-O- α -D-glucopyranosido-D-sorbitol

(1,6-GPS) and 1-O- α -D-glucopyranosido-D-mannitol-dihydrate (1,1-GPM-dihydrate).

Isomalt has been approved for use in the United States since 1990. It is also permitted for use in Australia, New Zealand, Norway and Holland.

Isomalt can be used in sugar sculpture and is preferred by some because it will not crystalize as quickly as sugar.

Other names	1-O-alpha-D-Glucopyranosyl-D-mannitol
Molecular formula	$C_{12}H_{24}O_{11}$
Molar mass	344 g / mol

Jaggery



A block of Indian jaggery

1 – Introduction :

Jaggery (also transliterated as *jaggeree*), **bella / gur** (India, Pakistan and Bangladesh), **hakuru** (Sri Lanka), **panela** (Spanish South America), and **rapadura** (Brazil) , is a traditional unrefined non-centrifugal sugar consumed in Asia, Africa and South America.^[1] It is made for direct consumption. This type of sugar is a concentrated product of cane juice without separation of the molasses and crystals, and can vary from golden brown to dark brown in color.^[1] It contains up to 50% sucrose, up to 20% invert sugars, moisture content of up to 20%, and the remainder made up of other insoluble matter such as ash, proteins and bagasse fibers.

2 - Origins and production:



Making jaggery in Burma near Mount Popa

Although the Merriam - Webster dictionary defines it as 'unrefined sugar from palm sap', the word *jaggery* is used for the products of both sugarcane and the palm tree. The sugar made from the sap of the date palm is both more prized and less available outside of the districts where it is made. The sago palm and coconut palm are also now tapped for producing jaggery in southern India, Pakistan and Sri Lanka.

In Mexico and South America, similar sugarcane products are known as "*panela*" or "*piloncillo*".

All types of the sugar come in blocks or pastes of solidified concentrated sugar syrup heated to 200°C. Traditionally, the syrup is made by boiling raw sugarcane juice or palm sap in a large shallow round - bottom vessel as shown here.

The Indian state of Maharashtra is the largest producer and consumer of jaggery. In Maharashtra most vegetables curries and dals contain jaggery. Jaggery is specially used during Makar Sankranti for making sweetmeat called *tilgul*. In rural Maharashtra, water and a piece of jaggery is given when someone arrives home from working under a hot sun. Kakvi, a byproduct from production of jaggery, is also used in rural Maharashtra as a sweetener. It contains many minerals not found in ordinary sugar and is considered beneficial to health by the traditional Ayurvedic medical system.

In addition, in the Indian state of Rajasthan, *gur* has a religious significance. Many of the festivals are incomplete without gur as it is offered to the deity during worship. Also, it is regularly consumed as a sweetener and is a part of many sweet delicacies such as gur ka chawal (rice with gur) which is a traditional Rajasthani dish.

In Myanmar, jaggery, known as *htanyet* (which means "toddy lick"), is harvested from toddy palm syrup. In central Myanmar and around Bagan (Pagan), toddy syrup is collected solely for the purpose of making jaggery. The translucent white syrup is boiled until it becomes golden brown, and then made into bite-sized pieces.

3 - Uses

Jaggery is used as an ingredient in both sweet and savory dishes across Pakistan, India and Sri Lanka. For example, a pinch of jaggery is sometimes added to sambar, rasam and other gravies which are staples in India.

Jaggery is also added to lentil soups (dāl) to add sweetness to balance the spicy, salty and sour components, particularly in Gujarati cuisine called (**gaur**) add in cooking.

In Pakistani and Bengali cuisine it is referred as *gur* , and is very common in making sweet dishes. Special sweet dishes are made by mixing jaggery with milk and coconut. Popular sweet dishes like *Naru* or *Patisapta Pitha* are made by mixing jaggery with coconut shreddings. Jaggery is also molded into novelty shapes as a type of candy.

Other uses include jaggery toffees and jaggery cake made with pumpkin preserve, cashew nuts, pea nuts and spices.

Jaggeries are also considered auspicious in many parts of India, and is eaten raw before commencement of good work or any important new venture, or after good news are shared by family and friends. The Muzaffarnagar District in Uttar Pradesh has the largest jaggery market in India, followed by Anakapalli of the Visakhapatnam District in Andhra Pradesh. These are the biggest and second biggest in the entire world. Kolhapur a district place in western Maharashtra is also famous for its variety which is yellow in color and is most sought after in Maharashtra. Jaggery from this place is exported.

In Myanmar jaggery is considered a sweet and is eaten by children and adults alike, usually in the afternoon along with a pot of green tea. It has been referred to locally as Burmese chocolate. Toddy palm jaggery is also sometimes mixed with coconut shreddings, jujube puree or sesame, depending on the area. This type of jaggery is also used in Burmese cooking, usually to add color and enrich the food.



Preparation of jaggery

4 - Health benefits

Jaggery is considered by some to be a particularly wholesome sugar and, unlike refined sugar, it retains more mineral salts. Moreover, the process does not involve chemical agents. Indian Ayurvedic medicine considers jaggery to be beneficial in treating throat and lung infections; Sahu and Saxena^[3] found that in rats jaggery can prevent lung damage from particulate matter such as coal and silica dust. Gandhi felt that jaggery was healthier than refined sugar, as it was not introduced into the blood as rapidly.^[4] As such, he used it in his own personal diet and recommended it for use in his invented goat-milk diet (and all other diets and eating styles).

5 - Names of Jaggery:

- *Gur* in Assamese , in Urdu , in Bengali , in Hindi & in Punjabi
- *Rapadura* in Brazil
- *Tapa de Dulce* in Costa Rica
- *Raspadura* in Cuba
- *Rapadou* in Haiti
- *Gaur* in Gujarati
- *Panela* and *piloncillo* in Latin American Languages
- *Gula Melaka* in Malay
- *Vellam / karumbu Sarkarai* in Tamil [for Jaggery made from Sugarcane]
- *Panocha* or *Panutsa* in the Philippines
- *Hakuru* in Sri Lanka

- *Sukari Nguuru* in Swahili (and all over Kenya.)
- *Karuppaṭṭi* in Tamil (for Jaggery made from Palm Wine)
- *Papelón* in Venezuela



Burmese jaggery at a market in Mandalay

Jallab

Jallab (from Arabic, **بالج**) is a type of syrup popular in the Middle East made from carob, dates, grape molasses and rose water. In Syria and Lebanon Jallab is very popular. It is made mainly of grape molasses and artificial coloring, then smoked with Arabic incense. It is usually sold with crushed ice and floating pine nuts and raisins.

Jiaogulan



Gynostemma pentaphyllum

Scientific classification

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Cucurbitales
Family:	Cucurbitaceae
Subfamily:	Zanonioideae
Subtribe:	Gomphogyninae
Genus:	<i>Gynostemma</i>
Species:	<i>G. pentaphyllum</i>

Binomial name

Gynostemma pentaphyllum

1 –Introduction :

Gynostemma pentaphyllum, also called **jiaogulan**, is an herbaceous vine of the family Cucurbitaceae (cucumber or gourd family) indigenous to the southern reaches of China, southern Korea and Japan. Jiaogulan is best known as an herbal medicine reputed to have powerful antioxidant and adaptogenic effects that increase longevity.

2 – Range :

Jiaogulan is a vine hardy to USDA zone 8 in which it may grow as a short lived perennial plant. It can be grown as an annual in most temperate climates, in well-drained soil with full sun. The plant is dioecious, meaning each plant exists either as male or female, thus if seeds are desired both a male and female plant must be grown. Unlike most of the Cucurbitaceae, jiaogulan does not show toxicity.

3 – Uses:

3 – 1 – Ethnomedicine:

The plant is best known for its use as an herbal medicine in traditional Chinese medicine. A botany book by Wu Qi-Jun from 1848 *Zhi Wu Ming Shi Tu Kao Chang Bian* discusses a few medicinal uses and seems to be the earliest known documentation of the herb. Jiaogulan had been cited previously as a survival food in Zu Xio's 1406 book *Materia Medica for Famine*. Until recently it was a locally known herb used primarily in regions of southern China. It is described by the local inhabitants as the immortality herb, because people within Guizhou Province, where jiaogulan tea is drunk regularly, are said have a history of living to a very old age.

Jiaogulan is most often consumed as an herbal tea, and is also available as an alcohol extract and in capsule or pill form.^[3] It is known as an adaptogen and antioxidant. Because of its adaptogenic effects it is frequently referred to as "Southern Ginseng," although it is not closely related to true *Panax ginseng*. Its adaptogenic constituents include the triterpenoid saponins gypenosides which are closely structurally related to the ginsenosides from the well-known medicinal plant ginseng. Jiaogulan is a calming adaptogen which is also useful in formula with codonopsis for jet lag and altitude sickness. Most research has been done since the 1960s when the Chinese realized that it might be an inexpensive source of adaptogenic compounds, taking pressure off of the ginseng stock.

Jiaogulan tea is also marketed in the United States under the trade names **Panta tea** or **Penta tea**, depending on the supplier.

Lactitol

1 – Introduction :

Lactitol is a sugar alcohol used as a replacement bulk sweetener for low calorie foods with approximately 40 % of the sweetness of sugar.

Other names	Lactitol Lacty
Properties	
Molecular formula	$C_{12}H_{24}O_{11}$
Molar mass	344 g / mol
Density	? g / cm ³
Melting point	146 °C

2 - Applications

Lactitol is used in a variety of low food energy or low fat foods. High stability makes it popular for baking. It is used in sugar-free candies, cookies (biscuits), chocolate, and ice cream. Lactitol also promotes colon health as a prebiotic. Lactitol only has 2.4 Calories (9 kilojoules) per gram, compared to 4 Calories (17 kJ) per gram for typical carbohydrates.

Lactitol is listed as an "inactive" ingredient in some prescription drugs, such as Adderall, or amphetamine.

3 - Safety and health

Lactitol, sorbitol, xylitol, mannitol, and maltitol are all sugar alcohols. The United States Food and Drug Administration (FDA) classifies sugar alcohols as "generally recognized as safe" (GRAS). They are approved as food additives, and are recognized as not contributing to tooth decay or causing increases in blood glucose. Lactitol is also approved for use in foods in most countries around the world.

Although endorsed by numerous diet and diabetic websites, Lactitol can cause cramping, flatulence, and diarrhoea in some individuals. This may be in part because "Lactitol is manufactured from whey, the lactose (milk sugar) rich by-product of cheese making and processed dairy foods" and people can be lactose intolerant. Those with other health conditions should consult their GP or dietician prior to consumption.

Lactitol is animal based and are there fore not suitable for vegans.

Lactose

1 – Introduction :

Lactose is a sugar that is found most notably in milk. Lactose makes up around 2– 8 % of milk (by weight), although the amount varies among species and individuals. It is extracted from sweet or sour whey. The name comes from *lacte*, the Latin word for milk, plus the -ose ending used to name sugars.

Other names	Milk sugar 4- <i>O</i> - β -D-galacto pyranosyl-D-glucose
Properties	
Molecular formula	$C_{12}H_{22}O_{11}$
Molar mass	342 g/mol
Appearance	white solid
Solubility in water	21.6 g / 100 mL

2 - Chemistry:

Lactose is a disaccharide that consists of galactose and glucose fragments bonded through a β -1 $\rightarrow$ 4 glycosidic linkage. Its systematic name is β -D-galactopyranosyl-(1 $\rightarrow$ 4)-D-glucose. The glucose fragment can be in either the α -pyranose form or the β -pyranose form, whereas the galactose fragment can only have the β -pyranose form: hence α -lactose and β -lactose refer to anomeric form of the glucopyranose ring alone.

As it gives free radicals by mechanochemistry, it is possible to use lactose to follow by ESR (electron spin resonance) the energy used during a milling process.

3 - Solubility

The solubility of lactose in water is 19 g at 25 °C, 25 g at 40 °C and 37 g at 60 °C per 100 g solution. Its solubility in ethanol is 0.0111 g at 40 °C and 0.0270 g at 60 °C per 100 g solution.

4 - Digestion of lactose (catabolism)

Infant mammals nurse on their mothers to drink milk, which is rich in the carbohydrate lactose. The intestinal villi secrete an enzyme called lactase (β -D-galactosidase) to digest it. This enzyme cleaves the lactose molecule into its two subunits, the simple sugars glucose and galactose, which can be absorbed.

Since lactose occurs mostly in milk, in most mammals the production of lactase gradually decreases with maturity due to a lack of constant consumption.

Many people with ancestry in Europe, the Middle East, India, and parts of East Africa maintain lactase production into adulthood. In many of these areas, milk from mammals such as cattle, goats, and sheep is used as a large source of food. Hence, it was in these regions that genes for lifelong lactase production first evolved. The genes of lactose tolerance have evolved independently in various ethnic groups.

People who are lactose intolerant may suffer uncomfortable or socially unacceptable symptoms of too much lactose consumption. In these people, lactose is not broken down and provides food for gas-producing gut flora. This can lead to bloating, flatulence, and other gastrointestinal symptoms.

Liquorice



Contents

- 1 Introduction
- 2 Cultivation and uses
 - 2.1 Use in medicine
 - 2.2 Use in alternative medicine
 - 2.3 Uses with tobacco
 - 2.4 Toxicity

1 – Introduction :

Liquorice is the root of *Glycyrrhiza glabra* from which a sweet flavour can be extracted. The liquorice plant is a legume (related to beans and peas), native to southern Europe and parts of Asia. It is not related to Anise, Star Anise or Fennel, which are the source of superficially similar flavouring compounds. It is an herbaceous perennial, growing to 1 m in height, with pinnate leaves about 7–15 centimetres long, with 9 – 17 leaflets. The flowers are 0.8 –1.2 cm long, purple to pale whitish blue, produced in a loose inflorescence.

The fruit is an oblong pod, 2–3 centimetres long, containing several seeds. The flavor of liquorice comes mainly from a sweet - tasting compound called anethole ("trans" -1-methoxy- 4 - (prop -1- enyl) benzene) , an aromatic, unsaturated ether compound also found in anise, fennel, and other herbs. Additional sweetness in liquorice comes from glycyrrhizic acid, an anti - viral compound significantly sweeter than sugar.

Scientific classification	
Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Tribe:	Galegeae
Genus:	<i>Glycyrrhiza</i>
Species:	<i>G. glabra</i>
Binomial name	
<i>Glycyrrhiza glabra</i> L.	

2 - Cultivation and uses:

Liquorice grows best in deep, fertile, well-drained soils, with full sun, and is harvested in the autumn, two to three years after planting.

In modern times, liquorice extract is produced by boiling liquorice root and subsequently evaporating most of the water. In fact, the name 'liquorice' / 'licorice' is derived (via the Old French *licoresse*), from the Ancient Greek *glukurrhiza*, meaning 'sweet root'.^[4] Liquorice extract is traded both in solid and syrup form. Its active principle is glycyrrhizin, a sweetener more than 50 times as sweet as sucrose which also has pharmaceutical effects.

Liquorice flavour is found in a wide variety of liquorice candies. The most popular in the United Kingdom are liquorice allsorts. In continental Europe, however, far stronger, saltier candies are

preferred. It should be noted, though, that in most of these candies the taste is reinforced by aniseed oil, and the actual content of liquorice is very low.

In the Netherlands, where liquorice candy ("drop") is one of the most popular forms of sweet, only a few of the many forms that are sold contain aniseed (although mixing it with mint, menthol or with laurel is popular, and mixing it with ammonium chloride creates the very popular salty liquorice known in Dutch as *zoute drop*).

Pontefract in Yorkshire was the first place where liquorice mixed with sugar began to be used as a sweet in the same way it is in the modern day. Pontefract Cakes were originally made there. In Yorkshire and Lancashire it is colloquially known as *Spanish*, supposedly because Spanish monks grew liquorice root at Rievaulx Abbey near Thirsk.

Liquorice flavouring is also used in soft drinks, and is in some herbal teas where it provides a sweet after-taste. The flavour is common in medicines to disguise unpleasant flavours. Dutch youth often make their own "dropwater" (liquorice water) by putting a few pieces of laurel liquorice and a piece of liquorice root in a bottle with water and then shake it to a frothy liquid. Also popular in the Netherlands is a liquorice based liqueur called "dropshot".

Liquorice is popular in Italy (particularly in the South) and Spain in its natural form. The root of the plant is simply dug up, washed and chewed as mouth-freshener. Throughout Italy unsweetened liquorice is consumed in the form of small black pieces made only from 100 % pure liquorice extract; the taste is bitter and intense. In Calabria a popular liqueur is made from pure liquorice extract. Liquorice is also very popular in Syria where it is sold as a drink. Dried liquorice root can be chewed as a sweet. Black liquorice contains approximately 100 calories per ounce (15 kJ / g).

Chinese cuisine uses liquorice as a culinary spice for savoury foods. It is often employed to flavour broths and foods simmered in soy sauce.

Other herbs and spices of similar flavour include anise, star anise, tarragon, and fennel.

It is also the main ingredient of a very well known soft drink in Egypt, called **فرع سوس** ('erk-soos).

2 – 1 - Use in medicine:

Powdered liquorice root is an effective expectorant, and has been used for this purpose since ancient times, especially in Ayurvedic medicine where it is also used in tooth powders and is known as **Jastimadhu**. Modern cough syrups often include liquorice extract as an ingredient. Additionally, liquorice may be useful in conventional and naturopathic medicine for both mouth ulcers and peptic ulcers. Non-prescription aphthous ulcer treatment Canker Melts incorporates glycyrrhiza in a dissolving adherent troche. Liquorice is also a mild laxative and may be used as a topical antiviral agent for shingles, ophthalmic, oral or genital herpes. The compound glycyrrhizic acid, found in liquorice, is now routinely used throughout Japan for the treatment and control of chronic viral hepatitis, and its transaminase-lowering effect is clinically well recognized.

Hepatoprotective mechanisms have been demonstrated in mice. Recent studies indicate that glycyrrhizic acid disrupts latent Kaposi sarcoma (as also demonstrated with other herpesvirus infections in the active stage), exhibiting a strong anti-viral effect.

Liquorice affects the body's endocrine system as it contains isoflavones (phytoestrogens). It can lower the amount of serum testosterone, but whether it affects the amount of free testosterone is unclear. Consuming liquorice is recommended for reducing high sex drive in men. Consuming liquorice can prevent hyperkalemia. Large doses of glycyrrhizic acid and glycyrrhetic acid in liquorice extract can lead to hypokalemia and serious increases in blood pressure, a syndrome known as apparent mineralocorticoid excess. These side effects stem from the inhibition of the enzyme 11 β -hydroxysteroid dehydrogenase (type 2) and subsequent increase in activity of cortisol on the kidney. 11 β - hydroxysteroid dehydrogenase normally inactivates cortisol in the kidney; thus, liquorice's inhibition

of this enzyme makes the concentration of cortisol appear to increase. Cortisol acts at the same receptor as the hormone aldosterone in the kidney and the effects mimic aldosterone excess, although aldosterone remains low or normal during liquorice overdose. To decrease the chances of these serious side effects, deglycyrrhizinated liquorice preparations are available. The disabling of similar enzymes in the gut by glycyrrhizinic acid and glycyrrhetinic acid also causes increased mucus and decreased acid secretion. It inhibits *Helicobacter pylori*, is used as an aid for healing stomach and duodenal ulcers, and in moderate amounts may soothe an upset stomach. Liquorice can be used to treat ileitis, leaky gut syndrome, irritable bowel syndrome and Crohn's disease as it is antispasmodic in the bowels.

The compounded carbenoxolone is derived from liquorice. Studies indicate it may inhibit an enzyme in the brain that is involved in making stress - related hormones, which have been associated with age-related mental decline.

2 – 2 - Use in alternative medicine:

In traditional Chinese medicine, liquorice is commonly used in herbal formulae to "harmonize" the other ingredients in the formula and to carry the formula to the twelve "regular meridians"^[17] and to relieve a spasmodic cough.

In herbalism it is used in the Hoxsey anti-cancer formula, and is a considered adaptogen which helps reregulate the hypothalamic-pituitary-adrenal axis. It can also be used for auto-immune conditions including lupus, scleroderma, rheumatoid arthritis and animal dander allergies.

2 – 3 - Uses with tobacco:

A significant amount of liquorice production goes toward flavouring, sweetening and conditioning tobacco products. Liquorice adds a mellow, sweet woody flavour, and it enhances the taste of tobacco. The burning liquorice also generates some toxins found in the smoke, and the glycyrrhizin expands the airways, which allows users to inhale more smoke.

2 – 4 - Toxicity:

Excessive consumption of liquorice or liquorice candy is known to be toxic to the liver and cardiovascular system, and may produce hypertension and oedema. There have been occasional cases where blood pressure has increased with excessive consumption of liquorice tea, but such occasions are rare and reversible when the herb is withdrawn . Most cases of hypertension from liquorice were caused by eating too much concentrated liquorice candy. Doses as low as 50 grams (2 oz) of liquorice daily for two weeks can cause a significant rise in blood pressure .

The European Commission 2008 report suggested that “people should not consume any more than 100mg of glycyrrhizic acid a day, for it can raise blood pressure or cause muscle weakness, chronic fatigue, headaches or swelling, and lower testosterone levels in men.” Haribo, manufacturer of Pontefract cakes, stated: “Haribo advises, as with any other food, liquorice products should be eaten in moderation.” A 56-year-old Yorkshire woman was hospitalized after liquorice overdose (200 grams or 7 ounces a day), which caused muscle failure. The hospital restored her potassium levels, by intravenous drip and tablets, allowing her to recover after 4 days.

Comparative studies of pregnant women suggest that liquorice can also adversely affect both IQ and behaviour traits of offspring.^[28]

Liquorice root

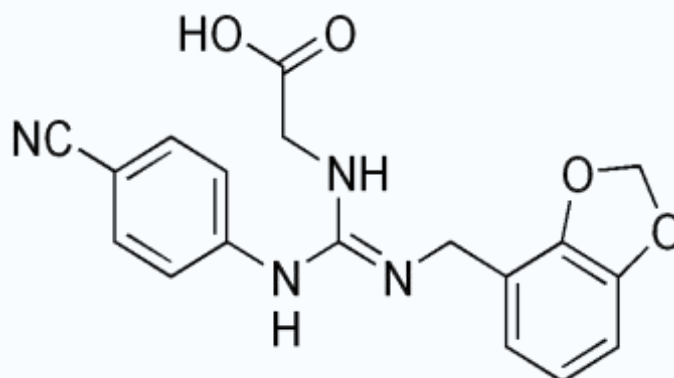


liquorice root

Liquorice root candy, or properly **Glycyrrhiza glabra**, is the dried root of the liquorice plant, which is eaten as a candy. It is also used in traditional Chinese medicine, as well as in the traditional medicines of Japan, Korea, Vietnam, and other Asian nations. Sticks of liquorice typically have a diameter between two and ten millimetres. Although they resemble plain wooden sticks, they are soft enough to be chewed on. They used to be popular among Dutch, Danish, Swedish, and Spanish children. Liquorice root can have either a salty or sweet taste. The thin sticks are usually quite salty and sometimes taste like salmiak (salty liquorice), whereas the thick sticks are usually quite sweet, with a salty undertone. The extract of the liquorice root is one of the main ingredients in liquorice confectionery. Liquorice root can be shredded and added to boiling water to create liquorice root tea. This tea has a very peculiar taste, and is often either enjoyed or disliked. Liquorice root is also widely available in Denmark, especially in The Old Town of Århus. It is also sold by the drugstore and drysalter chain Matas and most greengrocers. Liquorice root has been traditionally used as a herbal remedy against different symptoms, such as cough and catarrh.^[1] People with heart conditions or high blood pressure should avoid ingesting extensive amounts of liquorice, as it can further heighten blood pressure and lead to stroke.

Liquorice root has also been reported to speed the healing of canker sores.

Lugduname



Molecular formula	$C_{18}H_{16}N_4O_4$
Molar mass	352 g mol^{-1}

Lugduname (from lat. „*Lugdunum*“ for *Lyon*) is one of the the most potent sweetening agents known. Lugduname has been estimated to be between 220,000 and 300,000 times as sweet as sucrose . with estimates varying between studies. It had been developed at University of Lyon in 1996. Lugduname is part of a family of extremely potent, guanidine carboxylic acid, sweeteners with acetic acid functional groups on guanidine.

Mabinlin

1 – Introduction :

Mabinlins are sweet-tasting proteins extracted from the seed of Mabinlang (*Capparis masaikai* Levl.), a Chinese plant growing in Yunnan province. There are four homologues. Mabinlin-2 was first isolated in 1983 and characterised in 1993, and is the most extensively studied of the four. The other variants of mabinlin-1, -3 and -4 were discovered and characterised in 1994.

2 - Protein structures

The 4 mabinlins are very similar in their amino acids sequences

It is a heterodimer consisting of two different chains A and B. The A chain is composed of 33 amino acid residues and the B chain is composed of 72 amino acid residues. The B chain contains two intramolecular disulfide bonds and is connected to the A chain through two intermolecular disulfide bridges.

Mabinlin-2 is the sweet - tasting protein with the highest known thermostability, which is due to the presence of the four disulfide bridges. It has been suggested also that the difference in the heat stability of the different mabinlin homologues is due to the presence of an arginine residue (heat-stable homologue) or a glutamine (heat-unstable homologue) at position 47 in the B-chain.

3 - Sweetness properties

Mabinlins sweetness were estimated to be about 100 - 400 times that of sucrose on weight basis, which make them less sweet than thaumatin (3000 times) but elicit a similar sweetness profile

The sweetness of mabinlin-2 is unchanged after 48 hours incubation at boiling point.

Mabinlin-3 and -4 sweetness stayed unchanged after 1 hour at 80°C, while mabinlin-1 loses sweetness after 1 hour at the same condition.

4 - As a sweetener:

Mabinlins, as proteins, are readily soluble in water and found to be highly sweet, however mabinlin-2 with its high heat stability has the best chance to be used as a sweetener.

During the past decade, attempts have been made to produce mabinlin-2 industrially. The sweet-tasting protein has been successfully synthesised by a stepwise solid-phase method in 1998, however the synthetic protein had an astringent-sweet taste.

Mabinlin-2 has been expressed in transgenic potato tubers, but no explicit results have been reported yet. However, patents to protect production of recombinant mabinlin by cloning and DNA sequencing have been issued.

Malt



Malted barley

1 – Introduction :

Malting is a process applied to cereal grains, in which the grains are made to germinate by soaking in water and are then quickly halted from germinating further by drying/heating with hot air.^{[2][3]} Thus, malting is a combination of two processes: the sprouting process and the kiln-drying process. These latter terms are often preferred when referring to the field of brewing for batches of beer or other beverages as they provide more specific information.

The term "malt" refers to several products of the process:

- the grains to which this process has been applied, for example malted barley;
- the sugar, heavy in maltose, derived from such grains, such as the baker's malt used in various cereals; or
- a product based on malted milk, similar to a malted milk shake (i.e., "malts").

Whisky or beer made from malted barley or rye can also be called malt

2 - Uses:

Malted grain is used to make malt beer, malt whisky, malted shakes, malt vinegar, Maltesers, and some baked goods, such as malt loaf. Malting grains develops the enzymes that are required to modify

the grain's starches into sugars, including mono saccharides (glucose, fructose, etc.) and di saccharides (sucrose, etc.). It also develops other enzymes, such as proteases, which break down the proteins in the grain into forms which can be utilized by yeast. Barley is the most commonly malted grain in part because of its high diastatic power or enzyme content. Also very important is the retention of the grain's husk even after threshing, unlike the bare seeds of threshed wheat or rye. This protects the growing acrospire (developing plant embryo) from damage during malting, which can easily lead to mold growth. It also allows the mash of converted grain to create a filter bed during lautering (see brewing). Other grains may be malted, especially wheat.



Homebrewing malt extracts : liquid in a can and spray dried.

3 - Maltings:

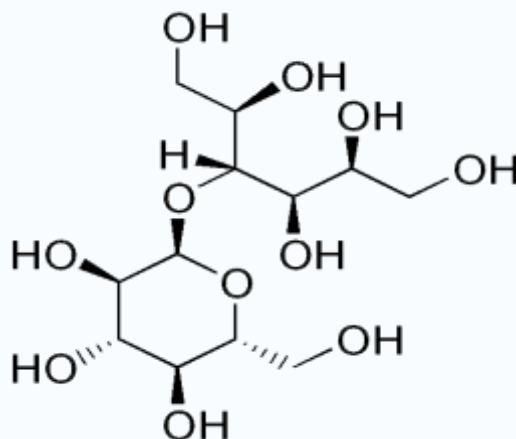
A **maltings**, some times called *malthouse*, or *malting floor*, is a building that houses the process of converting barley into malt, for use in the brewing or distilling process. This is done by kiln - drying the sprouted barley. This is usually done by spreading the sprouted barley on a perforated wooden floor. Smoke, coming from an oasting fireplace (via smoke channels) is then used to heat the wooden floor (and thus, the sprouted grain with it). The temperature thus employed is usually around 55° C. A typical floor maltings is a long, single-story building with a floor that slopes slightly from one end of the building to the other. Floor maltings began to be phased out in the 1940s in favor of 'pneumatic plants'. Here large industrial fans are

used to blow air through the germinating grain beds and to pass hot air through the malt being kilned. Like floor maltings these pneumatic plants are batch processes but of considerably greater size, typically 100 tonne batches compared with 20 tonne batches for a floor maltings.

4 - Malt categories

Malt is often divided into two categories by brewers: *base malts* and *specialty malts*. Base malts have enough diastatic power to convert their own starch and usually that of some amount of starch from unmalted grain, called adjuncts. Specialty malts have little diastatic power; they are used to provide flavor, color, or "body" (viscosity) to the finished beer. *Caramel* or *crystal* malts are specialty malts that have been subjected to heat treatment that converts their starches to sugars non-enzymatically. Within these categories are a variety of types distinguished largely by the kilning temperature (see mash ingredients). In addition, malts are distinguished by the two major species of barley used for malting, two-row and six-row.^[5] A new encapsulating technology permits the production of malt granules. Malt granules are the dried liquid extract from malt using in the brewing or distilling process.

Maltitol



Other names	Amalty Maltitol Maltisorb Maltisweet
Molecular formula	$C_{12}H_{24}O_{11}$
Molar mass	344 g / mol
Melting point	145 °C

1 – Introduction :

Maltitol is a sugar alcohol (a polyol) used as a sugar substitute. It has 75 – 90 % of the sweetness of sucrose and nearly identical properties, except for browning. It is used to replace table sugar because it has fewer calories, does not promote tooth decay and has a somewhat lesser effect on blood glucose. Chemically, maltitol is also known as **4-O- α -gluco pyranosyl -D-sorbitol**. Commercially, it is known under trade names such as **Maltisorb** and **Maltisweet**.

2 - Production and uses:

Commercially, maltitol is a disaccharide produced by Corn Products Specialty Ingredients (formerly SPI Polyols), Cargill, Roquette, and Towa, among other companies. Maltitol is made by

hydrogenation of maltose obtained from starch. Its high sweetness allows it to be used without being mixed with other sweeteners, and exhibits negligible cooling effect (positive heat of solution) in comparison with other sugar alcohols, and is very similar to the subtle cooling effect of sucrose. It is used especially in production of sweets: sugarless hard candies, chewing gum, chocolates, baked goods, and ice cream. The pharmaceutical industry uses maltitol as an excipient where it is utilised as a low-calorie sweetening agent. Its similarity to sucrose allows it to be used in syrups with the advantage that crystallization (which may cause bottle caps to stick) is less likely. Maltitol may also be used as a plasticiser in gelatine capsules, as an emollient, and as a humectant.

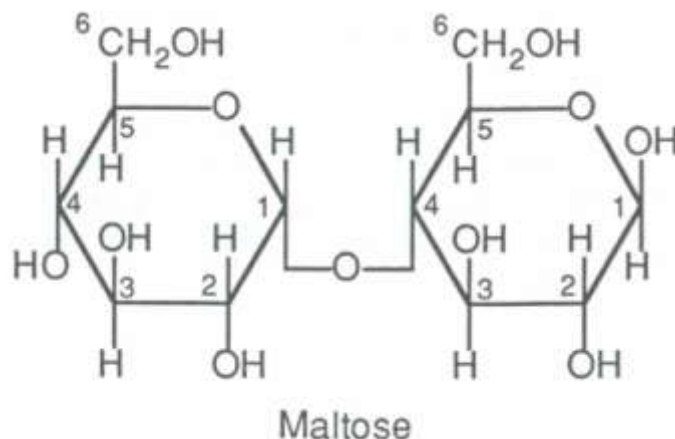
3 – Metabolism:

Maltitol does not brown and caramelize after liquifying by exposure to intense heat. It is not metabolized by oral bacteria, so it does not promote tooth decay. It is somewhat more slowly absorbed than sucrose which makes it somewhat more suitable for people with diabetes than sucrose. Its food energy value is 2.1 kilo calories per gram ; (sucrose is 4.0 kcal / g).

Due to its slow absorption, excessive consumption can have laxative effect and sometimes can cause gas and/or bloating. It is very easy for food producers to use it in vast quantities, due to its similarity to sugar, so consumers often end up ingesting far more than they could most other sugar alcohols. This means that maltitol is particularly associated with gastric issues.

In some countries, it carries a mandatory warning such as "Excessive consumption may have a laxative effect."

Maltose



Other names	4-O- α -D-Glucopyranosyl-D-glucose
Molecular formula	$C_{12}H_{22}O_{11}$
Molar mass	342 g / mol
Appearance	white powder or crystals
Density	1.54 g / cm ³
Melting point	160 - 165 °C (anhydrous) 102 - 103 °C (monohydrate)
Solubility in water	1.080 g / L (20 °C)
Chiral rotation $[\alpha]_D$	+140.7°

1 – Introduction :

Maltose, or malt sugar, is a disaccharide formed from two units of glucose joined with an α (1 $\rightarrow$ 4) linkage. It is the second member of an important biochemical series of glucose chains. The addition of another glucose unit yields maltotriose; further additions will produce dextrans (also called malto dextrans) and eventually starch (glucose polymer). Maltose is the disaccharide produced when amylase breaks down starch. It is found in germinating seeds such as Barley as they break down their starch stores to use for food.

Maltose can be broken down into two glucose molecules by hydrolysis. In living organisms, the enzyme maltase can achieve this very rapidly. In the laboratory, heating with a strong acid for several minutes will produce the same result.

The production of maltose from germinating cereals, such as barley, is an important part of the brewing process. When barley is malted, it is brought into a condition in which the concentration of maltose-producing amylases has been maximized. Mashing is the process by which these amylases convert the cereal's starches into maltose. Metabolism of maltose by yeast during fermentation then leads to the production of ethanol and carbon dioxide.

4 - Maltose as food :

Plain maltose has a sweet taste, about half as sweet as glucose and about one - sixth as sweet as fructose.

In Southern China, Taiwan, Hong Kong and Macau, maltose is a common ingredient in confectionery. The most common way to consume it is to put a layer of maltose between two pieces of biscuits .

Miraculin



The Miracle Fruit, origin of Miraculin

1 – Introduction :

Miraculin is a glycoprotein extracted from the miracle berry or miracle fruit plant, a shrub native to West Africa (*Synsepalum dulcificum* or *Richadella dulcifica*).

Local names for the plant include *taami*, *asaa*, and *ledidi*. Miraculin itself is not sweet, but the human tongue, once exposed to miraculin, perceives ordinarily sour foods, such as citrus, as sweet for up to an hour afterwards. This small red berry has been used in West Africa to improve the taste of acidic foods. Because the miracle fruit itself has no distinct taste, this taste-modifying function of the fruit had been regarded as a miracle.

The active substance, isolated by Prof. Kenzo Kurihara (a Japanese scientist in 1968).

2 - Glycoprotein structure:

Miraculin was first sequenced in 1989 and was found to be a glycoprotein consisting of 191 amino acids and some carbohydrate chains.

Miraculin occurs as a tetramer , a combination of 4 monomers group by dimer. Within each dimer 2 miraculin glycoproteins are linked by a disulfide bridge. The molecular weight of the glycoprotein is 24.6 kDa including 3.4 kDa (13.9 % of the weight) of sugar

constituted (on molar ratio) of glucosamine (31 %), mannose (30 %), fucose (22 %), xylose (10 %) and galactose (7 %).

3 - Sweetness properties:

Miraculin, unlike curculin (another taste-modifying agent), is not sweet by itself, but it can change a sour beverage into a sweet beverage, even for a long period after consumption. The anti-sweet compound, Gymnemic acid suppresses the sweet taste of miraculin, like it does for sucrose. The duration and intensity of the taste-modifying phenomena depends on various factors — miraculin concentration, duration of contact of the miraculin with the tongue, and acid concentration. Maximum sweet-induced response has been shown to be equivalent to the sweetness of 17 % sucrose solution.

Glycoprotein is sensitive to heat: when heated over 100 °C, miraculin loses its taste - modifying property. Miraculin activity is inactivated at pH below 3 and pH above 12 at room temperature. The sweet modifying effect stays at pH 4 (in acetate buffer), for 6 months at 5 °C.

The detailed mechanism of the taste-inducing behaviour is still unknown. It has been suggested that the miraculin protein can change the structure of taste cells on the tongue. As a result, the sweet receptors are activated by acids, which are sour in general. This effect remains until the taste buds return to normal. The two histidine residues (i.e. His29 and His59) appear to be mainly responsible for the taste-modifying behavior. One site maintains the attachment of the protein to the membranes while the other (with attached xylose or arabinose) activates the sweet receptor membrane in acid solutions. The presence of positively charged ions (Ca^{2+} and/or Mg^{2+}) interferes with the binding of the active sugar of miraculin to the sweet receptor and therefore inactivates the effect.

4 - As a sweetener:

As miraculin is a readily soluble protein and relatively heat stable, it is a potential sweetener in acidic food (e.g. soft drinks). Japanese researchers' more or less successful attempts to mass

produce it are focused on recombinant technology. While attempts to express it in yeast, and tobacco plants have failed, researchers have succeeded in preparing genetically modified *E. coli* bacteria and lettuce that express miraculin. The scientists' crops resulted in 40 micrograms of miraculin per gram of lettuce leaves, which was considered a large amount. Two grams of lettuce leaves produced roughly the same amount of miraculin as in one miracle fruit berry.^[11]

Miraculin was never approved for use as a sweetener by the United States Food and Drug Administration (FDA). When attempts were made to get it classified as a dietary supplement the requests were turned down and the company attempting such were informed that it would have to be classified as a food additive, after which the company failed to provide the required materials for such and stopped any of their research into the use of Miraculin.

Miraculin has no legal status in the European Union. However it is approved in Japan as a harmless additive, according to the List of Existing Food Additives published by the Ministry of Health and Welfare .

Mizuame

1 – Introduction :

Mizuame is a sweetener from Japan which is translated literally to 'water candy'. A clear, thick, sticky liquid, it is made by converting starch to sugars. Mizuame is added to wagashi to give them a sheen, eaten in ways similar to honey and can be a main ingredient in sweets. Mizuame is produced in a very similar fashion to corn syrup and is very similar in taste.

There are two methods used to convert the starches to sugars. The traditional method is to take glutinous rice mixed with malt and let the natural enzymatic process take place converting the starch to syrup. The second and more common method uses potatoes or sweet potatoes as the starch source and then adding an acid such as hydrochloric, sulfuric or nitric acids. If done by the first method, the final product is known as **barley mizuame** and considered more flavorful than the potato version.

Molasses

1 – Introduction :

Molasses is a viscous byproduct of the processing of sugar cane or sugar beets into sugar. The word *molasses* comes from the Portuguese word *melaço*, which ultimately comes from *mel*, the Latin word for "honey". The quality of molasses depends on the maturity of the sugar cane or sugar beet, the amount of sugar extracted, and the method of extraction. Sweet sorghum syrup is known in some parts of the United States as molasses, though it is not true molasses.

2 - Cane molasses :

Sulphured molasses is made from young sugar cane. Sulphur dioxide, which acts as a preservative, is added during the sugar extraction process. Unsulphured molasses is made from mature sugar cane, which does not require treatment with sulphur. There are three grades of molasses: mild or barbados , also known as *first molasses*; dark, or *second molasses*; and black strap. These grades may be sulphured or unsulphured.

To make molasses, the sugar cane plant is harvested and stripped of its leaves. Its juice is extracted from the canes, usually by crushing or mashing; it can also be removed by cutting. The juice is boiled to concentrate it, which promotes the crystallization of the sugar. The result of this first boiling and removal of the sugar crystals is *first molasses*, which has the highest sugar content because comparatively little sugar has been extracted from the source. *Second molasses* is created from a second boiling and sugar extraction, and has a slight bitter tinge to its taste.

The third boiling of the sugar syrup makes *black strap molasses*. The majority of sucrose from the original juice has been crystallized, but blackstrap molasses is still mostly sugar by calories. However, unlike refined sugars, it contains significant amounts of vitamins and minerals. Black strap molasses is a source of calcium, magnesium, potassium, and iron; one tablespoon provides up to 20% of the daily

value of each of those nutrients. Blackstrap, often sold as a health supplement, is also used in the manufacture of cattle feed and for other industrial uses.

3 - Sugar beet molasses

Molasses that comes from the sugar beet is different from cane molasses. Only the syrup left from the final crystallization stage is called molasses; intermediate syrups are referred to as *high green* and *low green*, and these are recycled within the crystallization plant to maximize extraction. Beet molasses is about 50 % sugar by dry weight, predominantly sucrose, but also contains significant amounts of glucose and fructose. Beet molasses is limited in biotin (Vitamin H or B₇) for cell growth; hence, it may need to be supplemented with a biotin source. The nonsugar content includes many salts, such as calcium, potassium, oxalate, and chloride. These are either as a result of concentration from the original plant material or as a result of chemicals used in the processing. As such, it is unpalatable, and is mainly used as an additive to animal feed (called "molassed sugar beet feed") or as a fermentation feed stock.

It is possible to extract additional sugar from beet molasses through a process known as molasses desugarisation. This technique exploits industrial - scale chromatography to separate sucrose from nonsugar components. The technique is economically viable in trade-protected areas, where the price of sugar is supported above the world market price. As such, it is practiced in the U.S. and parts of Europe. Molasses is also used for yeast production.

4 - Substitutes:

Cane molasses is a common ingredient in baking, often used in baked goods such as ginger bread cookies. There are a number of substitutions that can be made for molasses.

For a cup of molasses, one of the following may be used : 1 cup of honey; $\frac{3}{4}$ cup of firmly packed brown sugar; 1 cup of dark corn syrup; 1 cup of granulated sugar with $\frac{1}{4}$ cup of water.

5 - Other forms:

In the cuisines of the Middle East, molasses is produced from several other materials: carob, grapes, dates, pomegranates, and mulberries.

6 - Nonculinary uses:

Because of its unusual properties, molasses has several uses beyond that of a straight forward food additive. It can be used as the base material for fermentation into rum, and as the carbon source for in situ remediation of chlorinated hydrocarbons. Also, it can be used as a minor component of mortar for brickwork.

It can be used as a chelating agent to remove rust where a rusted part stays a few weeks in a mixture of 1 part molasses and 10 parts water.

In Australia, molasses is fermented to produce ethanol for use as an alternative fuel in motor vehicles, and is also used to treat burns.

Molasses is added to some brands of tobacco used for smoking through a Middle Eastern water pipe (e.g., hookah, shisha, narghile, etc.). It is mixed into the tobacco along with glycerine and flavorings; sometimes it is used along with honey and other syrups or fully substituted by them.

Molasses is also used in fishing ground bait.

Molasses can also be added to the soil of almost every plant to promote microbial activity.

Blackstrap Molasses is often used in horticulture as a flower blooming and fruiting enhancer, particularly in organic hydroponics.

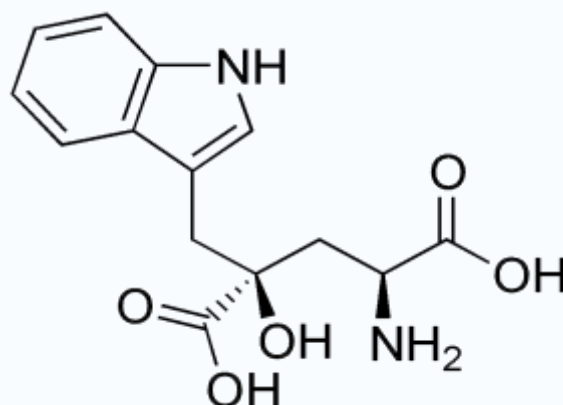
Blackstrap Molasses may also be used as an iron supplement for those who can not tolerate the constipation associated with iron supplementation. Specifically for pregnant women, 2 tbsp blackstrap molasses may be taken twice daily to replace supplemental iron tablets.

Molasses is also used as an additive in livestock grains to increase the protein content.

Molasses is also commonly used in dark brewed beverages like stout and very heavy dark ales.

Molasses can also be used as the "Fuel Oil" portion of ANFO - Ammonium Nitrate / Fuel Oil, a powerful explosive.

Monatin



Other names	2-Hydroxy-2-(indol-3-ylmethyl)-4-amino glutaric acid (S)-4-Hydroxy-4-(1 <i>H</i> -indol-3-ylmethyl)-L-glutamic acid
Molecular formula	C ₁₄ H ₁₆ N ₂ O ₅
Molar mass	292 g mol ⁻¹

1- Introduction :

Monatin is a naturally-occurring, high intensity sweetener isolated from the plant *Sclerochiton ilicifolius*, found in the Transvaal region of South Africa. Monatin contains no carbohydrate or sugar, and nearly no calories, unlike sucrose or other nutritive sweeteners.^[1]

Monellin

1 – Introduction :

Monellin is a sweet protein which was discovered in 1969 in the fruit of the West African shrub known as serendipity berry (*Dioscoreophyllum cumminsii*), it was first reported as a carbohydrate. The protein was named in 1972 after the Monell Chemical Senses Center in Philadelphia, U.S.A., where it was isolated and characterized.

2 - Protein composition:

So far, five high intensity sweet proteins have been reported: monellin (1969), thaumatin (1972), pentadin (1989), mabinlin (1983) and brazzein (1994).

Monellin's molecular weight is 10.7 kDa. Monellin is a two noncovalently associated polypeptide chains: an A chain sequence with 44 amino acid residues, and a B chain with 50 residues.

Monellin has a secondary structure consisting of five Beta - strands that form an anti - parallel Beta - sheet and a 17- residue Alpha - helix.

In its natural form, monellin is composed of 2 chains (A and B, of 44 and 50 amino acids as shown above), but is unstable at high temperatures or at extremes of pH. In order to enhance its stability, single - chain monellin proteins were created in which the two natural chains are joined via a Gly - Phe dipeptide linker. This modified version of the protein (MNEI) has been studied using NMR and X - ray diffraction.

The image displayed on this page shows the structure of monellin derived from X - ray diffraction at a 1.15 Angstrom resolution. The high resolution used to obtain the structure provided a more detailed look at monellin and its properties than previously possible. In addition to its secondary structure, four stably bound

sulfate ions were located on the monellin protein, three on the concave face of the protein and one on the convex face of the protein.

The sulfate ion on the convex face of the protein is of particular interest because it lies adjacent to a patch of positive surface potential, which may be important in electrostatic interactions with the negative T1R2-T1R3 sweet taste protein receptor .

3 - Sweetness properties

Monellin is perceived as sweet by humans and some Old World primates, but is not preferred by other mammals. The relative sweetness of monellin varies from 800 to 2000 times sweeter than sucrose, depending on the sweet reference it is assessed against. It is reported to be 1500-2000 times sweeter than a 7 % sucrose solution on a weight basis, and 800 times sweeter than sucrose when compared with a 5 % sucrose solution on a weight basis. Monellin has a slow onset of sweetness and lingering aftertaste. Like miraculin, monellin's sweetness is pH dependent; the protein is tasteless below pH 2 and above pH 9. Blending the sweet protein with bulk and/or intense sweeteners reduces the persistent sweetness and shows a synergistic sweet effect.

Heat over 50°C at low pH denatures monellin proteins causing a loss of the sweetness.

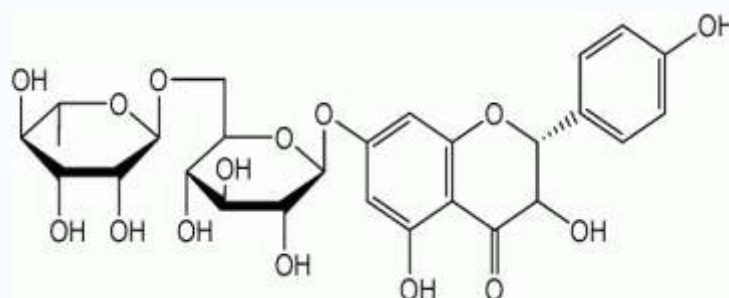
4 - As a sweetener:

Monellin can be useful for sweetening some foods and drinks as it is a protein readily soluble in water due to its hydrophilic properties. However it may have limited application because it denatures under high temperature conditions which makes it unsuitable for processed food. It may be relevant as noncarbohydrate tabletop sweetener, especially for individuals such as diabetics who must control their sugar intake.

In addition, monellin is costly to extract from the fruit and the plant is difficult to grow. Alternative production such as chemical synthesis and expression in micro-organisms are being investigated.

For instance, monellin has been expressed successfully in yeast (*Candida utilis*) and synthesised by solid - phase method. The synthetic monellin produce by yeast was found to be 4000 times sweeter than sucrose when compared to 0.6 % sugar solution. Legal issues are the main barrier in widespread use as a sweetener as Monellin has no legal status in the European Union or the United States. However, it is approved in Japan as a harmless additive, according to the List of Existing Food Additives issued by the Ministry of Health and Welfare .

Naringin



Other names	Naringin 4',5,7-Trihydroxyflavanone-7-rhamnoglucoside 4',5,7-Trihydroxyflavanone-7-rutinoside
Molecular formula	C ₂₇ H ₃₂ O ₁₄
Molar mass	580 g / mol
Melting point	166 °C

1 – Introduction :

Naringin is the major flavonoid glycoside in grapefruit and gives grapefruit juice its bitter taste. It is metabolized to the flavanone naringenin in humans. Both naringenin and hesperetin, which are the aglycones of naringin and hesperidin, occur naturally in citrus fruits.

2 - Activity

Naringin exerts a variety of pharmacological effects such as antioxidant activity, blood lipid lowering, anticancer activity, and inhibition of selected drug-metabolizing cytochrome P450 enzymes, including CYP3A4 and CYP1A2, which may result in drug-drug interactions *in vivo*. Ingestion of naringin and related flavonoids can also affect the intestinal absorption of certain drugs, leading to either an increase or decrease in circulating drug levels. To avoid interference

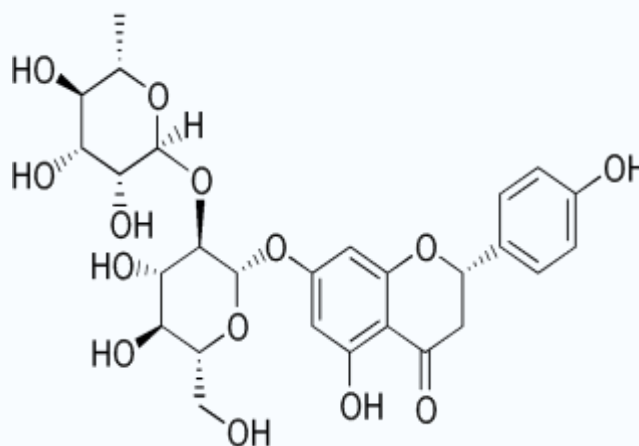
with drug absorption and metabolism, the consumption of citrus (esp. grapefruit) and other juices with medications is contraindicated.

Naringin, followed by rutin, was the most potent flavonoid inhibitor of VEGF release, which causes angiogenesis, out of 21 flavonoids.

3 - Use:

When Naringin is treated with potassium hydroxide or another strong base, and then catalytically hydrogenated, it becomes a naringin dihydrochalcone, a compound roughly 300 - 1800 times sweeter than sugar at threshold concentrations.

Naringin dihydrochalcone



Other names	Naringin DC
Molecular formula	$C_{27}H_{34}O_{14}$
Molar mass	582 g / mol
Appearance	White powder
Melting point	169-170°C

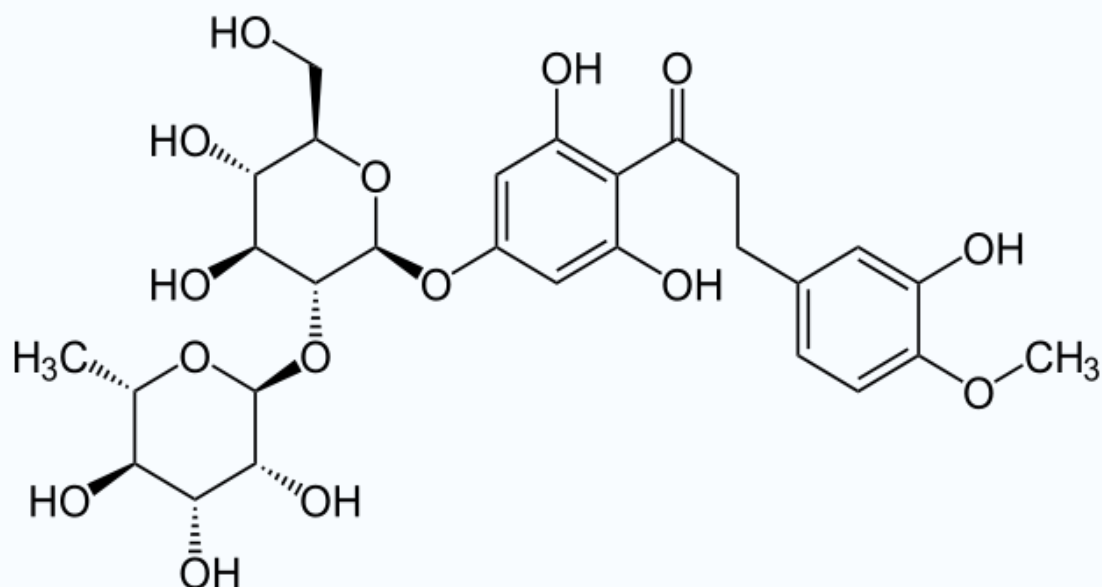
Introduction :

Naringin dihydrochalcone, some times abbreviated to **naringin DC**, is an artificial sweetener derived from naringin, a bitter compound found in citrus.

Naringin dihydrochalcone is a phloretin glycoside discovered at the same time as neohesperidin dihydrochalcone during the 1960s as part of a United States Department of Agriculture research program to find methods for minimizing the taste of bitter flavorants in citrus juices.

When Naringin is treated with potassium hydroxide or another strong base, and then catalytically hydrogenated, it becomes a dihydrochalcone, a compound roughly 300 - 1800 times sweeter than sugar at threshold concentrations.

Neohesperidin dihydrochalcone



Molecular formula	C ₂₈ H ₃₆ O ₁₅
Molar mass	612.58 g/mol
Exact mass	582.194856

1 – Introduction :

Neohesperidin dihydrochalcone, sometimes abbreviated to **neohesperidin DC** or simply **NHDC**, is an artificial sweetener derived from citrus.

NHDC was discovered during the 1960s as part of a United States Department of Agriculture research program to find methods for minimizing the taste of bitter flavorants in citrus juices. Neohesperidin is one such bitter compound. When treated with potassium hydroxide or another strong base, and then catalytically hydrogenated, it becomes

NHDC, a compound roughly 1500 -1800 times sweeter than sugar at threshold concentrations; around 340 times sweeter than sugar weight-for-weight. Its potency is naturally affected by such factors as the application in which it is used, and the pH of the product.

Like other highly sweet glycosides, such as glycyrrhizin and those found in stevia, NHDC's sweet taste has a slower onset than sugar's and lingers in the mouth for some time. Unlike aspartame, NHDC is stable to elevated temperatures and to acidic or basic conditions, and so can be used in applications that require a long shelf life. NHDC itself can stay foodsafe for up to five years when stored in optimal conditions.

The European Union approved NHDC's use as a sweetener in 1994. It has not been approved as a sweetener in the United States. It is sometimes said that NHDC is considered a Generally Recognized as Safe flavour enhancer by the Flavour and Extract Manufacturers' Association, which is a trade group with no legal standing. NHDC has never appeared on the FDA's GRAS listing.

It is particularly effective in masking the bitter tastes of other compounds found in citrus, including limonin and naringin. Industrially, it is produced by extracting neohesperidin from the bitter orange, and then hydrogenating this to make NHDC.

The product is well known for having a strong synergistic effect when used in conjunction with other artificial sweeteners such as aspartame, saccharin, acesulfame potassium, and cyclamate, as well as sugar alcohols such as xylitol. NHDC usage boosts the effects of these sweeteners at lower concentrations than would otherwise be required; smaller amounts of other sweeteners are needed. This provides a cost benefit.

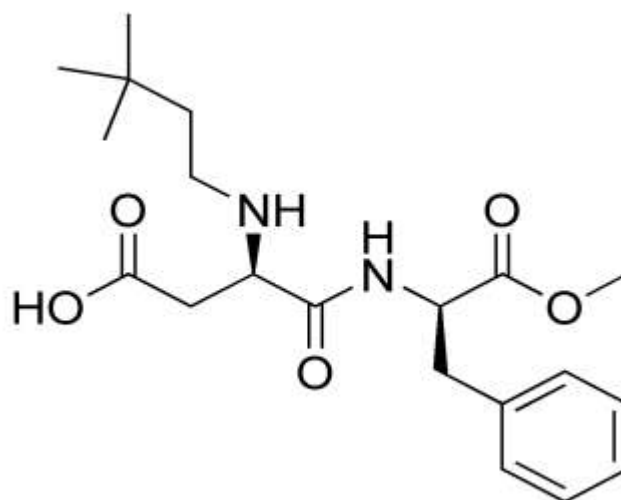
As a flavour enhancer, NHDC is used in a wide range of products and is indicated by the E number E 959. It is noted particularly for enhancing sensory effects (known in the industry as 'mouth feel'). An example of this is 'creaminess' in dairy foods such as yogurt and ice

cream, but is also widely favoured for use in otherwise naturally bitter products. Pharmaceutical companies are fond of the product as a means of reducing the bitterness of pharmacological drugs in tablet form, and it has been used for livestock feed as a means of reducing feeding time. Other products NHDC can be found in may include a wide variety of alcoholic beverages (and non - alcoholic), savoury foods, toothpaste, mouthwash and condiments such as ketchup and mayonnaise.

NHDC in pure form is found as a white substance not unlike powdered sugar. In food it is used as a flavour enhancer in concentrations of around 4 - 5 parts per million (ppm) and as an artificial sweetener at around 15-20 ppm.

Research has shown that at strengths of around and above 20 ppm, NHDC can produce side effects such as nausea and migraine. This is not widely documented, however is unquestionably known within the food science communities that have worked with the product, and many recommend wearing a surgical mask when handling pure NHDC.

Neotame



Molecular formula	C ₂₀ H ₃₀ N ₂ O ₅
Molar mass	378 g / mol

1- Introduction :

Neotame is an artificial sweetener made by NutraSweet that is between 7,000 and 13,000 times sweeter than sucrose . In the European Union it is known by the E number **E961**. Neotame is moderately heat stable and extremely potent. Neotame is rapidly metabolized, completely eliminated, and does not accumulate in the body.

The major metabolic pathway is hydrolysis of the methyl ester by esterases that are present throughout the body, which yields de-esterified neotame and methanol. Because only trace amounts of neotame are needed to sweeten foods, the amount of methanol derived from neotame is much lower than that found in common foods, such as fruit and vegetable juices. It has the characteristic aftertaste common to artificial sweeteners.

The product is attractive to food manufacturers as its use greatly lowers the cost of production compared to using sugar or high fructose corn syrup (due to the lower quantities needed to achieve the same sweetening) while also benefitting the consumer by providing fewer "empty" sugar calories and a lower impact on blood sugar.

It is chemically similar to the artificial sweetener aspartame, but is used at vastly lower levels and is more stable. Chemically, it has a 3,3-dimethylbutyl group attached to the amino group of the aspartic acid portion of the molecule. Peptidases, which would typically break the peptide bond between the aspartic acid and phenylalanine moieties, are effectively blocked by the presence of the 3,3- di methyl butyl moiety, thus reducing the production of phenylalanine, thereby making its consumption by those who suffer from phenyl ketonuria safe.

Neotame was approved by the Food and Drug Administration (FDA) for general use in July 2002, but is not yet widely used in food products. Neotame also is approved for use in Australia and New Zealand. Neotame is assigned the International Numbering System (INS) food additive code 961.

2 - Controversies:

Although over 100 studies were conducted on neotame to prove its safety prior to FDA approval, the controversy relating to aspartame has caused a stir among opponents of artificial sweeteners.

However, Neotame is one of only two artificial sweeteners ranked as "safe" by the consumer advocacy group Center for Science in the Public Interest. The other is Sucralose.

Panela

Botanical	Panela
Source plant	Sugar cane
Part of plant	Cane
Geographic origin	Latin America
Uses	Water of Panela
Main producers	Colombia
Main consumers	Colombia and Ecuador

1 – Introduction :

Panela is an unrefined food product, typical of Central and South America, which is basically a solid piece of sucrose and fructose obtained from the boiling and evaporation of sugarcane juice.

Common Spanish names: **chancaca**, **papelón**, **piloncillo**, **panocha**, **rapadura**, **atado dulce** or **empanizao**. In India and Pakistan a similar product is made which is called **gur** or **jaggery**. In Brazil, it's called **rapadura**.

2 - Economics of panela



Panela is commonly sold in this form.



Brazilian panela in tablets.

The main producer of panela is Colombia (about 1.4 million tons/year), where panela production is one of the most important economic activities, with the highest index of panela consumption per capita worldwide. Panela is also produced in Ecuador, Venezuela, Guatemala, Panamá, Mexico, Peru and Bolivia. In Colombia, the panela industry is an important source of employment with about 350.000 people working in nearly 20.000 **trapiches** (panela farms).

3 - Process:

The sugarcane plant is processed in a large press, to obtain the juice, which is cooked at very high temperatures. The panela can be manufactured in disc-shaped pieces or in cubic pieces of cake form and is usually gold or brown in color. Besides Sugar, panela also contains large amounts of proteins, calcium, iron and ascorbic acid.

4 - Uses:

The main use of the panela is in aguapanela which is one of the most widely drunk beverages in Colombia. Also it is used as a sweetener and in the preparation of desserts. Since it is a very solid block, most Colombian homes have a resistant river stone (**la piedra de la panela**) to break the panela into smaller, more manageable pieces.

In Perú **chancaca** is used in typical food such as "champús", "picarones", "calabaza al horno" and "mazamorra cochina". In Costa Rica it is used in preparations such as "tapa de dulce" and "agua de sapo".

In México the term **piloncillo** is used. They are also often seen in the shape of small truncated cones. Many Mexican desserts are made with piloncillo, such as atole, capirotada, champurrado and flan.

In the Philippines **Panocha** or in filipinized term **Panutsa** is traditionally used as an ingredient for "Latik" and "Kalamay".

The city of Palmira Colombia on November 30th of 2009 broke the world record for the largest and heaviest **Panela**, with one that measured 10 feet and 20 inches and weighting 715 kgrs .For this purpose 70 tons of sugar cane were needed and 90 people worked for 28 consecutive hours.

Pekmez



Pekmez with Tahin

1 - Introduction :

Pekmez (Turkish) or **dibs** (Arabic) is a molasses - like syrup obtained after condensing juices of fruit must, especially grape, fig or mulberry, by boiling with coagulant agents. It is used as a syrup or mixed with tahini for breakfast.

Dibis is a similar product made from dates. There is also another kind of Pekmez, made from carob, called **keçiboynuzu pekmezi** or **harnup pekmezi** in the Turkish language.

2 - Regions:

Most of the grape products in Turkey are in the form of pekmez and raisins, particularly sultanas.

Pekmez is also known and made in the Balkans though it's more like jam in its texture.

2 - History:

Fruit molasses goes back to the classical period .

Raisin



Sultana Raisins

Raisins	
Nutritional value per 100 g	
Energy	299 k cal
Carbohydrates	79 g
Sugars	59 g
Dietary fiber	4 g
Fat	0.5 g
Protein	3 g
Calcium	50 mg
Iron	1.9 mg
Potassium	750 mg
Sodium	11 mg

1- Introduction :

Raisins are dried grapes. They are produced in many regions of the world, such as Armenia, the United States, Australia, Chile, Argentina, Macedonia, Mexico, Greece, Syria, Turkey, India, Iran, Pakistan, Iraq, China, Afghanistan, Togo, and Jamaica, as well as South Africa and Southern and Eastern Europe. Raisins may be eaten raw or used in cooking and baking.

2 - Etymology:

The word *raisin* dates back to Middle English and is a loanword from Old French; in Old French and French, *raisin* means "grape," while, in French, a dried grape is referred to as a *raisin sec*, or "dry grape." The Old French word in turn developed from the Latin word *racemus*, "a bunch of grapes."

3 - Varieties:

Raisin varieties depend on the type of grape used. Seedless varieties include the Sultana (also known as "Thompson Seedless" in the USA) and Flame. Raisins are typically sun-dried, but may also be "water-dipped," or dehydrated. "Golden raisins" are made from Sultanas, treated with Sulfur Dioxide (SO₂) , and flame dried to give them their characteristic color. A particular variety of seedless grape, the Black Corinth, is also sun dried to produce Zante currants, mini raisins that are much darker in color and have a tart, tangy flavour. Several varieties of raisins are produced in Asia and, in the West, are only available at ethnic specialty grocers. Green raisins are produced in Iran. Raisins have a variety of colors (green, black, blue, purple, yellow) and sizes.

4 - Regional variations:

In the United Kingdom, Ireland, Australia, and New Zealand the word **raisin** is reserved for the dried large dark grape, with **sultana** being a dried large white grape, and **currant** being a dried small Black

Corinth grape. In India and Pakistan, the black raisin is known as kishmish (a Hindi word). In Dutch the word *krent* is reserved for Corinth based raisins, and raisin cognate *rozijn* for the rest.

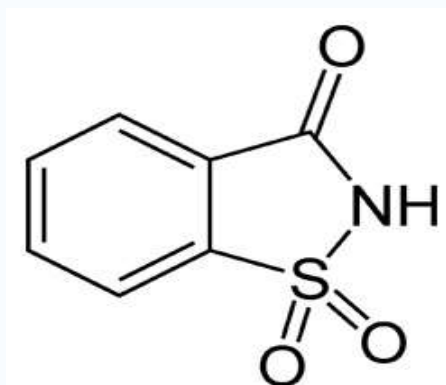
5 - Nutritional value:

Raisins range from about 67 % to 72 % sugars by weight, most of which is fructose. Raisins, like prunes and apricots, are also high in certain antioxidants. As with all dried fruits, raisins have a very low vitamin C content.

6 - Sweetness:

Raisins are sweet due to their high concentration of sugars. The sugar inside the fruit crystallizes if they are stored for a long period. This makes the dry raisins gritty, but does not affect their usability. The sugar grains dissolve when the raisins are swelled in (hot) water.

Saccharin



Other names	Benzoic sulfimide E954
Molecular formula	$C_7H_5NO_3S$
Molar mass	183 g mol^{-1}
Appearance	White crystalline solid
Density	0.828 g / cm^3
Melting point	$228.8 - 229.7\text{ }^{\circ}\text{C}$
Solubility in water	1 g per 290 mL

1 – Introduction :

Saccharin is an artificial sweetener. The basic substance, benzoic sulfimide, has effectively no food energy and is much sweeter than sucrose, but has an unpleasant bitter or metallic aftertaste, especially at high concentrations. In countries where saccharin is allowed as a food additive, it is used to sweeten products such as drinks, candies, medicines, and toothpaste.

2 - Properties:

Saccharin is unstable when heated but it does not react chemically with other food ingredients. As such, it stores well. Blends of saccharin

with other sweeteners are often used to compensate for each sweetener's weaknesses and faults. A 10 : 1 cyclamate : saccharin blend is common in countries where both these sweeteners are legal; in this blend, each sweetener masks the other's off-taste. Saccharin is often used together with aspartame in diet soda, so that some sweetness remains should the fountain syrup be stored beyond aspartame's relatively short shelf life. Saccharin is believed to be an important discovery, especially for diabetics, as it goes directly through the human digestive system without being digested. Although saccharin thus has no food energy, it can trigger the release of insulin in humans and rats, apparently as a result of its taste.

In its acid form, saccharin is not water - soluble. The form used as an artificial sweetener is usually its sodium salt. The calcium salt is also sometimes used, especially by people restricting their dietary sodium intake. Both salts are highly water-soluble: 0.67 grams per milliliter water at room temperature.

3 - History:

Saccharin was first produced in 1878 by Constantin Fahlberg, a chemist working on coal tar derivatives in Ira Remsen's laboratory at the Johns Hopkins University. Fahlberg and Remsen published articles on benzoic sulfinide in 1879 and 1880. In 1884, now working on his own in New York City, Fahlberg applied for patents in several countries describing methods of producing this substance that he named saccharin. Fahlberg would soon grow wealthy, while Remsen merely grew irate, believing that he deserved credit for substances produced in his laboratory. On the matter, Remsen commented, "Fahlberg is a scoundrel. It nauseates me to hear my name mentioned in the same breath with him."

Although saccharin was commercialized not long after its discovery, it was not until sugar shortages during World War I that its use became widespread. Its popularity further increased during the 1960s and 1970s among dieters, since saccharin is a calorie-free

sweetener. In the United States saccharin is often found in restaurants in pink packets; the most popular brand is "Sweet'N Low".

4 – Chemistry:

Saccharin has the chemical formula $C_7H_5NO_3S$ and it can be produced in various ways.^[8] The original route starts with toluene, but yields from this starting point are low. In 1950, an improved synthesis was developed at the Maumee Chemical Company of Toledo, Ohio. In this synthesis, anthranilic acid successively reacts with nitrous acid, sulfur dioxide, chlorine, and then ammonia to yield saccharin. Another route begins with o - chloro toluene. It is also known as ortho sulfo benzoic acid.

Saccharin can be used to prepare exclusively di substituted amines from alkyl halides via a Gabriel synthesis.

5 - Government regulation:

Starting in 1907, the USDA began investigating saccharin. Problems with saccharin and the USDA have not been resolved since then. The initial series of investigations begun by the USDA in 1907 was a direct result of the Pure Food and Drug Act. This act was passed in 1906 in the wake of a storm of health controversies concerning the meat-packing industry.

Harvey Wiley was one particularly well-known figure involved in the investigation of saccharin. Wiley, then the director of the bureau of chemistry for the USDA, had suspected saccharin to be damaging to human health. Wiley first battled saccharin in 1908. In a clash that epitomizes the controversial history of saccharin, Harvey told then President Theodore Roosevelt directly that "Everyone who ate that sweet corn was deceived. He thought he was eating sugar, when in point of fact he was eating a coal tar product totally devoid of food value and extremely injurious to health." In a heated exchange, Roosevelt angrily answered Harvey by stating "Anybody who says saccharin is injurious to

health is an idiot." In 1911, the Food Inspection Decision 135 stated that foods containing saccharin were adulterated. However in 1912, Food Inspection Decision 142 stated that saccharin was not harmful. The government's stance on saccharin has continued to waver ever since. More controversy was stirred in 1969 with the discovery of files from the Food and Drug Administration's investigations of 1948 and 1949. These investigations, which had originally argued against saccharin use, were shown to prove little about saccharin being harmful to human health. In 1972 the USDA made an attempt to completely ban the substance.^[14] However, this attempt was unsuccessful and the sweetener remains widely available in the United States; it is the third-most popular after sucralose and aspartame. Cyclamate, however, was banned in the U.S. in 1969 and saccharin was banned in Canada in 1977, leading to different product formulations being marketed in these countries.

In the European Union saccharin is also known by the E number (additive code) **E954**.

6 – Cancer:

Throughout the 1960s, various studies suggested that saccharin might be an animal carcinogen. Concern peaked in 1977, after the publication of a study indicating an increased rate of bladder cancer in rats fed large doses of saccharin. In that year, Canada banned saccharin while the United States Food and Drug Administration also proposed a ban. At the time, saccharin was the only artificial sweetener available in the U.S., and the proposed ban met with strong public opposition, especially among diabetics. Eventually, the U.S. Congress placed a moratorium on the ban, requiring instead that all saccharin-containing foods display a warning label indicating that saccharin may be a carcinogen.

Many studies have since been performed on saccharin, some showing a correlation between saccharin consumption and increased frequency of cancer in rats (especially bladder cancer) and others finding no such correlation. No study has ever shown a clear causal relationship

between saccharin consumption and health risks in humans at normal doses, though some studies have shown a correlation between consumption and cancer incidence. It appears that there is insufficient data to test hypotheses about humans from certain animal studies that have been performed.^[16] According to saccharin.org, a group which represents the low-calorie and reduced - fat food and beverage industry, the products of those it represents containing saccharin are perfectly safe: "Concerns over saccharin's safety were first raised twenty years ago after a flawed study that administered huge quantities of the sweetener to laboratory rats produced bladder tumors in rats. New and better scientific research has decisively shown that the earlier rat studies are not at all applicable to humans." The U.S. National Institute of Environmental Health Sciences came to the same conclusion in 2000, recommending that saccharin be removed from the list of known or suspected human carcinogens. The mechanism appears to be due the way that rats metabolize sodium, and bladder cancer which cannot be replicated in other mammals has also been observed with rat consumption of other sodium salts such as sodium citrate and bicarbonate. Saccharin has, however, also been linked to thyroid cancer in mice.

In 1991, after fourteen years, the FDA formally withdrew its 1977 proposal to ban the use of saccharin, and in 2000, the U.S. Congress repealed the law requiring saccharin products to carry health warning labels.

Siraitia grosvenorii



Siraitia grosvenorii (luohan guo) fruits

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- 1 Introduction
- 2 Cultivation
- 3 Traditional uses
- 4 Active agents
 - 4.1 Toxicity
 - 4.2 Current research
- 5 Cultivation and marketing
 - 5.1 Traditional processing
 - 5.2 The Procter & Gamble process
 - 5.3 Products
- 6 History
 - 6.1 Rediscovery in the 20th century

1 – Introduction :

Siraitia grosvenorii is an herbaceous perennial vine native to southern China and Northern Thailand and best known for its fruit,. It is one of four species in the genus ***Siraitia***. Botanical synonyms include *Momordica grosvenorii* and *Thladiantha grosvenorii*. The fruit is one of several that have been called longevity fruit.

The other species of the genus *Siraitia* are: *S. siamensis* from Thailand, *S. sikkimensis* and *S. silomaradjae* from India, and *S. taiwaniana* from the Republic of China (Taiwan).

The vine grows to 3 to 5 m long, climbing over other plants by means of tendrils which twine round anything they touch. The narrow, heart-shaped leaves are 10–20 cm long. The fruit is globose, 5 – 7 cm in diameter, and contains a sweet, fleshy, edible pulp and numerous seeds.

The fruit extract is nearly 300 times sweeter than sugar and has been used as a natural sweetener in China for nearly a millennium due to its flavor and lack of food energy, only 2.3 kcal/g (9.6 kJ/g). It has also been used in traditional Chinese medicine.

Scientific classification

Kingdom: Plantae
 Division: Magnoliophyta
 Class: Magnoliopsida
 Order: Violales
 Family: Cucurbitaceae
 Subfamily: Cucurbitoideae
 Tribe: Joliffieae
 Subtribe: Thladianthinae
 Genus: ***Siraitia*** Merr.
 Species: ***S. grosvenorii***

Binomial name

Siraitia grosvenorii

Synonyms

Neoluffa Chakrav.

2 - Cultivation:

It is grown primarily in the southwestern Chinese province of Guangxi (mostly in the mountains of Guilin), as well as in Guangdong, Guizhou, Hunan, and Jiangxi. These mountains lend the plants shadows and often are surrounded by mists; because of this the plants are protected from the sun. Nonetheless, the climate in this southern province is warm. The plant is rarely found in the wild and has hence been cultivated for hundreds of years.

Records as early as 1813 mention the cultivation of this plant in the Guangxi province. At present, the Guilin mountains harbor a plantation of 16 square kilometers with a yearly output of about 10,000 fruits. Most of the plantations are located in Yongfu County and Lingui County, which in China are renowned for the extraordinary number of centenarians. This is usually attributed to the consumption of this fruit and the unspoiled nature. The inhabitants themselves, however, are of the opinion that the reason lies in their calm lifestyle and simple nutrition.

Longjiang town ("Dragon River") in Yongfu County has acquired the name "home of the Chinese *luohanguo* fruit"; a number of companies specialised in making *luohanguo* extracts and finished products have been set up in the area. The Yongfu Pharmaceutical Factory is the oldest of these.

3 - Traditional uses:

The plant is most prized for its sweet fruits, which are used for medicinal purposes, and as a sweetener. The fruits are generally sold in dried form, and traditionally used in herbal tea or soup. They are used for respiratory ailments, sore throats and reputed to aid longevity.

The best way to describe the medicinal use of *luohan guo* in southern China during the 20th century can be found in the book ^[5]

written by Dai and Liu. It was written in Chinese in 1982 and translated into English in 1986. Here is their description:

The dried fruit may be bought in a market. The surface of the fruit is round and smooth, it has a yellow-brownish or green-brownish colour, and is covered by fine hairs. The fruit has a hard but thin shell. Inside, one finds a partially dried, soft substance which contains the juice and a large quantity of seeds. All components are very sweet. Their nature is cool and not toxic. The fruit can act as a remedy for sun stroke, wet the lungs, remove phlegm, stop cough and aid defecation.

Heat stroke and thirst

Take a fruit, break it open and pour hot water on it to make an infusion. Drink the infusion in place of tea.

Acute or chronic infection of the larynx (aphonia)

Take the halves of a fruit and 3 to 5 sterculia seeds, cover this with water and leave it to boil. Swallow very slowly.

Chronic cough

Take a piece of the fruit, cover it with water and leave it to boil. Drink the resulting liquid twice daily.

Constipation due to old age

Take two fruits and, using only the soft parts and seeds, divide it into pieces. Cover these pieces with water, boil it, and drink the liquid before going to bed.

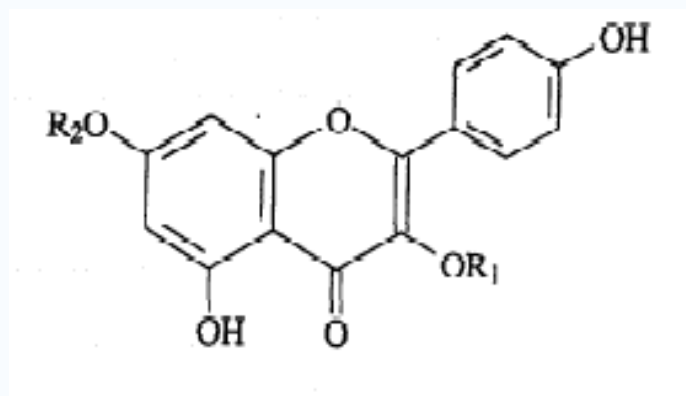
Diabetes

Take an appropriate amount of fruit squash or boil it so as to get concentrated juice. Use this as a substitute for sugar in your nutrition.

4 - Active agents:

The sweet taste of *luohan guo* comes mainly from the *mogrosides*, a group of Triterpene - Glycosides that make up approximately 1 % of the flesh of the fresh fruit. Through extraction, a powder containing 80% mogrosides can be obtained.

Five different mogrosides are known and they are known by names with the numbers 1 to 5. The main mogroside in this plant is mogroside-5, that was previously known as *esgoside*.



Structural formula of mogroside

Other similar agents in *luohan guo* are Siamenoside and Neomogroside.

The pure mogroside mix present results in a sweetness that is 300 times sweeter than sugar. The 80 % mix is approximately 250 times sweeter. Pure mogroside-5 and -5 can be up to 400 times as sweet.

4 – 1 - Toxicity:

There are no reported incidents of negative side effects of *luohan guo* that are known. It is classed by the American Food and Drug Administration as a GRAS (generally recognized as safe) product. There are no restrictions on consuming the fruit or its extracts.

4 – 2 - Current research:

Recent research on *luohan guo* suggests that the mogroside works as an antioxidant and that it helps to prevent cancer.

The use of *luohan guo* as a remedy for diabetes and overweight has been mentioned, as it can be used as a substitute for sugar.

Luohan guo has been shown to be useful against the Epstein-Barr virus.

The plant also contains a glycoprotein called momorgrosvin, which has been shown to inhibit ribosomal protein synthesis

5 - Cultivation and marketing:

5 – 1 - Traditional processing:



Dried Siraitia grosvenorii fruit, cut open

Luohan guo is harvested in the form of a round green fruit, which becomes brown on drying. It is rarely used in its fresh form, as it is hard to store. Furthermore, it develops a rotten taste on fermentation, which adds to the unwanted flavours already present.

Thus the fruits are usually dried before further use and are sold in precisely this fashion in Chinese herbal shops. The fruits are slowly dried in ovens, which preserves it and removes most of the unwanted aromas. However, this technique also leads to the formation of several bitter and astringent aromas. This limits the use of the dried fruits and extracts to the preparation of diluted tea, soup, and as a sweetener for products that would usually have sugar or honey added to them.

5 – 2 - The Procter & Gamble process:

The process for the manufacture of a useful sweetener from *luohan guo* was patented in 1995 by Procter & Gamble. The patent states that, while *luohan guo* is very sweet, it has too many interfering aromas, which render it useless for general application. Thus the company developed a process for the removal of the interfering aromas.

In this process, the fresh fruit is harvested before it is fully mature, and is then matured in storage so that it may be processed precisely when it is mature. The shell and seeds are then removed, and the pulped fruit is made into a fruit concentrate or puree. This is then used in the further production of food. Solvents are used, amongst other things, to remove the interfering aromas.

5 – 3 - Products:

There are a number of commercially prepared *luohan guo* products:

One of the most famous ones is powdered instant *luohan guo*, which is also sold by the Yongfu company. It is sold in China, Hong Kong and in Chinese shops in the West.

In addition, there are a number of other products which contain *luohan guo* either on its own or in a mix with other herbs. For example it is used with Ginkgo against cough, with chrysanthemum against heatstroke and headache or with asparagus, *Oldenlandia*, *Scutellaria*, and pearl powder to detoxify.

Recently, IZZE, a sparkling juice beverage company debuted their IZZE esque line of low - calorie sparkling juices containing less than half the calories of the regular IZZE. Rather than these using artificial sweeteners, *luo han guo* juice is used.

Celestial Seasonings has a winter Holiday tea called *Gingerbread Spice* that lists it as the last ingredient.

6 – History:

During the Tang dynasty, Guilin was one of the most important Buddhist retreats containing many temples. The fruit was named after the arhats *luóhàn*, a group of Buddhist monks who, due to their proper way of life and meditation, achieved enlightenment and were said to have been redeemed. According to Chinese history, the fruit was first mentioned in the records of the 13th century monks who used it.

However, plantation space was limited: it existed mainly in the slopes of the Guangxi and Guangdong mountains, and to a lesser degree in Guizhou, Hunan, Jiangxi, and Hainan. This and the difficulty of cultivation meant that the fruit did not become part of the Chinese herbal tradition, which depended on more readily available products. This is also the reason why one finds no mention of it in the traditional guides to herbs.

6 – 1 - Rediscovery in the 20 th century:

The herb became better known in the 20 th century. The first report on the herb in English was found in an unpublished manuscript written in 1938 by Professor G. W. Groff and Hoh Hin Cheung. The report stated that the fruits were often used as the main ingredients of "cooling drinks," that is, as remedies for hot weather, fever, or other dysfunctions traditionally associated with warmth or heat.

It was known that the juice of the fruits was very sweet.

Groff and Hoh realised that the fruit was an important Chinese domestic remedy for the treatment of cold and pneumonia when consumed with pork.

Interviews have confirmed that the fruit only recently gained importance in Chinese history. Nonetheless, it appears that a small group of people had mastered its cultivation a long time ago and had

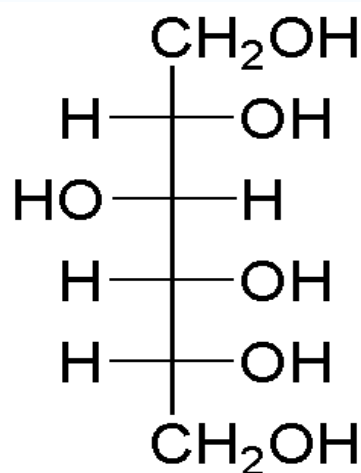
accumulated extensive knowledge on growth, pollination, and climatic requirements of the plant.

The fruit came to the United States in the early 20th century. Groff mentions that during a visit to the American ministry of agriculture in 1917, the botanic Frederick Coville showed him a *luohanguo* fruit bought in a Chinese shop in Washington. Seeds of the fruit which had been bought in Chinese shop in San Francisco were entered into the universal botanic description of the species in 1941.

The first research into the sweet component of *luohanguo* is attributed to C. H. Lee, who wrote an English report on it in 1975, and also to Tsunematsu Takemoto, who worked on it the early 1980s in Japan (later Takemoto decided to concentrate on the similar sweet plant, *jiaogulan*).

The development of *luohanguo* products in China has continued ever since, focusing in particular on the development of concentrated extracts.

Sorbitol



Contents:

- 1 Introduction
- 2 Uses
 - 2.1 Sweetener
 - 2.2 Laxative
 - 2.3 Medical applications
 - 2.4 Health care, food, and cosmetic uses
- 3 Medical importance
- 4 Adverse medical effects
- 5 Overdose effects
- 6 Other uses

Other names	D - glucitol D - Sorbitol
Molecular formula	$\text{C}_6 \text{H}_{14} \text{O}_6$
Molar mass	182 g mol^{-1}
Density	1.489 g / cm^3
Melting point	$95 \text{ }^\circ\text{C}$
Boiling point	$296 \text{ }^\circ\text{C}$

1 Introduction :

Sorbitol, also known as **glucitol**, is a sugar alcohol that the human body metabolises slowly. It is obtained by reduction of glucose changing the aldehyde group to an additional hydroxyl group.

2 – Uses:

2 – 1 - Sweetener:

Sorbitol is a sugar substitute. It may be listed under the inactive ingredients listed for some foods and products. Sorbitol is referred to as a nutritive sweetener because it provides dietary energy: 2.6 kilo calories per gram versus the average 4 kilo calories for carbohydrates. It often is used in diet foods (including diet drinks and ice cream), mints, cough syrups, and sugar - free chewing gum. It also occurs naturally in many stone fruits and berries from trees of the genus *Sorbus*.

2 – 2 – Laxative:

Sorbitol can be used as a non - stimulant laxative via an oral suspension or enema. It works by drawing water into the large intestine, thereby stimulating bowel movements. Sorbitol has been determined safe for use by the elderly, although it is not recommended without consultation with a clinician.

2 – 3 - Medical applications:

Sorbitol is used in bacterial culture media to distinguish *Escherichia coli* 0154 : H7 from most other strains of *E. coli*

Sorbitol, combined with kayexalate , helps the body rid itself of excess potassium ions in a hyperkalaemic state. The kayexalate exchanges sodium ions for potassium ions in the bowel, while sorbitol helps to eliminate it.

2 – 4 - Health care, food, and cosmetic uses:

Sorbitol often is used in modern cosmetics as a humectant and thickener. Sorbitol often is used in mouth wash and toothpaste. Some transparent gels can be made only with sorbitol, as it has a refractive index sufficiently high for transparent formulations.

Sorbitol is used as a cryoprotectant additive (mixed with sucrose and sodium poly phosphates) in the manufacture of surimi, a highly refined fish paste most commonly produced from Alaska (or walleye) pollock (*Theragra chalcogramma*). It is also used as a humectant in some cigarettes.

Sorbitol some times is used as a sweetener and humectant in cookies and other foods that are not identified as "dietary" items.

3 - Medical importance:

Even in the absence of dietary sorbitol, cells produce sorbitol naturally.

Too much sorbitol trapped in eye and nerve cells can damage these cells, leading to retinopathy and neuropathy. Substances that prevent or slow the action of aldose reductase are being studied as a way to prevent or delay these complications of diabetes. Aldose reductase is the first enzyme in the sorbitol pathway. This pathway is responsible for the conversion of glucose to sorbitol, and of galactose to galactitol. Under conditions of hyperglycemia, sorbitol accumulation occurs. Aldose reductase inhibitors prevent the accumulation of intracellular sorbitol..^[6] Sensitivity to the substance may result in severe pain among individuals who are intolerant of it and exhibit adverse symptoms from sorbitol.

Diabetic retinopathy and neuropathy may be related to excess sorbitol in the cells of the eyes and nerves. The source of this sorbitol in diabetics is excess glucose, which goes through the sorbitol-aldose reductase pathway.

In some human enzyme deficiencies such as galactosemia, sorbitol excess arises and can cause damage to the body. In diabetes mellitus, enzyme deficiency in the lens of the eye may cause sorbitol accumulation and cataracts`

4 - Adverse medical effects:

Sorbitol also may aggravate irritable bowel syndrome, and similar gastrointestinal conditions, resulting in severe abdominal pain for those affected, even from small amounts ingested.

5 - Overdose effects:

Ingesting large amounts of sorbitol can lead to abdominal pain, gas, and mild to severe diarrhea . Sorbitol ingestion of 20 grams per day as sugar - free gum has led to severe diarrhea leading to unintended weight loss of 11 kilo grams in a woman originally weighing 52 kilo grams; another patient required hospitalization after habitually consuming 30 grams per day.

6 - Other uses;

A mixture of sorbitol and potassium nitrate has found some success as an amateur solid rocket fuel.

Sorbitol is identified as a potential key chemical intermediate from biomass resources. Complete reduction of sorbitol opens the way to alkanes such as hexane which can be used as a biofuel. Sorbitol itself provides much of the hydrogen required for the transformation.



The above chemical reaction is exothermic; 1.5 mole of sorbitol generates approximately 1 mole of hexane. When hydrogen is co - fed, no carbon dioxide is produced.

Splenda



Front of yellow Splenda consumer packet.

1 – Introduction :

Splenda is a sucralose - based artificial sweetener marketed initially in North America.

Since its United States introduction in 1999, sucralose has overtaken Equal in the \$1.5 billion artificial sweetener market, holding a 62 % market share. According to market research firm IRI, as reported in the *Wall Street Journal*, Splenda sold \$ 212 million in 2006 in the U.S. while Equal sold \$ 48.7 million.

Its patent is owned by the British company Tate & Lyle. In April 2009, the International Trade Commission closed a patent infringement case that will permit Chinese manufacturers to produce copycat versions of Splenda products which will be sold under different brand names.^[5]

2 - Cooking strategies:

In 2008, McNeil Nutritionals recommended to home bakers to alter their recipes to replace one cup of sucrose with 3/4 cup granulated sucralose and 1/4 cup sucrose, in order to give a more authentic texture, moisture, and mouth feel to baked goods made with sucralose. The caloric load of traditional Southern sweet tea can be offset by substituting Splenda for 1/3 of the sugar ingredient typically used, thus adding a 2 : 1 sugar- splenda mixture that preserves the integrity of traditional recipes.

3 - Energy (caloric) content:

Though marketed in the U.S. as *No Calorie Sweetener*, Splenda products that also include bulking agents contain 12.4 % the calories of the same volume of sugar. When sucralose is added to commercial products such as diet drinks, the bulking agent is not present and no caloric energy is added.

Although the "nutritional facts" label on Splenda's retail packaging states that a single serving of 1 gram contains zero calories, each individual, tear-open package or 1 gram serving contains 3.31 calories. Such labeling is permitted in the U.S. because the FDA's regulations allow a product to be labeled as "zero calories" if the "food contains less than 5 calories per reference amount customarily consumed and per labeled serving". Because Splenda contains a relatively small amount of sucralose, little of which is metabolized, virtually all of Splenda's caloric content derives from the highly fluffed dextrose or malto dextrin bulking agents that give Splenda its volume. Like other carbohydrates, dextrose and malto dextrin have 3.75 calories per gram.

4 - Retail pack formats:

In the United States, Splenda is available in granulated and packet formats. Granulated product measures and sweeteners and pour cup for cup like sugar . 1g packets are the equivalent of 2 teaspoons of sugar. The granulated product is available in 110 g pour spout boxes and 275 g big bags. The packets are available in 50, 100, 200, 700 count 1g packets. In the United Kingdom, Splenda is available in granulated and tablet format. The granulated is available in 75 g and 125 g reseal able card cartons. The tablets are the equivalent of 1 teaspoon of sugar but low calorie and available in 100, 300, 500 tablet packs.

5 - Health and safety regulation:

Splenda usually contains 95 % dextrose and malto dextrin which the body readily metabolizes, combined with a small amount of

indigestible sucralose. Sucralose is derived from table sugar through a patented, multi - step process that selectively substitutes three chlorine atoms for three hydrogen - oxygen groups on the sugar molecule . The tightly bound chlorine atoms create a molecular structure that is remarkably stable.^[9] Splenda is recognized as safe to ingest as a diabetic sugar substitute.^[10] Research suggests that the amount of sucralose that can be consumed on a daily basis over a person's lifetime without any adverse effects is 15 mg / kg / day, or about 1 g for a 70 kilo gram person. This is equivalent to about 75 packets of Splenda or the sweetness of 612 g or 2500 kcal of sugar.

6 - Marketing controversy:

In 2006 Merisant, the maker of Equal, filed suit against McNeil Nutritionals in federal court in Philadelphia alleging that Splenda 's tagline "Made from sugar, so it tastes like sugar" is misleading. McNeil argued during the trial that it had never deceived consumers or set out to deceive them, since the product is in fact made from sugar. Merisant asked that McNeil be ordered to surrender profits and modify its advertising. The case ended with an agreement reached outside of court, with undisclosed settlement conditions.^[12] The lawsuit was the latest move in a long - simmering dispute. In 2004, Merisant filed a complaint with the Better Business Bureau regarding McNeil's advertising. McNeil alleged that Merisant 's complaint was in retaliation for a ruling in federal court in Puerto Rico, which forced Merisant to stop packaging Equal in packages resembling Splenda 's. McNeil filed suit in Puerto Rico seeking a ruling which would declare its advertising to not be misleading. Following Merisant's lawsuit in Philadelphia, McNeil agreed to a jury trial and to the dismissal of its lawsuit in Puerto Rico. Currently, Splenda is advertised with the slogan, "It starts with sugar. It tastes like sugar. But it's not sugar " .

In 2007, Merisant France prevailed in the Commercial Court of Paris against subsidiaries of McNeil Nutritionals LLC. The court awarded Merisant \$ 54,000 in damages and ordered the defendants to

cease advertising claims found to violate French consumer protection laws, including the slogans "Because it comes from sugar, sucralose tastes like sugar" and "With sucralose: Comes from sugar and tastes like sugar".

A Sugar Association complaint to the Federal Trade Commission points out that "Splenda is not a natural product. It is not cultivated or grown and it does not occur in nature " · McNeil Nutritionals, the manufacturer of Splenda, has responded that its "advertising represents the products in an accurate and informative manner and complies with applicable advertising rules in the countries where Splenda brand products are marketed."^[16] The U.S. Sugar Association has also started a web site where they put forward their criticism of sucralose.

Stevia



Stevia rebaudiana flowers.

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Eudicots
(unranked):	Asterids
Order:	Asterales
Family:	Asteraceae
Tribe:	Eupatorieae
Genus:	<i>Stevia</i> Cav.

Species

About 240 species, including:

Stevia eupatoria

Stevia ovata

Stevia plummerae

Stevia rebaudiana

Stevia salicifolia

Stevia serrata

Contents:

- 1 Introduction
- 2 History and use
 - 2.1 Medicinal use
 - 2.2 Availability
- 3 Production
- 4 Controversies
 - 4.1 Health controversy
 - 4.2 Political controversy
- 5 Names in other countries

1 –Introduction:

Stevia is a genus of about 240 species of herbs and shrubs in the sunflower family (Asteraceae), native to subtropical and tropical South America and Central America. The species *Stevia rebaudiana*, commonly known as **sweet leaf, sweet leaf, sugar leaf**, or simply **stevia**, is widely grown for its sweet leaves. As a sweetener and sugar substitute, stevia 's taste has a slower onset and longer duration than that of sugar, although some of its extracts may have a bitter or licorice-like aftertaste at high concentrations.

With its extracts having up to 300 times the sweetness of sugar, stevia has garnered attention with the rise in demand for low-carbohydrate, low-sugar food alternatives. Medical research has also shown possible benefits of stevia in treating obesity and high blood pressure. Because stevia has a negligible effect on blood glucose, it is attractive as a natural sweetener to people on carbohydrate-controlled diets. However, health and political controversies have limited stevia's availability in many countries; for example, the United States banned it in the early 1990s unless labeled as a supplement, although in 2008 it became commercially available as a sweetener. Stevia is widely used as a sweetener in Japan, and it is available in Canada as a dietary supplement.

2 - History and use:

The genus *Stevia* consists of 240^[1] species of plants native to South America, Central America, and Mexico, with several species found as far north as Arizona, New Mexico, and Texas. They were first researched by botanist and physician Pedro Jaime Esteve; the word *stevia* is a Latinized derivation of his surname. Human use of the sweet species *S. rebaudiana* originated in South America. The leaves of the stevia plant have 30–45 times the sweetness of sucrose (ordinary table sugar).^[4] The leaves can be eaten fresh, or put in teas and foods.

In 1899, the Swiss botanist Moisés Santiago Bertoni, during his research in eastern Paraguay first described the plant and the sweet taste in detail.^[5] But only limited research was conducted on the topic, until in 1931, two French chemists isolated the glycosides that give stevia its sweet taste. These compounds were named stevioside and rebaudioside, and are 250 – 300 times sweeter than sucrose, heat stable, pH stable, and non-fermentable. The exact structure of the aglycone and the glycoside were published in 1955.

In the early 1970s, Japan began cultivating stevia as an alternative to artificial sweeteners such as cyclamate and saccharin, which were suspected carcinogens. The plant's leaves, the aqueous extract of the leaves, and purified steviosides are used as sweeteners. Since the Japanese firm Morita Kagaku Kogyo Co., Ltd. produced the first commercial stevia sweetener in Japan in 1971, the Japanese have been using stevia in food products, soft drinks (including Coca Cola),^[9] and for table use. Japan currently consumes more stevia than any other country, with stevia accounting for 40 % of the sweetener market.

Today, stevia is cultivated and used in food elsewhere in east Asia, including in China (since 1984), Korea, Taiwan, Thailand, and Malaysia. It can also be found in Saint Kitts and Nevis, in parts of South America (Brazil, Colombia, Peru, Paraguay, and Uruguay) and in Israel. China is the world's largest exporter of stevioside.

Stevia species are found in the wild in semi-arid habitats ranging from grassland to mountain terrain. Stevia does produce seeds, but only a small percentage of them germinate. Planting cloned stevia is a more effective method of reproduction.

2 – 1 - Medicinal use:



S. rebaudiana foliage

For centuries, the Guaraní tribes of Paraguay, Bolivia and Brazil used stevia, which they called **ka'a he'ê** ("sweet herb"), as a sweetener in yerba mate and medicinal teas for treating heartburn and other ailments. More recent medical research has shown promise in treating obesity and hypertension. Stevia has a negligible effect on blood glucose, even enhancing glucose tolerance; therefore, it is attractive as a natural sweetener to diabetics and others on carbohydrate-controlled diets.

Possible treatment of osteoporosis has been suggested by the patent application claim that eggshell breakage can be reduced by 75% by adding a small percentage of stevia leaf powder to chicken feed.^[17] It has also been suggested that pigs fed stevia extract had twice as much calcium content in their meat, but these claims have been unverified.

2 – 2 - Availability:

Steviol glycosides were first commercialized as a sweetener in 1971 by the Japanese firm Morita Kagaku Kogyo Co., Ltd., a leading stevia extract producer in Japan.

Stevia has been grown on an experimental basis in Ontario, Canada since 1987 for the purpose of determining the feasibility of growing the crop commercially. In the United States, Rebiana is generally recognized as safe as of December 2008, and stevia is also recognized as a dietary supplement. Stevia has also been approved as a dietary supplement in Australia, New Zealand and Canada. Since June 2008 it is approved as a sweetener for food and beverages in Australia and New Zealand. In Japan and South American countries, stevia may also be used as a food additive. Stevia is currently banned for use in food in the European Union except in France which approved it for a 2-year test starting September 2009.

In 2007, The Coca-Cola Company announced plans to obtain approval for their stevia-derived sweetener **rebiana** for use as a food additive within the United States by 2009, as well as plans to market rebiana - sweetened products in 12 countries that allow stevia's use as a food additive. In May 2008, Coke and Cargill announced the availability of Truvia, a consumer brand stevia sweetener containing erythritol and Rebiana, which the FDA permitted as a food additive in December 2008. Coca - Cola announced intentions to release stevia -sweetened beverages in late December 2008.

Shortly afterward, PepsiCo and Pure Circle announced **PureVia**, their brand of stevia-based sweetener, but withheld release of beverages sweetened with reb - A until receipt of FDA confirmation. Since the FDA permitted Truvia and PureVia, both Coca Cola and PepsiCo have announced products that will contain their new sweetener.

Critics note that the FDA has not actually permitted the stevia plant itself to be used as a food additive, but only the Reb - A extract.

3 - Production:

To produce rebaudioside A commercially, stevia plants are dried and subjected to a water extraction process. This crude extract contains about 50 % rebaudioside A and is refined using crystallization and separation technologies to separate the various glycoside molecules in the extract. This allows the manufacturer to isolate pure rebaudioside A.

The National Research Council of Canada has patented a process for extracting sweet compounds from Stevia by column extraction at temperatures from 0-25°C , followed by purification by nano filtration. A micro filtration pretreatment step is used to clarify the extract. Purification is by ultra filtration followed by nano filtration.

4 - Controversies:

Steviol is the basic building block of stevia's sweet glycosides: Stevioside and rebaudioside A are constructed by replacing the bottom hydrogen atom with glucose and the top hydrogen atom with two or three linked glucose groups, respectively.

4 – 1 - Health controversy:

A 1985 study reported that steviol , a breakdown product from stevioside and rebaudioside (two of the sweet steviol glycosides in the stevia leaf), is a mutagen in the presence of a liver extract of pre - treated rats - but this finding was criticized on procedural grounds that the data were mishandled in such a way that even distilled water would appear mutagenic.^[32] Over the following years bioassay, cell culture, and animal studies have shown mixed results in terms of toxicology and adverse effects of stevia constituents, but in general, they have not been found to be harmful. While reports emerged that found steviol and stevioside to be weak mutagens,^{[33][34]} the bulk of studies show an absence of harmful effects. In a 2008 review, 14 of 16 studies cited showed no genotoxic activity for stevioside, 11 of 15 studies showed genotoxic activity for steviol, and no studies showed genotoxicity for

Rebaudioside A. Nevertheless, even if a chemical can cause DNA damage in the controlled conditions of a bioassay (e.g., in bacteria, in mammalian cell cultures) it is a fundamentally different question whether it causes cancer in intact organisms (e.g., rodents, humans) or is teratogenic (i.e., causes birth defects). No evidence for stevia constituents causing cancer or birth defects has been found.

Other studies have shown stevia to improve insulin sensitivity in rats and possibly even to promote additional insulin production, helping to reverse diabetes and metabolic syndrome. Preliminary human studies suggest that stevia can help reduce hypertension although another study has shown it to have no effect on hypertension. Indeed, millions of Japanese have been using stevia for over thirty years with no reported or known harmful effects. Similarly, stevia leaves have been used for centuries in South America spanning multiple generations in ethno medical tradition as a treatment for type II diabetes.

In 2006, the World Health Organization (WHO) performed a thorough evaluation of recent experimental studies of stevioside and steviol conducted on animals and humans, and concluded that "*stevioside and rebaudioside A are not genotoxic in vitro or in vivo and that the genotoxicity of steviol and some of its oxidative derivatives in vitro is not expressed in vivo.*"^[44] The report also found no evidence of carcinogenic activity. Furthermore, the report noted that "*stevioside has shown some evidence of pharmacological effects in patients with hypertension or with type-2 diabetes*"^[44] but concluded that further study was required to determine proper dosage.

Whole foods proponents draw a distinction between consuming (and safety testing) only parts, such as stevia extracts and isolated compounds like stevioside, versus the whole herb. However, professionals in pharmacognosy, as well as physicians and science journalists disagree that whole foods are beneficial over extracted components, and may even be harmful.

4 – 2 - Political controversy:

In 1991, the United States Food and Drug Administration (FDA) labeled stevia as an "unsafe food additive" and restricted its import. The FDA's stated reason was "toxicological information on stevia is inadequate to demonstrate its safety." This ruling was controversial, as stevia proponents pointed out that this designation violated the FDA's own guidelines under which natural substances used prior to 1958, with no reported adverse effects, should be generally recognized as safe (GRAS) as long as the substance was being used in the same way and format as prior to 1958.

Stevia occurs naturally, requiring no patent to produce it. As a consequence, since the import ban in 1991, marketers and consumers of stevia have shared a belief that the FDA acted in response to industry pressure. Arizona congressman Jon Kyl, for example, called the FDA action against stevia "a restraint of trade to benefit the artificial sweetener industry." To protect the complainant, the FDA deleted names in the original complaint in its responses to requests filed under the Freedom of Information Act.

Stevia remained banned until after the 1994 Dietary Supplement Health and Education Act forced the FDA in 1995 to revise its stance to permit stevia to be used as a dietary supplement, although not as a food additive - a position that stevia proponents regard as contradictory because it simultaneously labels stevia as safe and unsafe, depending on how it is sold.

Although unresolved questions remain about whether metabolic processes can produce a mutagen from stevia in animals, let alone in humans, the early studies nevertheless prompted the European Commission in 1999 to ban stevia's use in food in the European Union pending further research. More recent data compiled in the safety evaluation released by the World Health Organization in 2006 suggest that these policies may be obsolete.

In December 2008, the FDA gave a "no objection" approval for GRAS status to Truvia (developed by Cargill and The Coca-Cola Company) and PureVia (developed by PepsiCo and the Whole Earth Sweetener Company, a subsidiary of Merisant), both of which are wholly-derived from the Stevia plant.

5 - Names in other countries:

Both the sweetener and the stevia plant *Stevia rebaudiana* (also known as *Eupatorium rebaudianum*) are known simply as "stevia" in English - speaking countries as well as in France, Germany, Greece, Italy, Portugal, Israel, Norway and Sweden — although some of these countries also use other terms as shown below. Similar pronunciations occur in Japan (*sutebia* or in *katakana*), and in Thailand (*satiwia*). In some countries (India, for example) the name translates literally as "sweet leaf." Below are some names for the stevia plant in various regions of the world:

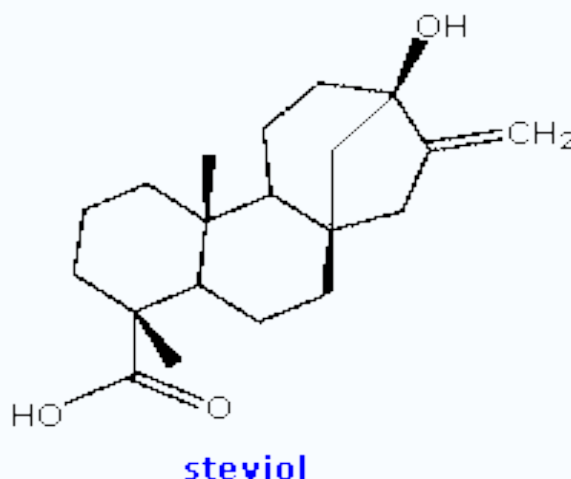


Stamp of Paraguay, containing the Guarani and the scientific name of the plant.

- China (*tian jü* – sweet chrysanthemum) , (*tian jü ye* – stevia leaf)
- Dutch-speaking countries: *honingkruid*
- English-speaking countries: candy leaf, sugar leaf, sweet leaf (USA), sweet honey leaf (Australia), sweet herb of Paraguay
- German speaking countries, also Switzerland: *Süßkraut*, *Süßblatt*, *Honigkraut*
- Hungary: *jázmin pakóca*

- India: *madhu parani* (Marathi), *gurmaar* (Punjabi), *madhu patra* (Sanskrit), *seeni tulsi* (Tamil), *madhu patri* (Telugu)
- Japan: (*amaha sutebia*)
- Paraguay: *ka´a he´ê* (sweet herb in Guarani)
- Portuguese-speaking countries: *capim doce* (sweet grass), *erva doce* (sweet herb, also a Portuguese term for fennel), *estévia* (Brazil), *folhas da stévia*
- Romania: *loboda*, *stevie*
- South Africa (Afrikaans): *heuningblaar* (honey leaf)
- Spanish-speaking countries: *estévia*, *hierba dulce*, *yerba dulce*
- Sweden: *sötflockel*
- Thailand: *satiwia*, (*ya wan*, or *sweet grass* in Bangkok)

Steviol glycoside



Molecular formula	$C_{20}H_{30}O_3$
Molar mass	318 g / mol

1 – Introduction :

The **steviol glycosides** are responsible for the sweet taste of the leaves of the stevia plant (*Stevia rebaudiana* Bertoni). These compounds range in sweetness from 40 to 300 times sweeter than sucrose.^[1] They are heat-stable, pH - stable, and do not ferment. They also do not induce a glycemic response when ingested, making them attractive as natural sweeteners to diabetics and others on carbohydrate - controlled diets.

2 - Structure:

Stevioside, formed by substituting two linked glucose molecules for the top hydrogen atom and one glucose molecule for the bottom hydrogen .

The diterpene known as **Steviol** is the aglycone of stevia 's sweet glycosides, which are constructed by replacing steviol 's carboxyl hydrogen atom (at the bottom of the figure) with glucose to form an

ester, and replacing the hydroxyl hydrogen (at the top of the figure in the info box) with combinations of glucose and rhamnose. The two primary compounds, stevioside and rebaudioside A, use only glucose: Stevioside has two linked glucose molecules at the hydroxyl site, whereas rebaudioside A has three, with the middle glucose of the triplet connected to the central steviol structure.

In terms of weight fraction, the four major steviol glycosides found in the stevia plant tissue are:

- * 5 – 10 % stevioside (250 – 300 X of sugar)
- * 2 – 4 % rebaudioside A — most sweet (350 – 450 X of sugar) .
- * 1 – 2 % rebaudioside C
- * ½ – 1 % dulcoside A.

Rebaudioside B, D, and E may also be present in minute quantities; however, it is suspected that rebaudioside B is a byproduct of the isolation technique. The two majority compounds stevioside and rebaudioside, primarily responsible for the sweet taste of stevia leaves, were first isolated by two French chemists in 1931.

3 – Stevia availability:

Steviol glycosides were first commercialized as a sweetener in 1971 by the Japanese firm Morita Kagaku Kogyo Co., Ltd., a leading stevia extract producer in Japan.

Rebiana is the trade name^[4] for a zero-calorie sweetener containing mainly rebaudioside A (also called Reb A). **Tru via** is the consumer brand for Rebiana marketed by Cargill and developed jointly with The Coca - Cola Company. **Pure Via** is PepsiCo's brand of Reb A sweetener. **Enliten** is Corn Products International's brand of Reb A sweetener.

4 - Toxicity

A 1985 study reporting that steviol may be a mutagen has been criticized on procedural grounds that the data were mishandled in such a way that even distilled water would appear mutagenic. More recent studies appear to establish the safety of steviol and its glycosides. In 2006, the World Health Organization (WHO) performed a thorough evaluation of recent experimental studies of stevia extracts conducted on animals and humans, and concluded that “*stevioside and rebaudioside A are not genotoxic in vitro or in vivo and that the genotoxicity of steviol and some of its oxidative derivatives in vitro is not expressed in vivo.*”^[9] The report also found no evidence of carcinogenic activity. The report also suggested the possibility of health benefits, in that “*stevioside has shown some evidence of pharmacological effects in patients with hypertension or with type - 2 diabetes*”, but concluded that further study was required to determine proper dosage.

Sucralose

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- 2 History
- 3 Production
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- 5 Packaging and storage
- 6 Health, safety, and regulation
 - 6.1 Safety studies
 - 6.2 Thymus
 - 6.3 Environmental effects
 - 6.4 Chlorinated substances
 - 6.5 Other potential effects

Other names	1',4,6'-Tri chloro galacto sucrose Tri chloro sucrose E955
Molecular formula	$C_{12}H_{19}Cl_3O_8$
Molar mass	397.5 g / mol
Melting point	125 °C, 398 K, 257 °F
Solubility in water	283 g / L (20 °C)

1 – Introduction:

Sucralose is a zero - calorie sugar substitute artificial sweetener. In the European Union, it is also known under the E number (additive code) **E955**. Sucralose is approximately 600 times as sweet as sucrose (table sugar),^[2] twice as sweet as saccharin, and 3.3 times as sweet as aspartame. Unlike aspartame, it is stable under heat and over a broad range of pH conditions. Therefore, it can be used in baking or in products that require a longer shelf life. The commercial success of

sucralose-based products stems from its favorable comparison to other low-calorie sweeteners in terms of taste, stability, and safety.

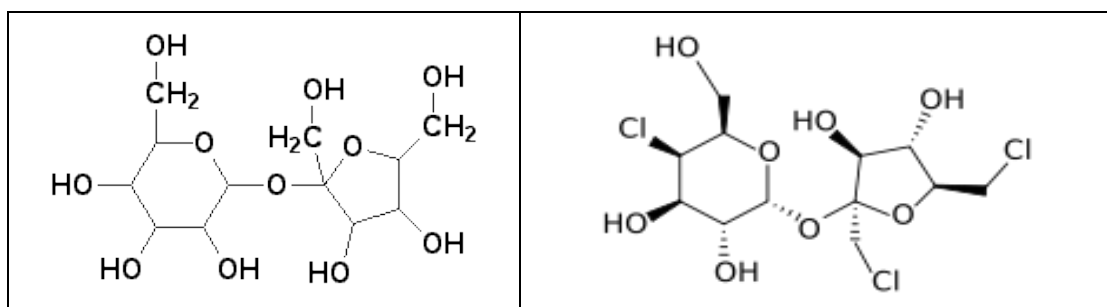
Sucralose is typically added to foods in very small quantities. Sucralose products manufactured in the US for domestic consumption are commonly formulated by the addition of "bulking" ingredients such as glucose (dextrose) and malto dextrin to give a degree of sweetness per unit volume comparable to sucrose, and to give some products an appearance similar to granular sugar. Some examples of these sweeteners are Splenda, SucraPlus, Candys and Cukren.

2 - History:

Sucralose was discovered in 1976 by scientists from Tate & Lyle, working with researchers Leslie Hough and Shashikant Phadnis at Queen Elizabeth College (now part of King's College London). On a late-summer day, Phadnis was told to test the powder. Phadnis thought that Hough asked him to *taste* it, so he did. He found the compound to be exceptionally sweet, as sucralose is 600 times as sweet as sucrose.

Sucralose was first approved for use in Canada in 1991. Subsequent approvals came in Australia in 1993, United States in 1998, European Union in 2004. As of 2008, it had been approved in over 80 countries, including Mexico, Brazil, China, India and Japan.

3 - Production



*Comparison of the chemical structures of :
sucros (lift) and sucralose (right) .*

Tate & Lyle manufactures sucralose at a plant in McIntosh, Alabama, with additional capacity in Jurong, Singapore. It is manufactured by the selective chlorination of sucrose (table sugar), which converts three of the hydroxyl groups to chlorides. The selective chlorination is achieved by selective protection of the primary alcohol groups followed by acetylation and then deprotection of the primary alcohol groups. Following an induced acetyl migration on one of the hydroxyl groups, the partially acetylated sugar is then chlorinated with a chlorinating agent such as phosphorus oxy chloride, followed by removal of the acetyl groups to give sucralose.

4 - Product uses:

Sucralose can be found in more than 4,500 food and beverage products. It is used because it is a no-calorie sweetener, does not promote dental cavities, and is safe for consumption by diabetics.^[8] Sucralose is used as a replacement for, or in combination with, other artificial or natural sweeteners such as aspartame, acesulfame potassium or high-fructose corn syrup. Sucralose is used in products such as candy, breakfast bars and soft drinks. It is also used in canned fruits wherein water and sucralose take the place of much higher calorie corn syrup based additives. Sucralose mixed with malto dextrin or dextrose (both made from corn) as bulking agents is sold internationally by McNeil Nutritionals under the Splenda brand name. In the United States and Canada, this blend is increasingly found in restaurants, including McDonald's, Tim Hortons and Starbucks, in yellow packets, in contrast to the blue packets commonly used by aspartame and the pink packets used by those containing saccharin sweeteners; though in Canada yellow packets are also associated with the Sugar Twin brand of cyclamate sweetener.

4 – 1 – Cooking:

Sucralose is a highly heat - stable artificial sweetener, allowing it to be used in many recipes with little or no sugar. Sucralose is available in a granulated form that allows for same - volume substitution with

sugar. This mix of granulated sucralose includes fillers, all of which rapidly dissolve in liquids. Unlike sucrose which dissolves to a clear state, sucralose suspension in clear liquids such as water results in a cloudy state. For example, gelatin and fruit preserves made with sucrose have a satiny, near jewel - like appearance, whereas the same products made with sucralose (whether cooked or not) appear translucent and marginally glistening. While the granulated sucralose provides apparent volume-for-volume sweetness, the texture in baked products may be noticeably different. Sucralose is non - hygroscopic, meaning it does not attract moisture, which can lead to baked goods that are noticeably drier and manifesting a less dense texture than baked products made with sucrose. Unlike sucrose which melts when baked at high temperatures, sucralose maintains its granular structure when subjected to dry, high heat (e.g., in a 180 °C oven). Thus, in some baking recipes, such as crème brûlée, which require sugar sprinkled on top to partially or fully melt and crystallize, substituting sucralose will not result in the same surface texture, crispness, or crystalline structure.

5 - Packaging and storage:

Pure sucralose is sold in bulk, but not in quantities suitable for individual use, although some highly concentrated sucralose - water blends are available online, using 1/4 tsp per 1 cup of sweetness or roughly 1 part sucralose to 2 parts water. Pure dry sucralose undergoes some decomposition at elevated temperatures. When it is in solution or blended with malto dextrin, it is slightly more stable.

Most products that contain sucralose add fillers and additional sweetener to bring the product to the approximate volume and texture of an equivalent amount of sugar. This is because sucralose is nearly 600 times as sweet as sucrose .

6 - Health, safety, and regulation

Sucralose has been accepted by several national and international food safety regulatory bodies, including the U.S. Food and Drug

Administration (FDA), Joint Food and Agriculture Organization / World Health Organization Expert Committee on Food Additives, The European Union's Scientific Committee on Food, Health Protection Branch of Health and Welfare Canada, and Food Standards Australia-New Zealand (FSANZ). Sucralose is one of two artificial sweeteners ranked as "safe" by the consumer advocacy group Center for Science in the Public Interest. The other is Neotame. According to the Canadian Diabetes Association, the amount of sucralose that can be consumed on a daily basis over a person's lifetime without any adverse effects is 15 mg/kg/day. "In determining the safety of sucralose, the FDA reviewed data from more than 110 studies in humans and animals. Many of the studies were designed to identify possible toxic effects, including carcinogenic, reproductive, and neurological effects. No such effects were found, and FDA's approval is based on the finding that sucralose is safe for human consumption." For example, McNeil Nutritional LLC studies submitted as part of its U.S. FDA Food Additive Petition 7A3987 indicated that "in the 2-year rodent bioassays...there was no evidence of carcinogenic activity for either sucralose or its hydrolysis products..."

6 – 1 - Safety studies:

Results from over 100 animal and clinical studies in the FDA approval process unanimously indicated a lack of risk associated with sucralose intake.^{[4][16][17][18]} However, some adverse effects were seen at doses that significantly exceeded the estimated daily intake (EDI), which is 1.1 mg / kg / day. When the EDI is compared to the intake at which adverse effects are seen, known as the highest no adverse effects limit (HNEL), at 1500 mg / kg / day, there is a large margin of safety. The bulk of sucralose ingested is not absorbed by the gastrointestinal (GI) tract and is directly excreted in the feces, while 11- 27 % of it is absorbed.^[2] The amount that is absorbed from the GI tract is largely removed from the blood stream by the kidneys and eliminated in the urine with 20 - 30 % of the absorbed sucralose being metabolized.

6 – 2 - Thymus:

Some concern has been raised about the effect of sucralose on the thymus. A report from the Australian National Industrial Chemicals Notification and Assessment Scheme (NICNAS) cites two studies on rats, both of which found "a significant decrease in mean thymus weight" at high doses. The sucralose dose which caused the effects was 3000 mg / kg / day for 28 days. For a 150 lb (68.2 kg) human, this would mean an intake of nearly 205 grams of sucralose a day, which is equivalent to more than 17,200 individual Splenda packets / day for approximately one month. The dose required to provoke *any* immunological response was 750 mg / kg / day, or 51 grams of sucralose per day, which is nearly 4,300 Splenda packets / day . After evaluation of these data and other toxicological findings, the NICNAS report concluded that sucralose does not pose a hazard to public health.

6 – 3 - Environmental effects:

According to one study, sucralose is digestible by a number of micro organisms and is broken down once released into the environment. However, measurements by the Swedish Environmental Research Institute have shown that wastewater treatment has little effect on sucralose, which is present in wastewater effluents at levels of several $\mu\text{g} / \text{l}$. There are no known eco - toxicological effects at such levels, but the Swedish Environmental Protection Agency warns that there may be a continuous increase in levels if the compound is only slowly degraded in nature.

6 – 4 - Chlorinated substances:

Sucralose belongs to a class of compounds known as organo chlorides (or chloro carbons). Some organo chlorides, particularly those that accumulate in fatty tissues, are toxic to plants or animals, including humans. Sucralose, however, is not known to be toxic in small quantities and is extremely insoluble in fat; it cannot accumulate in fat like chlorinated hydrocarbons. In addition, sucralose does not break down or

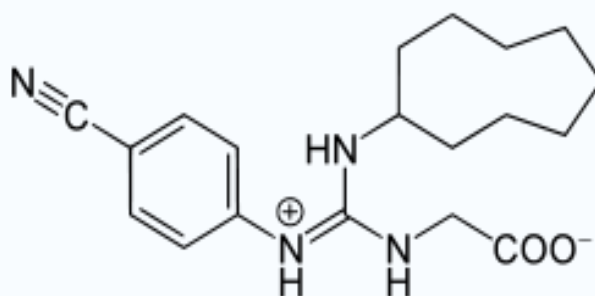
de chlorinate. The chemistry of organo chlorides differs from that of inorganic chlorine salts. Therefore, comparisons of sucralose to the safety of chloride salts, such as those made by the International Food Information Council (IFIC), are not relevant.

6 - 5 - Other potential effects:

A Duke University study, commissioned and funded by a sugar industry lobbying group, found evidence that doses of Splenda of between 100 and 1000 mg / kg, containing sucralose at 1.1 to 11 mg / kg (compare to the FDA Acceptable Daily Intake of 5 mg / kg), reduced the amount of good bacteria in the intestines of rats by up to 50 %, increased the pH level in the intestines, contributed to increases in body weight, and affected the levels of P - glycoprotein (P - gp). These effects have not been reported in humans. An expert panel, including scientists from Rutgers University, New York Medical College, Harvard School of Public Health, Columbia University, and Duke University reported in *Regulatory Toxicology and Pharmacology* that the Duke study was "not scientifically rigorous and is deficient in several critical areas that preclude reliable interpretation of the study results".^[30] Another report suggests sucralose was a possible trigger for some migraine patients.^[31] Another study published in the *Journal of Mutation Research* linked doses of sucralose equivalent to 11,450 packets per day in a person to DNA damage in mice.

Allergic reactions to sucralose have not been documented, but individuals sensitive to either malto dextrin or dextrose should consult a physician about using any sweeteners containing these fillers.

Sucrononic acid



Molecular formula	$C_{19}H_{26}N_4O_2$
Molar mass	342 g / mol

1 – Introduction :

Sucrononic acid is Guanidino derivative artificial sweetener. It is currently the most potent sweetener known, with a sweetness 200,000 times that of sucrose .

It has not been approved for use in food.

Sucrose

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1 – Introduction :

Sucrose is the organic compound commonly known as table sugar. This white, odorless, crystalline powder has a pleasing, sweet taste. It is best known for its role in human nutrition. The molecule is a disaccharide derived from glucose and fructose with the molecular formula $C_{12}H_{22}O_{11}$. About 150,000,000 tons are produced annually.

Other names	sugar, saccharose
Molecular formula	$C_{12}H_{22}O_{11}$
Molar mass	342 g / mol
Appearance	white solid
Density	1.587 g / cm ³ , solid
Melting point	186 °C decomp.
Solubility in water	200 g / 100 mL (25 °C)

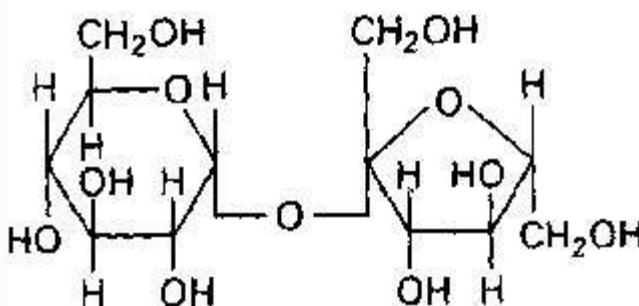
2 - Physical and chemical properties :

Sucrose is a complicated molecule with many stereo centers and many sites that could or are reactive. Despite this simplicity, the molecule exists as a single isomer.

Solubility of Pure Sucrose	
Temperature (C)	g Sucrose / g Water
50	2.59
55	2.73
60	2.89
65	3.06
70	3.25
75	3.46
80	3.69
85	3.94
90	4.20

2 – 1 - Structural β -D-fructo furanosyl-(2 $\rightarrow$ 1)- α -D-gluco pyranoside:

In sucrose, the component glucose and fructose are linked via an ether bond between C1 on the glucosyl subunit and C2 on the fructosyl unit. The bond is called a glycosidic linkage. Glucose exists predominantly as two isomeric "pyranoses" (α and β), but only one of these forms the links to the fructose. Fructose itself also exists as a mixture of forms, each of which has α and β isomers, but again only one particular isomer links to the glucosyl unit. What is notable about sucrose is that unlike most disaccharides, the glycosidic bond is formed between the reducing ends of both glucose and fructose, and not between the reducing end of one and the non reducing end of the other. This linkage inhibits further bonding to other saccharide units. Since it contains no anomeric hydroxyl groups, it is classified as a non reducing sugar.

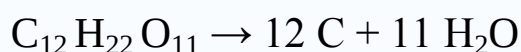


Crystallography is the technique that gives highly precise information on molecular structure. Sucrose crystallizes in the monoclinic space group $P2_1$, with values at 300K being $a = 1.08631$ nm, $b = 0.87044$ nm, $c = 0.77624$ nm, $\beta = 102.938^\circ$.

The usual measure of purity of sucrose is by polarimetry — the measurement of the rotation of plane-polarized light by a solution of sugar. The specific rotation at 20 C using "sodium-D" light is $+ 66.47^\circ$. Commercial samples of sugar are assayed using this parameter.

2 – 2 - Thermal and oxidative degradation:

Sucrose decomposes as it melts at 186 °C to form caramel. Like other carbohydrates, it combusts to carbon dioxide and water. For example, in the amateur rocket motor propellant called rocket candy it is the fuel together with the oxidizer potassium nitrate . Sucrose can be dehydrated with sulfuric acid to form a black, carbon - rich solid, as indicated in the following idealized equation:



2 – 3 - Hydrolysis:

Hydrolysis breaks the glycosidic bond, converting sucrose into glucose and fructose. Hydrolysis is, however, so slow that solutions of sucrose can sit for years with negligible change. If the enzyme sucrase is added, however, the reaction will proceed rapidly. Hydrolysis can also be accelerated with acids, such as cream of tartar or lemon juice.

3 - Synthesis and biosynthesis of sucrose:

The biosynthesis of sucrose proceeds via the precursors glucose 1-phosphate and fructose 6 - phosphate. Sucrose is formed by plants but not by other organisms. Sucrose is found naturally in many food plants along with the monosaccharide fructose. In many fruits, such as pineapple and apricot, sucrose is the main sugar. In others, such as grapes and pears, fructose is the main sugar.

3 – 1 - Chemical synthesis:

Although sucrose is invariably isolated from natural sources, its chemical synthesis was first achieved in 1953 by Raymond Lemieux.

4 - As a food :

Refined sugar was originally a luxury, but sugar eventually became sufficiently cheap and common to influence standard cuisine. Britain

and the Caribbean islands have cuisines where the use of sugar became particularly prominent.

Sugar forms a major element in confectionery and in desserts . Cooks use it as a food preservative as well as for sweetening. Sucrose is important to the structure of many foods including biscuits and cookies, cakes and pies, candy, and ice cream and sorbets. Sucrose also assists in the preservation of foods. As such it is common in many processed and so - called “junk foods.”

5 - Metabolism of sucrose:

In mammals, sucrose is readily digested in the stomach into its component sugars, by acidic hydrolysis. This step is performed by a glycoside hydrolase , which catalyzes the hydrolysis of sucrose to the mono saccharides glucose and fructose. Glucose and fructose are rapidly absorbed into the bloodstream in the small intestine. Undigested sucrose passing into the intestine is also broken down by sucrase or iso maltase glycoside hydrolases , which are located in the membrane of the micro villi lining the duodenum. These products are also transferred rapidly into the bloodstream. Sucrose is digested by the enzyme invertase in bacteria and some animals.

Sucrose is an easily assimilated macronutrient that provides a quick source of energy, provoking a rapid rise in blood glucose upon ingestion. Over consumption of sucrose has been linked with adverse health effects. The most common is dental caries or tooth decay, in which oral bacteria convert sugars (including sucrose) from food into acids that attack tooth enamel. Sucrose, as a pure carbohydrate, has an energy content of 3.94 kilo calories per gram (or 17 kilo joules per gram). When a large amount of foods that contain a high percentage of sucrose is consumed, beneficial nutrients can be displaced from the diet, which can contribute to an increased risk for chronic disease. It has been suggested that sucrose-containing drinks may be linked to the development of obesity and insulin resistance. Most soft drinks in the

USA are now made with high fructose corn syrup, not sucrose, HFCS 55 contains 55 % fructose and 45 % glucose.

The rapidity with which sucrose raises blood glucose can cause problems for people suffering from defective glucose metabolism, such as persons with hypoglycemia or diabetes mellitus. Sucrose can contribute to the development of metabolic syndrome.^[8] In an experiment with rats that were fed a diet one-third of which was sucrose, the sucrose first elevated blood levels of triglycerides, which induced visceral fat and ultimately resulted in insulin resistance. Another study found that rats fed sucrose-rich diets developed high triglycerides, hyperglycemia, and insulin resistance.

6 - Human health:

Human beings have long sought sugars, but aside from wild honey, have not had access to the large quantities that characterize the modern diet. Studies have indicated potential links between processed sugar consumption and health hazards, including obesity and tooth decay. John Yudkin showed that the consumption of sugar and refined sweeteners is closely associated with coronary heart disease. It is also considered as a source of endogenous glycation processes.

6 – 1 - Tooth decay:

Tooth decay has arguably become the most prominent health hazard associated with the consumption of sugar. Oral bacteria such as *Streptococcus mutans* live in dental plaque and metabolize sugars into lactic acid. High concentrations of acid may result on the surface of a tooth, leading to tooth demineralization.

6 – 2 - Glycemic index:

Sucrose has a high glycemic index, which in turn causes an immediate response within the body's digestive system. Thus sucrose is

transported directly into the blood. This causes an increase in blood sugar levels from a normal 90 mg / dL to up over 150 mg / dL.

6 – 3 - Diabetes:

Diabetes, a disease that causes the body to metabolize sugar poorly, occurs when either:

1 - the body attacks the cells producing insulin, the chemical that allows the metabolizing of sugar in the body's cells (Type 1 diabetes)

2 - the body's cells exhibit impaired responses to insulin (Type 2 diabetes)

When glucose builds up in the bloodstream, it can cause two problems:

1 - in the short term, cells become starved for energy because they do not have access to the glucose

2 - in the long term, frequent glucose build-up increases the acidity of the blood, damaging many of the body's organs, including the eyes, kidneys, nerves and/or heart

Authorities advise diabetics to avoid sugar-rich foods to prevent adverse reactions.

6 – 4 – Obesity:

The National Health and Nutrition Examination Survey I and Continuous indicates that the population in the United States has increased its proportion of energy consumption from carbohydrates and decreased its proportion from total fat while obesity has increased. This implies, along with the United Nations report cited below, that obesity may correlate better with sugar consumption than with fat consumption, and that reducing fat consumption while increasing sugar consumption actually increases the level of obesity. The following table summarizes this study (based on the proportion of energy intake from different food

sources for US Adults 20 – 74 years old, as carried out by the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, Hyattsville, MD):

Year	Sex	Carbohydrate %	Fat %	Protein %	Obesity %
1971	Male	42.4	36.9	16.5	12.1
1971	Female	45.4	36.1	16.9	16.6
2000	Male	49.0	32.8	15.5	27.7
2000	Female	51.6	32.8	15.1	34.0

A 2002 study conducted by the U.S. National Academy of Sciences concluded “There is no clear and consistent association between increased intakes of added sugars and BMI.” (BMI or "Body mass index" measures body-weight and height.)

6 – 5 - Gout:

The occurrence of the disorder is connected with an excess production of uric acid. A diet rich in sucrose may lead to gout as it raises the level of insulin, which prevents excretion of uric acid from the body. As the concentration of uric acid in the body increases, so does the concentration of uric acid in the joint liquid and beyond a critical concentration, the uric acid begins to precipitate into crystals. Researchers have implicated sugary drinks high in fructose in a surge in cases of the painful joint disease gout.

6 – 6 – Cancer:

A link between sugar and cancer has been conjectured for some time but this remains a controversial topic. Some recent studies lend support to this theory, but no major medical or nutritional organization currently recommends reducing sugar consumption to prevent cancer.

6 – 7 - United Nations nutritional advice:

In 2003, four United Nations agencies (including the World Health Organization and the Food and Agriculture Organization) commissioned a report compiled by a panel of 30 international experts. The panel stated that the total of free sugars (all mono saccharides and disaccharides added to foods by manufacturers, cooks or consumers, plus sugars naturally present in honey, syrups and fruit juices) should not account for more than 10 % of the energy intake of a healthy diet, while carbohydrates in total should represent between 55 % and 75 % of the energy intake.

6 - 8 - Debate on extrinsic sugar:

Argument continues as to the value of extrinsic sugar (sugar added to food) compared to that of intrinsic sugar (naturally present in food). Adding sugar to food particularly enhances taste, but does increase the total number of calories, among other negative effects on health and physiology.

In the US, sugar has become increasingly evident in food products, as more food manufacturers add sugar or high fructose corn syrup to a wide variety of consumables. Candy bars, soft drinks, chips, snacks, fruit juice, peanut butter, soups, ice cream, jams, jellies, yogurt, and many breads may have added sugars.

6 – 9 - Concerns of vegetarians and vegans:

The sugar refining industry often uses bone char (calcinated animal bones) for decolorizing. About 25 % of sugar produced in the U.S. is processed using bone char as a filter, the remainder being processed with activated carbon. As bone char does not get into the sugar .

7 - Production:

Table sugar (sucrose) comes from plant sources. Two important sugar crops predominate: sugar cane (*Saccharum spp.*) and sugar beets

(*Beta vulgaris*), in which sugar can account for 12 % to 20 % of the plant's dry weight. Minor commercial sugar crops include the date palm (*Phoenix dactylifera*), sorghum (*Sorghum vulgare*), and the sugar maple (*Acer saccharum*). In the financial year 2001 / 2002, worldwide production of sugar amounted to 134.1 million tones. Sucrose is obtained by extraction of these crops with hot water, concentration of the extract gives syrups, from which solid sucrose can be crystallized.

The first production of sugar from sugarcane took place in India. Alexander the Great's companions reported seeing "honey produced without the intervention of bees" and it remained exotic in Europe until the Arabs started producing it in Sicily and Spain. Only after the Crusades did it begin to rival honey as a sweetener in Europe. The Spanish began cultivating sugarcane in the West Indies in 1506 (and in Cuba in 1523). The Portuguese first cultivated sugarcane in Brazil in 1532.

Most cane sugar comes from countries with warm climates, such as Brazil, India, China, Thailand, Mexico and Australia, the top sugar-producing countries in the world. Brazil overshadows most countries, with roughly 30 million tones of cane sugar produced in 2006, while India produced 21 million, China 11 million, and Thailand and Mexico roughly 5 million each. Viewed by region, Asia predominates in cane sugar production, with large contributions from China, India and Thailand and other countries combining to account for 40 % of global production in 2006. South America comes in second place with 32 % of global production; Africa and Central America each produce 8 % and Australia 5 %. The United States, the Caribbean and Europe make up the remainder, with roughly 3 % each.

Beet sugar comes from regions with cooler climates: northwest and eastern Europe, northern Japan, plus some areas in the United States (including California). In the northern hemisphere, the beet - growing season ends with the start of harvesting around September. Harvesting and processing continues until March in some cases. The availability of

processing plant capacity, and the weather both influence the duration of harvesting and processing - the industry can lay up harvested beet until processed, but a frost - damaged beet becomes effectively un process able.

The European Union (EU) has become the world's second - largest sugar exporter. The Common Agricultural Policy of the EU sets maximum quotas for members' production to match supply and demand, and a price. Europe exports excess production quota (approximately 5 million tones in 2003). Part of this, "quota" sugar, gets subsidized from industry levies, the remainder (approximately half) sells as "C quota" sugar at market prices without subsidy. These subsidies and a high import tariff make it difficult for other countries to export to the EU states, or to compete with the Europeans on world markets.

The United States sets high sugar prices to support its producers, with the effect that many former consumers of sugar have switched to corn syrup (beverage manufacturers) or moved out of the country (candy makers).

The low prices of glucose syrups produced from wheat and corn (maize) threaten the traditional sugar market. Used in combination with artificial sweeteners, they can allow drink manufacturers to produce very low - cost goods.

7 – 1 - Politics of sugar vs HFCS:

Sucrose has been partially replaced in American industrial food production by other sweeteners such as fructose syrups or combinations of functional ingredients and high intensity sweeteners. This shift is attributable to governmental subsidies of U.S. sugar and an import tariff on foreign sugar, raising the price of sucrose to levels above those of the rest of the world. Because of the artificially elevated price of sucrose, HFCS is cost efficient for many sweetener applications.

7 – 2 - Sugar Cane:



Since the 6th century BC cane sugar producers have crushed the harvested vegetable material from sugarcane in order to collect and filter the juice. They then treat the liquid (often with lime (calcium oxide)) to remove impurities and then neutralize it. Boiling the juice then allows the sediment to settle to the bottom for dredging out, while the scum rises to the surface for skimming off. In cooling, the liquid crystallizes, usually in the process of stirring, to produce sugar crystals. Centrifuges usually remove the uncrystallized syrup. The producers can then either sell the resultant sugar, as is, for use; or process it further to produce lighter grades. This processing may take place in another factory in another country.

7 – 3 – Sugar Beet



Beet sugar producers slice the washed beets, then extract the sugar with hot water in a "diffuser". An alkaline solution ("milk of lime" and carbon dioxide from the lime kiln) then serves to precipitate impurities. After filtration, evaporation concentrates the juice to a content of about 70 % solids, and controlled crystallization extracts the sugar. A centrifuge removes the sugar crystals from the liquid, which gets recycled in the crystallizer stages. When economic constraints prevent the removal of more sugar, the manufacturer discards the remaining liquid, now known as molasses.

Sieving the resultant white sugar produces different grades for selling..

7 – 4 - Cane versus beet:

Little perceptible difference exists between sugar produced from beet and that from cane. Chemical tests can distinguish the two, and some tests aim to detect fraudulent abuse of European Union subsidies or to aid in the detection of adulterated fruit juice.

The production of sugarcane needs approximately four times as much water as the production of sugar beet, therefore some countries that traditionally produced cane sugar (such as Egypt) have seen the building of new beet sugar factories recently. On the other hand, sugar cane tolerates hot climates better. Some sugar factories process both sugar cane and sugar beets and extend their processing period in that way.

The production of sugar results in residues which differ substantially depending on the raw materials used and on the place of production. While cooks often use cane molasses in food preparation, humans find molasses from sugar beet unpalatable, and it therefore ends up mostly as industrial fermentation feedstock (for example in alcohol distilleries), or as animal feed. Once dried, either type of molasses can serve as fuel for burning.

7 – 5 - Culinary sugars:

So - called **raw sugars** comprise yellow to brown sugars made by clarifying the source syrup by boiling and drying with heat, until it becomes a crystalline solid, with minimal chemical processing. Raw beet sugars result from the processing of sugar beet juice, but only as intermediates *en route* to white sugar. Types of raw sugar include *demerara*, *muscovado*, and *turbinado*. Mauritius and Malawi export significant quantities of such specialty sugars. Manufacturers sometimes prepare raw sugar as loaves rather than as a crystalline powder, by pouring sugar and molasses together into molds and allowing the mixture to dry. This results in sugar-cakes or loaves, called *jaggery* or *gur* in India, *pingbian tang* in China, and *panela*, *panocha*, *pile*, *piloncillo* and *pão-de-açúcar* in various parts of Latin America. In South America, truly raw sugar, unheated and made from sugarcane grown on farms, does not have a large market - share.

Mill white sugar, also called **plantation white**, **crystal sugar**, or **superior sugar**, consists of raw sugar where the production process does not remove colored impurities, but rather bleaches them white by exposure to sulfur dioxide. Though the most common form of sugar in sugarcane-growing areas, this product does not store or ship well; after a few weeks, its impurities tend to promote discoloration and clumping.

Blanco directo, a white sugar common in India and other south Asian countries, comes from precipitating many impurities out of the cane juice by using *phosphatation* — a treatment with phosphoric acid and calcium hydroxide similar to the carbonatation technique used in beet sugar refining. In terms of sucrose purity, blanco directo is more pure than mill white, but less pure than white refined sugar.

White refined sugar has become the most common form of sugar in North America as well as in Europe. Refined sugar can be made by dissolving raw sugar and purifying it with a phosphoric acid method similar to that used for blanco directo, a carbonatation process involving calcium hydroxide and carbon dioxide, or by various filtration strategies.

It is then further purified by filtration through a bed of activated carbon or bone char depending on where the processing takes place. Beet sugar refineries produce refined white sugar directly without an intermediate raw stage. White refined sugar is typically sold as *granulated sugar*, which has been dried to prevent clumping.

Granulated sugar comes in various crystal sizes — for home and industrial use — depending on the application :

- * Coarse - grained sugars, such as *sanding sugar* (also called "pearl sugar", "decorating sugar", *nibbed sugar* or *sugar nibs*) adds "sparkle" and flavor for decorating to baked goods, candies, cookies/biscuits and other desserts. The sparkling effect occurs because the sugar forms large crystals which reflect light. Sanding sugar, a large - crystal sugar, serves for making edible decorations. It has larger granules that sparkle when sprinkled on baked goods and candies and will not dissolve when subjected to heat.

- * Normal granulated sugars for table use: typically they have a grain size about 0.5 mm across

- * Finer grades result from selectively sieving the granulated sugar

Powdered sugar , *confectioner's sugar* (0.060 mm), or *icing sugar* (0.024 mm), produced by grinding sugar to a fine powder. The manufacturer may add a small amount of anti caking agent to prevent clumping - either cornstarch (1 % to 3 %) or tri - calcium phosphate.



Sugar cubes.

sugar cubes or lumps for convenient consumption of a standardized amount. Suppliers of sugar cubes make them by mixing sugar crystals with sugar syrup.



Brown sugar crystals .

Brown sugars come from the late stages of sugar refining, when sugar forms fine crystals with significant molasses content, or from coating white refined sugar with a cane molasses syrup . Their color and taste become stronger with increasing molasses content, as do their moisture-retaining properties. Brown sugars also tend to harden if exposed to the atmosphere, although proper handling can reverse this.

7 – 6 - Dissolved sugar content:

Scientists and the sugar industry use degrees Brix (symbol °Bx), introduced by Antoine Brix , as units of measurement of the mass ratio of dissolved substance to water in a liquid. A 25 °Bx sucrose solution has 25 grams of sucrose per 100 grams of liquid; or, to put it another way, 25 grams of sucrose sugar and 75 grams of water exist in the 100 grams of solution.

The Brix degrees are measured using an infrared sensor. This measurement does not equate to Brix degrees from a density or refractive index measurement, because it will specifically measure dissolved sugar concentration instead of all dissolved solids. When using a refracto meter, one should report the result as "refracto metric dried substance" (RDS). One might speak of a liquid as having 20 °Bx RDS. This refers to a measure of percent by weight of *total* dried solids and,

although not technically the same as Brix degrees determined through an infrared method, renders an accurate measurement of sucrose content, since sucrose in fact forms the majority of dried solids. The advent of in-line infrared Brix measurement sensors has made measuring the amount of dissolved sugar in products economical using a direct measurement.

8 - History of sugar (sucrose) production:

Originally, people chewed the cane raw to extract its sweetness. Indians discovered how to crystallize sugar during the Gupta dynasty, around AD 350.

Sugarcane was originally from tropical South Asia and Southeast Asia. Different species likely originated in different locations with *S. barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea.

During the Muslim Agricultural Revolution, Arab entrepreneurs adopted the techniques of sugar production from India and then refined and transformed them into a large - scale industry. Arabs set up the first large scale sugar mills, refineries, factories and plantations.

The 1390s saw the development of a better press, which doubled the juice obtained from the cane. This permitted economic expansion of sugar plantations to Andalucía and to the Algarve. The 1420s saw sugar production extended to the Canary Islands, Madeira and the Azores.

The Portuguese took sugar to Brazil. Hans Staden, published in 1555, writes that by 1540 Santa Catarina Island had 800 sugar mills and that the north coast of Brazil, Demarara and Suriname had another 2,000. Approximately 3,000 small mills built before 1550 in the New World created an unprecedented demand for cast iron gears, levers, axles and other implements. Specialist trades in mold-making and iron-casting developed in Europe due to the expansion of sugar production. Sugar mill construction developed technological skills needed for a nascent industrial revolution in the early 17th century .

After 1625 the Dutch carried sugarcane from South America to the Caribbean islands - where it became grown from Barbados to the Virgin Islands. With the European colonization of the Americas, the Caribbean became the world's largest source of sugar. These islands could supply sugarcane using slave labor and produce sugar at prices vastly lower than those of cane sugar imported from the East.

During the eighteenth century, sugar became enormously popular and the sugar market went through a series of booms. As Europeans established sugar plantations on the larger Caribbean islands, prices fell, especially in Britain. By the eighteenth century all levels of society had become common consumers of the former luxury product. At first most sugar in Britain went into tea, but later confectionery and chocolates became extremely popular. Suppliers commonly sold sugar in solid cones and consumers required a sugar nip, a pliers - like tool, to break off pieces.

Beginning in the late 18th century, the production of sugar became increasingly mechanized. The steam engine first powered a sugar mill in Jamaica in 1768, and soon after, steam replaced direct firing as the source of process heat. During the same century, Europeans began experimenting with sugar production from other crops. Andreas Marggraf identified sucrose in beet root and his student Franz Achard built a sugar beet processing factory in Silesia. However the beet-sugar industry really took off during the Napoleonic Wars, when France and the continent were cut off from caribbean sugar. Today 30% of the world's sugar is produced from beets.

Today, a large beet refinery producing around 1,500 tones of sugar a day needs a permanent work force of about 150 for 24 - hour production.

Sugar beet



Two sugar beets. The one on the left has been selectively bred to be smoother than the traditional beet, so that it traps less soil.

Scientific classification

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Caryophyllales
Family:	Amaranthaceae
Subfamily:	Chenopodiaceae
Genus:	<i>Beta</i>
Species:	<i>B. vulgaris</i>

Binomial name

Beta vulgaris L.

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1 – Introduction :

Sugar beet (*Beta vulgaris* L.), a member of the *Chenopodiaceae* family, is a plant whose root contains a high concentration of sucrose. It is grown commercially for sugar production.

The sugar comes from the bulb of the beetroot plant, chard and fodder beet, all descended by cultivation from the sea beet.

The European Union, the United States, and Russia are the world's three largest sugar beet producers, although only the European Union and Ukraine are significant exporters of sugar from beets. The U.S. harvested 1,004,600 acres of sugar beets in 2008 alone. Beet sugar accounts for 30 % of the world's sugar production.

In the United States, genetically modified sugar beets resistant to glyphosate , a herbicide, were planted for the first time in the spring of

2008. Sugar from the biotechnology - enhanced sugar beet has been approved for human and animal consumption in the European Union. This action by the EU executive body allows unrestricted imports of food and feed products made from (H7-1) glyphosate - tolerant sugar beets. On September 21, 2009, a federal court ruled that the USDA had violated federal law in deregulating Roundup Ready sugar beets without adequately evaluating the environmental and socio - economic impacts of allowing commercial production, and will be considering an appropriate injunction.

2 – Culture:

Sugar beet is a hardy biennial plant that can be grown commercially in a wide variety of temperate climates. During its first growing season, it produces a large (1–2 kg) storage root whose dry mass is 15 – 20 % sucrose by weight. If the plant is not harvested at this time, then during its second growing season, nutrients in the root will be used to produce flowers and seeds and the root will decrease in size. In commercial beet production .

In most temperate climates, beets are planted in the spring and harvested in the autumn. At the northern end of its range, growing seasons as short as 100 days can produce commercially viable sugar beet crops . In warmer climates, such as in California's Imperial Valley, sugar beets are a winter crop, planted in the autumn and harvested in the spring. In recent years, Syngenta AG has developed the so-called tropical sugar beet. It allows the plant to grow in tropical and subtropical regions. Beets are planted from a small seed; 1 kg of beet seed comprises 100,000 seeds and will plant over a hectare of ground .

Up until the latter half of the 20th century, sugar beet production was highly labor - intensive, as weed control was managed by densely planting the crop, which then had to be manually thinned with a hoe two or even three times during the growing season. Harvesting also required many workers. Although the roots could be lifted by a plough-like device which could be pulled by a horse team, the rest of the preparation

was by hand. One laborer grabbed the beets by their leaves, knocked them together to shake free loose soil, and then laid them in a row, root to one side, greens to the other. A second worker equipped with a beet hook (a short-handled tool between a billhook and a sickle) followed behind, and would lift the beet and swiftly chop the crown and leaves from the root with a single action. Working this way, he would leave a row of beets that could be forked into the back of a cart.

**Top Ten Sugar Beet Producers - 2005
(million metric tons)**

France	29
Germany	25
United States	25
Russia	22
Ukraine	16
Turkey	14
Italy	12
Poland	11
United Kingdom	8
Spain	7
World Total	242

Today, mechanical sowing, herbicide application for weed control and mechanical harvesting have removed this reliance on numerous workers. Harvesting is now entirely mechanical. A roto beater uses a series of blades to chop the leaf and crown (which is high in non - sugar impurities) from the root. The beet harvester lifts the root, and removes excess soil from the root in a single pass over the field. A modern harvester is typically able to cover six rows at the same time. The beets are dumped into trucks as the harvester rolls down the field and delivered to the factory. The conveyor then removes more soil.

If the beets are to be left for later delivery, they are formed into clamps. Straw bales are used to shield the beets from the weather. Provided the clamp is well built with the right amount of ventilation, the beets do not significantly deteriorate. Beets that freeze and then defrost produce complex carbohydrates that cause severe production problems in the factory. In the UK, loads may be hand examined at the factory gate before being accepted.

In the US, the fall harvest begins with the first hard frost, which arrests photosynthesis and the further growth of the root. Depending on the local climate, it may be carried out over the course of a few weeks or be prolonged throughout the winter months. The harvest and processing of the beet is referred to as "the campaign", reflecting the organization required to deliver the crop at a steady rate to processing factories that run 24 hours a day for the duration of the harvest and processing (for the UK the campaign lasts approx 5 months). In the Netherlands this period is known as "*de bietencampagne*", a time to be careful when driving local roads in the area the beets are grown. The reason for this is the naturally high clay content of the soil, causing slippery roads when soil falls from the trailers during transport.

Sebewaing, Michigan is known (to Americans) as the sugar beet capital of the world. Sebewaing lies in the Thumb region of Michigan; both the region and state are major sugar beet producers. Sebewaing is home to one of three Michigan Sugar Company factories. The town sponsors an annual "Michigan Sugar Festival".



A beet harvester

3 – Processing:

3 – 1 - Reception:

After they are harvested, beets are hauled to a factory. In the U.K., beets are transported by a hauler, or by a tractor and a trailer by local farmers. Railways and boats are no longer used. Some beets were carried by rail in the Republic of Ireland, until the shutdown of sugar beet production in 2006 after the end of the government subsidies.

Each load is weighed and sampled before it gets tipped onto the reception area, typically a "flat pad" of concrete, where it is moved into large heaps. The beet sample is checked for

- * soil tare - the amount of non beet delivered
- * crown tare - the amount of low sugar beet delivered
- * sugar content ("pol") - amount of sucrose in the crop
- * nitrogen content - for recommending future fertilizer use to the farmer.

From these elements, the actual sugar content of the load is calculated and the grower's payment determined.

The beet is moved from the heaps into a central channel or gully, where it is washed towards the processing plant.

3 - 2 – Diffusion:

After reception at the processing plant, the beet roots are washed, mechanically sliced into thin strips called **cossettes**, and passed to a machine called a diffuser to extract the sugar content into a water solution.

Diffusers are long vessels of many meters in which the beet slices go in one direction while hot water goes in the opposite direction. The

movement may either be by a rotating screw or the whole unit rotates, and the water and cossettes move through internal chambers. There are three common designs of diffuser: the horizontal rotating 'RT' (*Raffinerie Tirlemontoise*, manufacturer), inclined screw 'DDS' (*De Danske Sukkerfabrikker*), or vertical screw "Tower". A less common design uses a moving belt of cossettes, with water pumped onto the top of the belt and poured through. In all cases the flow rates of cossettes and water are in the ratio one to two. Typically cossettes take about 90 minutes to pass through the diffuser, the water only 45 minutes. These are all countercurrent exchange methods that extract more sugar from the cossettes using less water than if they merely sat in a hot water tank. The liquid exiting the diffuser is called **raw juice**. The colour of raw juice varies from black to a dark red depending on the amount of oxidation, which is itself dependent on diffuser design.

The used cossettes, or **pulp**, exits the diffuser at about 95% moisture but low sucrose content. Using screw presses, the wet pulp is then pressed down to 75 % moisture. This recovers additional sucrose in the liquid pressed out of the pulp, and reduces the energy needed to dry the pulp. The pressed pulp is dried and sold as animal feed, while the liquid pressed out of the pulp is combined with the raw juice, or more often introduced into the diffuser at the appropriate point in the countercurrent process. The final by product, Vinasse, is used as fertilizer or growth substrate for yeast cultures.

During diffusion, there is a degree of breakdown of the sucrose into invert sugars. These can undergo further breakdown into acids. These breakdown products are not only losses of sucrose but also have knock-on effects reducing the final output of processed sugar from the factory. To limit (thermo philic) bacterial action, the feed water may be dosed with formaldehyde and control of the feed water pH is also practiced. There have been attempts at operating diffusion under alkaline conditions, but the process has proven problematic. The improved sucrose extraction in the diffuser is offset by processing problems in the next stages.

3 – 3 – Carbonatation:

Carbonatation is a procedure which removes impurities from raw juice before it undergoes crystallization. First, the juice is mixed with hot milk of lime (a suspension of calcium hydroxide in water). This treatment precipitates a number of impurities, including multivalent anions such as sulfate, phosphate, citrate and oxalate, which precipitate as their calcium salts and large organic molecules such as proteins, saponins and pectins, which aggregate in the presence of multivalent cations. In addition, the alkaline conditions convert the simple sugars, glucose and fructose, along with the amino acid glutamine, to chemically stable carboxylic acids. Left untreated, these sugars and amines would eventually frustrate crystallization of the sucrose.

Next, carbon dioxide is bubbled through the alkaline sugar solution, precipitating the lime as calcium carbonate (chalk). The chalk particles entrap some impurities and absorb others. A recycling process builds up the size of chalk particles and a natural flocculation occurs where the heavy particles settle out in tanks (clarifiers). A final addition of more carbon dioxide precipitates more calcium from solution; this is filtered off, leaving a cleaner, golden light-brown sugar solution called *thin juice*.

Before entering the next stage, the thin juice may receive soda ash to modify the pH and sulphitation with a sulfur-based compound to reduce colour formation due to decomposition of mono saccharides under heat.

3 – 4 - Evaporation:

The thin juice is concentrated via multiple - effect evaporation to make a *thick juice*, roughly 60 % sucrose by weight and similar in appearance to pancake syrup. Thick juice can be stored in tanks for later processing, reducing load on the crystallization plant.

3 – 5 – Crystallization:

Thick juice is fed to the crystallizers. Recycled sugar is dissolved into it, and the resulting syrup is called mother liquor. The liquor is concentrated further by boiling under vacuum in large vessels, seeded with fine sugar crystals. These crystals grow, as sugar from the mother liquor forms around them. The resulting sugar crystal and syrup mix is called a *massecuite*, from "cooked mass" in French. The *massecuite* is passed to a centrifuge where the liquid is removed from the sugar crystals. Remaining syrup is rinsed off with water and the crystals dried in a granulator using warm air.

The remaining syrup is fed to another crystallizer from which a second batch of sugar is produced. This sugar ("raw") is of lower quality with a lot of color and impurities and is the main source of the sugar that is dissolved again into the mother liquor. The syrup from the raw is also sent to a crystallizer. From this a very low-quality sugar crystal is produced (known in some systems as "AP sugar") that is also redissolved. The syrup separated is molasses, which still contains sugar but contains too much impurity to undergo further processing economically.

Actual procedure may vary from the above description, with different recycling and crystallization processes.

4 - Other uses:

4 – 1 - Beverages:

In a number of countries, most notably the Czech Republic, sugar from sugar beet is used to make a type of "rum" which is now known as *tuzemak*. On the Åland Islands, a similar drink is made under the brand name *Kobba Libre*. In some European countries, especially in the Czech Republic and Germany, sugar beet is also used to make rectified spirit and vodka.

4 – 2 - Sugar beet syrup:

An unrefined sugary syrup can be produced directly from sugar beet. This thick, dark syrup is produced by cooking shredded sugar beet for several hours, then pressing the resulting sugar beet mash and concentrating the juice produced until it has the consistency similar to that of honey. No other ingredients are used. In Germany, particularly the Rhineland area, this sugar beet syrup (called *Zuckerrüben-Sirup* in German) is used as a spread for sandwiches, as well as for sweetening sauces, cakes and desserts.

Commercially, if the syrup has a Dextrose Equivalency above 30 DE, the product has to be hydrolyzed and converted to a high - fructose syrup, much like high - fructose corn syrup, or iso - glucose syrup in the EU.

4 – 3 - Betaine:

Betaine can be isolated from the by-products of sugar beet processing. Production is chiefly by chromatographic separation, using techniques such as the "simulated moving bed".

4 – 4 – Uridine:

Uridine can be isolated from sugar beet. Uridine in combination with omega 3 fatty acids has been shown to alleviate depression.^[6]

4 – 5 - Alternative fuel:

There are plans by BP and Associated British Foods to use agricultural surpluses of sugar beet to produce bio butanol in East Anglia in the United Kingdom.

5 - History:

A large root vegetable in 4000 – year - old Egyptian temple artwork may be a beet. Although beets have been grown as vegetables

and for fodder since antiquity, their use as a sugar crop is relatively recent. As early as in 1590, the French botanist Olivier de Serres extracted a sweet syrup from beetroot, but the practice was not widely used. The Prussian chemist Andreas Sigismund Marggraf used alcohol to extract sugar from beets (and carrots) in 1747, but the methods did not lend themselves to industrial scale production.

His former pupil and successor Franz Karl Achard began selectively breeding sugar beet from the *White Silesian* fodder beet in 1784. By the beginning of the 19th century, his beet was approximately 5 – 6 percent sucrose by weight, compared to around 20 percent in modern varieties. Under the patronage of Frederick William III of Prussia, he opened the world's first beet sugar factory in 1801, at Cunern in Silesia.

The beet sugar industry in Europe rapidly developed after the Napoleonic Wars. In 1807, the British began a blockade of France, which prevented the import of sugarcane from the Caribbean. Partly in response, in 1812 Frenchman Benjamin Delessert devised a process of sugar extraction suitable for industrial application. In 1813, Napoleon instituted a retaliatory embargo. By the end of the wars, over 300 sugar beet mills operated in France and central Europe.

The first sugar beet mill in the U.S. opened in 1838, and the first commercially successful mill was established by E. H. Dyer in 1879.

6 – Agriculture:

Sugar beet is an important part of a rotating crop cycle.

Sugar beet plants are susceptible to rhizomania ("root madness") which turns the bulbous tap root into many small roots making the crop economically un process able. Strict controls are enforced in European countries to prevent the spread, but it is already endemic in some areas.

Continual research looks for varieties with resistance as well as increased sugar yield. Sugar beet breeding research in the United States is most prominently conducted at various USDA Agricultural Research Stations, including one in Fort Collins, Colorado, headed by Linda Hanson and Leonard Panella; one in Fargo, North Dakota, headed by John Wieland; and one at Michigan State University in East Lansing, Michigan, headed by J. Mitchell McGrath.

Other economically important members of the Chenopodioideae subfamily:

- Beet root
- Chard
- *Mangelwurzel* or Fodder Beet

Sugar cane



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- 2 Cultivation and uses
- 3 History of sugarcane
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- 5 Pests
- 6 Processing
 - * 6.1 Milling
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- 7 Production
- 8 Cane ethanol
- 9 Sugarcane as food
- 10 Nitrogen fixation

1 – Introduction:

Sugar cane , is any of six to thirty-seven species (depending on taxonomic system) of tall perennial grasses of the genus *Saccharum* (family Poaceae). Native to warm temperate to tropical regions of Asia, they have stout, jointed, fibrous stalks that are rich in sugar, and measure two to six meters (six to nineteen feet) tall. All sugar cane species interbreed, and the major commercial cultivars are complex hybrids. Brazil produces about one - third of the world's sugarcane.

Scientific classification

Kingdom:	Plantae
Phylum:	Magnoliophyta
(unranked):	Monocots
(unranked):	Commelinids
Order:	Poales
Family:	Poaceae
Genus:	<i>Saccharum</i> L.

2 - Cultivation and uses:

According to dr. Aashish Vishnoi Institute of Agribusiness Management NOIDA Sugar cane is grown in over 110 countries with an estimated total production of 1,591 million metric tons^[1] in 2007, more than six times the output of sugar beet. In 2005, the world's largest producer of sugar cane was Brazil, followed by India.^[2] Sugar cane products include table sugar, Falernum, molasses, rum, cachaça (the national spirit of Brazil), and ethanol. The bagasse that remains after sugar cane crushing may be burned to provide heat and electricity. It may also, because of its high cellulose content, serve as raw material for paper, cardboard, and eating utensils that, because they are by-products, may be branded as "environmentally friendly."

3 - History of sugar cane:

Sugar cane is indigenous to tropical South Asia and Southeast Asia. Different species likely originated in different locations with *S. barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea. Crystallized sugar was reported 5,000 years ago in India.

Around the eighth century AD. Dromnomy, Arabs introduced sugar to the Mediterranean, Mesopotamia, Egypt, North Africa, and Spain. By the tenth century, sources state, there was no village in

Mesopotamia that did not grow sugar cane. It was among the early crops brought to the Americas by the Portuguese.



The diffusion of sugar cane in pre - Islamic times (shown in red), in the medieval Muslim world (green) and by Europeans (violet)

Boiling houses in the 17th through 19th centuries converted sugarcane juice into raw sugar. These houses were attached to sugar plantations in the western colonies. Slaves often ran the boiling process, under very poor conditions. Made of cut stone, rectangular boxes of brick or stone served as furnaces with an opening at the bottom to stoke the fire and remove ashes. At the top of each furnace were up to seven copper kettles or boilers, each one smaller and hotter than the previous one. The cane juice began in the largest kettle. The juice was then heated and lime added to remove impurities. The juice was skimmed, then channeled to successively smaller kettles. The last kettle, which was called the 'teache', was where the cane juice became syrup. The next stop was a cooling trough, where the sugar crystals hardened around a sticky core of molasses. This raw sugar was then shoveled from the cooling trough into wooden barrels, and from there into the curing house.

Sugar cane is still extensively grown in the Caribbean. Christopher Columbus first brought it during his second voyage to the Americas, initially to the island of Hispaniola (modern day Haiti and the Dominican Republic). In colonial times, sugar formed one side of the triangular trade of New World raw materials, European manufactures,

and African slaves. France found its sugarcane islands so valuable, it effectively traded its portion of Canada, famously dubbed "a few acres of snow," to Britain for their return of Guadeloupe, Martinique and St. Lucia at the end of the Seven Years' War. The Dutch similarly kept Suriname, a sugar colony in South America, instead of seeking the return of the New Netherlands (New York). Cuban sugarcane produced sugar that received price supports from and a guaranteed market in the USSR; the dissolution of that country forced the closure of most of Cuba's sugar industry. Sugarcane remains an important part of the economy of Belize, Barbados, Haiti, along with the Dominican Republic, Guadeloupe, Jamaica, and other islands.

Sugar cane production greatly influenced many tropical Pacific islands, including Okinawa and, most particularly, Hawaii and Fiji. In these islands, sugarcane came to dominate the economic and political landscape after the arrival of powerful European and American agricultural businesses, which promoted immigration of workers from various Asian countries to tend and harvest the crop. Sugar was the dominant factor in diversifying the islands' ethnic makeup, profoundly affecting their politics and society.

Brazil is the biggest grower of sugarcane, which goes for sugar and ethanol for gasoline - ethanol blends (gasohol) for transportation fuel. In India, sugarcane is sold as jaggery, and also refined into sugar, primarily for consumption in tea and sweets, and for the production of alcoholic.

4 - Cultivation

Sugarcane cultivation requires a tropical or temperate climate, with a minimum of 60 centimeters (24 in) of annual moisture. It is one of the most efficient photo synthesizers in the plant kingdom. It is a C-4 plant, able to convert up to 2 percent of incident solar energy into biomass. In prime growing regions, such as India, Peru, Brazil, Bolivia, Colombia, Australia, Ecuador, Cuba, the Philippines, El Salvador and Hawaii, sugar cane can produce 20 kilo grams for each square meter exposed to the sun.

Although sugarcane produce seeds, modern stem cutting has become the most common reproduction method. Each cutting must contain at least one bud and the cuttings are sometimes hand-planted. In more advanced countries like the United States and Australia, billet planting is common. Billets harvested from a mechanical harvester are planted by a machine which opens and recloses the ground. Once planted, a stand can be harvested several times; after each harvest, the cane sends up new stalks, called **ratoons**. Successive harvests give decreasing yields, eventually justifying replanting. Two to ten harvests may be possible between plantings .

Sugarcane is harvested by hand and mechanically. Hand harvesting accounts for more than half of production, and is dominant in the developing world. In hand harvesting the field is first set on fire. The fire burns dry leaves, and kills any lurking, venomous snakes, without harming the water-rich stalks and roots. Harvesters then cut the cane just above ground-level using cane knives or machetes. A skilled harvester can cut 500 kilo grams of sugarcane per hour.

Mechanical harvesting uses a sugarcane combine (or chopper harvester), a harvesting machine originally developed in Australia. The Austoft 7000 series was the original modern harvester design that has now been copied by other companies including Cameco / John Deere. The machine cuts the cane at the base of the stalk, strips the leaves and deposits the cane into a transporter, while blowing the thrash back onto the field. Such machines can harvest 100 long tons (100 t) each hour, but machine-harvested cane must rapidly arrive at the processing. Once cut, sugarcane begins to lose its sugar content, and damage to the cane during mechanical harvesting accelerates this decline.

5 - Pests:

The cane grub can substantially reduce crop yield by eating roots; it can be controlled with Confidor or Lorsban. Other important pests are the larvae of some butterfly/moth species, including the turnip moth, the sugarcane borer (*Diatraea saccharalis*), the Mexican rice borer

(*Eoreuma loftini*); leaf-cutting ants, termites, spittlebugs (especially *Mahanarva fimbriolata* and *Deois flavopicta*), and the beetle *Migdolus fryanus* also are significant pests. The planthopper insect *Eumetopina flavipes* acts as a phytoplasma vector, which causes the sugarcane disease ramu stunt^[5]. But sugar cane grown in the land becomes unfertile

6 - Processing:

Traditionally, sugarcane processing requires two stages. Mills extract raw sugar from freshly harvested cane, and sometimes bleach it to make "mill white" sugar for local consumption. Refineries, often located nearer to consumers in North America, Europe, and Japan, then produce refined white sugar, which is 99 percent sucrose. These two stages are slowly merging. Increasing affluence in the sugar-producing tropics increased demand for refined sugar products, driving a trend toward combined milling and refining.

6 – 1 - Milling:

Small rail networks are a common method of transporting cane to a mill. Refineries test newly arrived cane for Brix and trash percentage.

The mill washes, chops, and uses revolving knives to shred the cane. Shredded cane is repeatedly mixed with water and crushed between rollers; the collected juices (called garapa in Brazil) contain 10 – 15 percent sucrose, and the remaining fibrous solids, called bagasse, are burned for fuel. Bagasse makes a sugar mill more than energy self-sufficient; surplus bagasse goes in animal feed, in paper manufacture, or to generate electricity for sale. The cane juice is next mixed with lime to adjust its pH to 7. This mixing arrests sucrose's decay into glucose and fructose, and precipitates some impurities. The mixture then sits, allowing the lime and other suspended solids to settle. The clarified juice is concentrated in a multiple - effect evaporator to make a syrup about 60 percent sucrose by weight. This syrup is further concentrated under vacuum until it becomes supersaturated, and then seeded with crystalline

sugar. On cooling, more sugar crystallizes from the syrup. A centrifuge separates the sugar from the molasses. Additional crystallizations extract more sugar; the final residue is called black strap.

Raw sugar is yellow to brown. Bubbling sulfur dioxide through the cane juice before evaporation bleaches many color - forming impurities into colorless ones. This *sulfitation* produces sugar known as "mill white", "plantation white", and "crystal sugar". Such sugar is the most commonly consumed in sugarcane - producing countries.

6 – 2 - Refining

Sugar refining further purifies the raw sugar. It is first mixed with heavy syrup and then centrifuged in a process called 'affination'. Its purpose is to wash away the sugar crystals' outer coating, which is less pure than the crystal interior. The remaining sugar is then dissolved to make a syrup, about 70 percent solids by weight.

The sugar solution is clarified by the addition of phosphoric acid and calcium hydroxide, which combine to precipitate calcium phosphate. The calcium phosphate particles entrap some impurities and absorb others, and then float to the top of the tank, where they can be skimmed off. An alternative to this "phosphatation" technique is 'carbonatation,' which is similar, but uses carbon dioxide and calcium hydroxide to produce a calcium carbonate precipitate.

After filtering any remaining solids, the clarified syrup is decolorized by filtration through activated carbon. Bone char is traditionally used in this role. Some remaining color - forming impurities adsorb to the carbon. The purified syrup is then concentrated to supersaturation and repeatedly crystallized in a vacuum, to produce white refined sugar. As in a sugar mill, the sugar crystals are separated from the molasses by centrifuging. Additional sugar is recovered by blending the remaining syrup with the washings from affination and again crystallizing to produce brown sugar. When no more sugar can be

economically recovered, the final molasses still contains 20 – 30 percent sucrose and 15 – 25 percent glucose and fructose.

To produce granulated sugar, in which individual grains do not clump, sugar must be dried, first by heating in a rotary dryer, and then by blowing cool air through it for several days.

6 – 3 - Ribbon cane syrup:

Ribbon cane is a subtropical type that was once widely grown in the southern United States, as far north as coastal North Carolina. The juice was extracted with horse or mule - powered crushers; the juice was boiled, like maple syrup, in a flat pan, and then used in the syrup form as a food sweetener. It is not currently a commercial crop, but a few growers find ready sales for their product. Most U.S. sugarcane production occurs in Florida and Louisiana, and to a lesser extent in Hawaii and Texas.

7 - Production:

Country	Production (Tones)
Brazil	514,080,000
India	355,520,000
China	106,316,000
Thailand	64,366,000
Pakistan	54,752,000
Mexico	50,680,000
Colombia	40,000,000
Australia	36,000,000
United States	27,750,000
Philippines	25,300,000

In the United States, sugar cane is grown commercially in Florida, Hawaii, Louisiana, and Texas.

8 - Cane ethanol

Ethanol is generally available as a by - product of sugar production. It can be used as a bio fuel alternative to gasoline, and is widely used in cars in Brazil. It is a promising alternative to gasoline, and may become the primary product of sugarcane processing, rather than sugar.

A textbook on renewable energy describes the energy transformation:

At present, 75 tons of raw sugar cane are produced annually per hectare in Brazil. The cane delivered to the processing plant is called burned and cropped (b & c), and represents 77 % of the mass of the raw cane. The reason for this reduction is that the stalks are separated from the leaves (which are burned and whose ashes are left in the field as fertilizer), and from the roots that remain in the ground to sprout for the next crop. Average cane production is, therefore, 58 tons of b & c per hectare per year.

Each ton of b & c yields 740 kg of juice (135 kg of sucrose and 605 kg of water) and 260 kg of moist bagasse (130 kg of dry bagasse). Since the higher heating value of sucrose is 16.5 MJ / kg, and that of the bagasse is 19.2 MJ / kg, the total heating value of a ton of b & c is 4.7 GJ of which 2.2 GJ come from the sucrose and 2.5 from the bagasse.

Per hectare per year, the biomass produced corresponds to 0.27 TJ. This is equivalent to 0.86 W per square meter. Assuming an average insulation of 225 W per square meter, the photosynthetic efficiency of sugar cane is 0.38 %.

The 135 kg of sucrose found in 1 ton of b & c are transformed into 70 liters of ethanol with a combustion energy of 1.7 GJ. The practical

sucrose-ethanol conversion efficiency is, therefore, 76 % (compare with the theoretical 97 %).

One hectare of sugar cane yields 4000 liters of ethanol per year (without any additional energy input, because the bagasse produced exceeds the amount needed to distill the final product). This however does not include the energy used in tilling, transportation, and so on. Thus, the solar energy-to-ethanol conversion efficiency is 0.13 %.

9 - Sugarcane as food :



Sugarcane juice vendors in Dhaka, Bangladesh

In most countries where sugar cane is cultivated, there are several foods and popular dishes derived directly from it, such as:

- Raw sugar cane: chewed to extract the juice
- Sugar cane Juice: Combining fresh juice, extracted by hand or small mills, with a touch of lemon and ice to make a popular drink, known variously as *ganne ka rass*, *guarab*, *guarapa*, *guarapo*, *papelón*, *aseer asab*, *Ganna sharbat*, *mosto* and *caldo de cana*
- Cachaça: The most popular distilled alcoholic beverage in Brazil. Is a liquor made of the distillation of sugarcane
- Jaggery: Solidified molasses, known as *Gur* or *Gud* in India, traditionally produced by evaporating juice to make a thick sludge and then cooling and molding it in buckets. Modern production partially freezes dry the juice to reduce caramelization

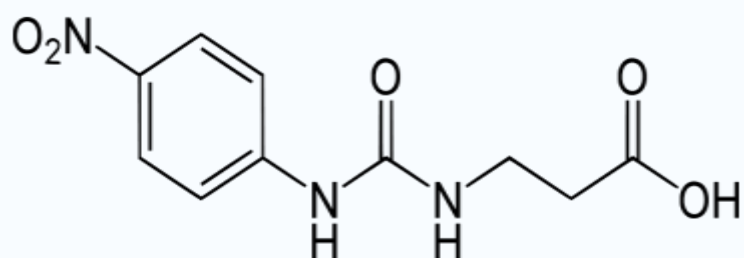
and lighten its color. It is used as sweetener in cooking traditional entrees, sweets and desserts.

- Molasses: as a sweetener and as a syrup accompanying other foods, such as cheese or cookies
- Rapadura: a candy made of flavored brown sugar in Brazil, which can be consumed in small hard blocks, or in pulverized form (flour), as an add-on to other desserts
- Rum: especially in the Caribbean
- Syrup: a traditional sweetener in soft drinks, now largely supplanted (in the US at least) by high - fructose corn syrup, which is less expensive
- Rock candy: crystallized cane juice

10 - Nitrogen fixation:

Some sugarcane varieties are known to be capable of fixing atmospheric nitrogen in association with a bacterium, *Acetobacter diazotrophicus*. Unlike legumes and other nitrogen fixing plants which form root nodules in the soil in association with bacteria, *Acetobacter diazotrophicus* lives within the intercellular spaces of the sugarcane's stem.

Suosan

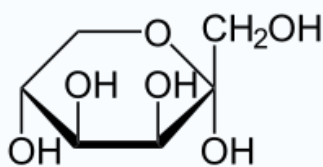


Other names	N- (((4-Nitro phenyl) amino) carbonyl) – beta - alanine mono sodium salt
Molecular formula	C ₁₀ H ₁₀ N ₃ Na O ₅
Molar mass	275 g mol ⁻¹
Melting point	240 °C

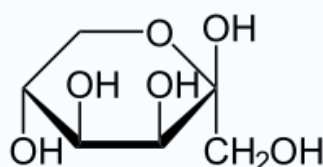
Suosan is calorie - free artificial sweetener derived from beta - Alanine.

Suosan is a sodium salt of beta - 4 – nitro anilide aspartic acid and is 700 times sweeter than sucrose with a bitter after taste .

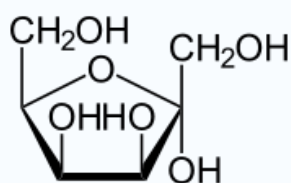
Tagatose



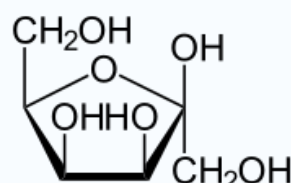
α -D-Tagatopyranose



β -D-Tagatopyranose



α -D-Tagatofuranose



β -D-Tagatofuranose

Molecular formula	$C_6 H_{12} O_6$
Molar mass	180 g / mol
Appearance	White solid
Melting point	133 - 135 °C

1 – Introduction :

Tagatose is a functional sweetener. It is a naturally occurring monosaccharide, specifically a hexose. It is often found in dairy products, and is very similar in texture to sucrose and is 92 % as sweet, but with only 38 % of the calories.

Tagatose is generally recognized as safe (GRAS) by the FAO / WHO and has been since 2001.

Since it is metabolized differently from sucrose, tagatose has a minimal effect on blood glucose and insulin levels. Tagatose is also approved as a tooth friendly ingredient.

2 - Production

Tagatose is present in only small amounts in dairy products. It can be produced commercially from lactose, which is first hydrolyzed to glucose and galactose. The galactose is isomerizes under alkaline conditions to D - tagatose by calcium hydroxide. The resulting mixture can then be purified and solid tagatose produced by crystallization.

3 - Development as a sweetener

Gilbert Levin, upon learning about hilarity, had the idea to search for a left - handed sugar. Cycling through the various left - handed sugars, he was accidentally sent D - tagatose, structurally similar to L - fructose. Even though Levin thought that his answer to a sweetener would be found in a left-handed sugar, it was the right-handed molecular form that proved to be a winner. FDA approved tagatose as a food additive in October 2003.

4 – Marketing:

In 1996, MD / Arla Foods acquired the rights to production from Spherix, the American license holder. In the following years, no products were brought to market by MD / Arla Foods, so Spherix brought them before the US Court of Arbitration for showing insufficient interest in bringing the product to market. The companies settled, with MD / Arla Foods agreeing to pay longer term royalties to Spherix and Spherix agreeing to not take further action.

In March 2006, Sweet Gradients (a joint venture company of Arla Foods and Nordzucker AG) decided to put the tagatose project "on hold". Sweet Gradients was the only world wide producer of tagatose. While progress has been made in creating a market for this innovative

sweetener, it has not been possible to identify a large enough potential to justify continued investments, and Sweet Gradients has decided to close down the manufacturing of tagatose in Nordstemmen, Germany.

In 2006, the Belgian Company NUTRILAB NV took over the Arla (Sweetgredients) stocks and project, and is setting up a production site for D-tagatose with the brand name Nutrilatose, with an enzymatic process method (different from the already published patents). Damhert N.V., the mother company of Nutrilab, has released the tagatose based sweetener Tagatesse under its own brand name, along with some other products (jams and some chocolate-based products) using on tagatose in October 2007 in the Benelux and France.

Tagatose has been approved in Europe as a novel food since December 14, 2005. However, the calorie content of 1.5 kcal/g approved in the USA, Canada, South Africa, is passed by the EU food council to EFSA (European Food Safety Agency) for opinion.

Thaumatococcus

1 – Introduction :

Thaumatococcus is a low - calorie (virtually calorie - free) protein sweetener and flavour modifier. The substance is often used primarily for its flavour modifying properties and not exclusively as a sweetener.^[1]

The thaumatococcus were first found as a mixture of proteins isolated from the katemfe fruit (*Thaumatococcus daniellii* Bennett) of west Africa. Some of the proteins in the thaumatococcus family are natural sweeteners roughly 2000 times more potent than sugar. Although very sweet, thaumatococcus 's taste is markedly different from sugar's. The sweetness of thaumatococcus builds very slowly. Perception lasts a long time leaving a liquorice - like aftertaste at high usage levels. Thaumatococcus is highly water - soluble, and stable to heating and stable under acidic conditions.

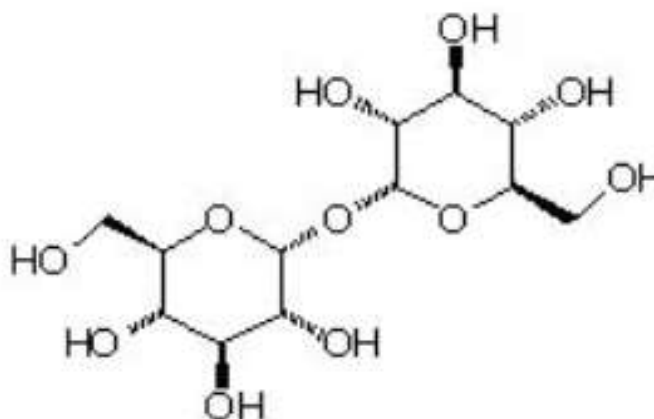
Thaumatococcus - like protein has been found in olive fruit, and it can cause allergic reactions. A worker in an olive - oil mill in Jaen, Spain had respiratory symptoms at work. His blood serum was used to extract a 23 kilodalton protein from olive pulp, which was purified and confirmed to cause an allergic reaction in a skin prick test.

2 - Production:

Within west Africa, the katemfe fruit has been locally cultivated and used to flavor foods and beverages for some time. The fruit's seeds are encased in a membranous sac, or aril, that is the source of thaumatococcus. In the 1970s, Tate & Lyle began extracting thaumatococcus from the fruit. In 1990, researchers at Unilever reported the isolation and sequencing of the two principal proteins found in thaumatococcus, which they dubbed **thaumatococcus I** and **thaumatococcus II**. These researchers were also able express thaumatococcus in genetically engineered bacteria. Now days thaumatococcus are commercialized under the Talin brand by Over seal company.

Trehalose

Chemical Formula: $C_{12}H_{22}O_{11}$



Other names	α -D- gluco pyranosyl α - D - gluco pyranoside (α,α -Trehalose)
Molecular formula	$C_{12} H_{22} O_{11}$
Molar mass	342 g / mol (anhydrous) 378 g / mol (dihydrate)
Appearance	White orthorhombic crystals
Density	1.58 g / cm ³ at 24°C
Melting point	203°C (anhydrous) 97°C (dihydrate)
Solubility in water	68.9 g per 100 g at 20°C
Solubility	soluble in ethanol, insoluble in diethyl ether and benzene

1 –Introduction :

Trehalose, also known as **mycose** or **tremalose**, is a natural alpha-linked disaccharide formed by an α, α -1, 1-glucoside bond between two α -glucose units. In 1832, Wiggers discovered trehalose in an ergot of rye, and in 1859 Berthelot isolated it from trehala manna, a substance

made by weevils, and named it trehalose. It can be synthesized by fungi, plants, and invertebrate animals. It is implicated in anhydrobiosis — the ability of plants and animals to withstand prolonged periods of desiccation. It has high water retention capabilities, and is used in food and cosmetics. The sugar is thought to form a gel phase as cells dehydrate, which prevents disruption of internal cell organelles, by effectively splinting them in position. Rehydration then allows normal cellular activity to be resumed without the major, lethal damage that would normally follow a dehydration / rehydration cycle. Trehalose has the added advantage of being an antioxidant. Extracting trehalose used to be a difficult and costly process, but, recently, the Hayashibara company (Okayama, Japan) confirmed an inexpensive extraction technology from starch for mass production. Trehalose is currently being used for a broad spectrum of applications.

2 - Structure

Trehalose is a disaccharide formed by a 1, 1 - glucoside bond between two α - glucose units. Because trehalose is formed by the bonding of two reducing groups, it has no capacity to reduce other compounds.

3 - Chemical properties :

Trehalose was first isolated from ergot of rye. Emil Fischer first described the trehalose - hydrolyzing enzyme in yeast. Trehalose is a non-reducing sugar formed from two glucose units joined by a 1-1 alpha bond, giving it the name of α - D – gluco pyranosyl - (1 $\rightarrow$ 1)- α -D-gluco pyranoside. The bonding makes trehalose very resistant to acid hydrolysis, and therefore is stable in solution at high temperatures, even under acidic conditions. The bonding also keeps non-reducing sugars in closed-ring form, such that the aldehyde or ketone end-groups do not bind to the lysine or arginine residues of proteins (a process called glycation). Trehalose is broken down by the enzyme trehalase into glucose. Trehalose has about 45 % the sweetness of sucrose. Trehalose is less soluble than sucrose, except at high temperatures (>80 °C).

Trehalose forms a rhomboid crystal as the dihydrate, and has 90% of the calorific content of sucrose in that form. Anhydrous forms of trehalose readily regain moisture to form the dihydrate. Anhydrous forms of trehalose can show interesting physical properties when heat-treated.

4 - Biological properties:

In nature, trehalose can be found in animals, plants, and microorganisms. In animals, trehalose is prevalent in shrimp, and also in insects, including grasshoppers, locusts, butterflies, and bees, in which blood-sugar is trehalose. The trehalose is then broken down into glucose by the catabolic enzyme trehalase for use. Trehalose is also present in the nutrition exchange liquid of hornets and their larvae.

In plants, the presence of trehalose is seen in sunflower seeds, Moonwort, [*Selaginella*] plants and sea algae. Within the fungus family, it is prevalent in some mushrooms such as shiitake (*Lentinula edodes*), maitake (*Grifola fondosa*), nameko (*Pholiota nameko*), and Judas's ear (*Auricularia auricula-judae*), which can contain 1% to 17% percent of trehalose in dry weight form (thus it is also referred to as mushroom sugar). Trehalose can also be found in such microorganisms as baker's yeast and wine yeast, and it is metabolized by a number of bacteria, including *Streptococcus mutans*, the common oral bacterium responsible for dental plaque.

When tardigrades (water bears) dry out, the glucose in their bodies changes to trehalose when they enter a state called cryptobiosis — a state wherein they appear dead. However, when they receive water, they revive and return to their metabolic state. It is also thought that the reason the larvae of sleeping chironomid (*Polypedilum vanderplanki*) and artemia (sea monkeys, brine shrimp) are able to withstand dehydration is because they store trehalose within their cells.

Even within the plant kingdom, selaginella (sometimes called the resurrection plant), which grows in desert and mountainous areas, may be cracked and dried out, but will turn green again and revive after a

rain, is because of the function of trehalose . It is also said that the reason dried shiitake mushrooms spring back into shape so well in water is because they contain trehalose.

The two prevalent theories as to how trehalose works within the organism in the state of cryptobiosis are the vitrification theory, a state that prevents ice formation, or the water displacement theory, whereby water is replaced by trehalose^[3], although it is possible that a combination of the two theories are at work.

The enzyme trehalase, a glycoside hydrolase, present but not abundant in most people, breaks trehalose into two glucose molecules, which can then be readily absorbed in the gut .

Trehalose is the major carbohydrate energy storage molecule used by insects for flight. One possible reason for this is that the double glycosidic linkage of trehalose, when acted upon by an insect trehalase, releases two molecules of glucose, which is required for the rapid energy requirements of flight. This is double the efficiency of glucose release from the storage polymer starch, for which cleavage of one glycosidic linkage releases only one glucose molecule.

5 - Natural sources

- Trehala manna
- Locust
- Resurrection plant
- Fungi

6 - Production:

Trehalose was previously being manufactured through an extraction process from cultured yeast, but, since production costs were prohibitive, use was limited to only certain cosmetics and chemicals.

In 1994, Hayashibara, a saccharified starch maker in Okayama prefecture, Japan, discovered a method of inexpensively mass -

producing trehalose from starch. The following year, Hayashibara started marketing trehalose by activating two enzymes, the glucosyl trehalose - producing enzyme that changes the reducing terminal of starch into a trehalose structure, and the trehalase free enzyme that detaches this trehalose structure. As a result, a high-purity trehalose from starch can be mass-produced for a very low price.

7 - Use

Trehalose has been accepted as a novel food ingredient under the GRAS terms in the U.S. and the EU. Trehalose has also found commercial application as a food ingredient. The uses for trehalose span a broad spectrum that cannot be found in other sugars, the primary one being its use in the processing of foods. Trehalose is used in a variety of processed foods such as dinners, western and Japanese confectionery, bread, vegetables side dishes, animal - derived deli foods, pouch-packed foods, frozen foods, and beverages, as well as foods for lunches, eating out, or prepared at home. This use in such a wide range of products is due to the multi-faceted effects of trehalose's properties, such as its inherently mild, sweet flavor; its preservative properties, which maintain the quality of the three main nutrients (carbohydrates, proteins, fats); its powerful water-retention properties, which preserve the texture of foods by protecting them from drying out or freezing; and its ability to suppress bitterness, stringency, harsh flavors, and the odor of raw foods, meats, and packaged foods. These properties, when combined, can potentially bring about promising results for broad-spectrum use. However, as it is less soluble and less sweet than sucrose, trehalose is seldom used as a direct replacement for conventional sweeteners, such as sucrose, which is regarded as the "gold standard." Technology for the production of trehalose was developed in Japan, where enzyme-based processes convert wheat and corn syrups to trehalose. It is also used as a protein-stabilizing agent in research. It is particularly effective when combined with phosphate ions. Trehalose has also been used in several biopharmaceutical monoclonal antibody formulations: trastuzumab and bevacizumab, marketed as **Herceptin** and **Avastin**, respectively, by

Genentech, and ranibizumab, marketed as **Lucentis** by Genentech and Novartis.

Cosmetics: Capitalizing on trehalose's moisture-retaining capacity, it is used as a moisturizer in many basic toiletries, such as bath oils and hair growth tonics.

Pharmaceuticals: Using trehalose's properties to preserve tissue and protein to full advantage, it is used in organ protection solutions for organ transplants.

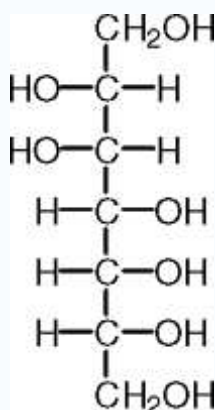
Other: Other fields of use for trehalose span a broad spectrum including fabrics that have deodorization qualities, plant activation, antibacterial sheets, and nutrients for larvae.

8 - Related research:

After trehalose became readily available in mass quantities at a low price, all kinds of research involving trehalose accelerated rapidly. Research is being conducted, especially in the field of medicine, to achieve uses for trehalose in post- surgery adhesion suppressants, dry-eye treatments and the manufacturing of dry blood.

It is rumored in the biomedical research community that trehalose, when eaten over a length of time in sufficient quantities, may sometimes provide a partial cure to Alzheimer's disease or dementia. A lot of research into brain - based illness has focused on proteins in the human brain, but it may be important in research to look at sugars that the brain uses, such as trehalose.

Volemitol



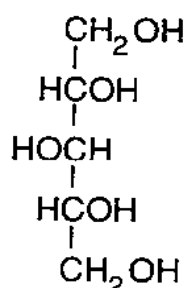
Other names	<i>D-glycero-D-talo-heptitol</i> , <i>alpha-sedoheptitol</i> , <i>beta-mannoheptitol</i>
Molecular formula	$\text{C}_7 \text{H}_{16} \text{O}_7$
Molar mass	212 g / mol
Melting point	152 - 153°C

Volemitol is a naturally occurring seven - carbon sugar alcohol. It is a substance widely distributed in plants, red algae, fungi, mosses, and lichens. It was also found in lipopolysaccharides from *E. coli*. In certain higher plants, such as *Primula*, volemitol plays several important physiological roles. It functions as a photosynthetic product, phloem translocate, and storage carbohydrate.

It is used as a natural sweetening agent.

Volemitol was first isolated as a white crystalline substance from the mushroom *Lactarius volemus* by the French scientist Émile Bourquelot in 1889.

Xylitol



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- 1 Introduction
- 2 Production of xylitol
- 3 Properties
- 4 Dietary use worldwide
- 5 Medical applications
 - 5.1 Dental care
 - 5.2 Diabetes
 - 5.3 Osteoporosis
 - 5.4 Ear and upper respiratory infections
 - 5.5 Infection
 - 5.6 Candida yeast
 - 5.7 Benefits for pregnant or nursing women
- 6 Safety

1 – Introduction :

Xylitol (from Greek "wood" + suffix *-itol*, used to denote sugar alcohols) is a sugar alcohol sweetener used as a naturally occurring sugar substitute. It is found in the fibers of many fruits and vegetables, including various berries, corn husks, oats, and mushrooms.^[2] It can be extracted from corn fiber, birch, raspberries, plums, and corn. Xylitol is roughly as sweet as sucrose with only two - thirds the food energy. As with most sugar alcohols, initial consumption can result in bloating,

diarrhea, and flatulence, although generally rather less so than other sugar alcohols like sorbitol .

Xylitol is an organic compound with the formula $(\text{CHOH})_3(\text{CH}_2\text{OH})_2$. This achiral species is one of four isomers of 1,2,3,4,5-pentapentanol.

Other names	1,2,3,4,5-Penta hydroxyl pentane ; Xylite
Molecular formula	$\text{C}_5\text{H}_{12}\text{O}_5$
Molar mass	152 g/mol
Density	1.52 g / cm^3
Melting point	92 - 96 °C
Boiling point	216 °C

2 - Production of xylitol:

Xylitol (Finnish *ksylitoli*) was first derived from birch trees in Finland in the 20th century and was first popularized in Europe as a safe sweetener for people with diabetes that would not impact insulin levels. Today, using hardwood or maize sources, the largest manufacturer globally is the Danish company Danisco, with several other suppliers from China.^{[4][5]} Xylitol is produced by hydrogenation of xylose, which converts the sugar (an aldehyde) into a primary alcohol.

3 - Properties:

One tea spoon (5 gm) of xylitol contains 9.6 calories, as compared to one teaspoon of sugar, which has 15 calories. Xylitol has virtually no aftertaste, and is advertised as "safe for diabetics and individuals with hyperglycemia." This tolerance is attributed to the lower impact of xylitol on a person's blood sugar, compared to that of regular sugars. and also has a very low glycemic index of 13 (glucose has a GI of 100 for reference)

4 - Dietary use world wide:

Xylitol is widely used in Finland, its "home country." Many Finnish confectioneries employ xylitol, or have a xylitol version available. Virtually all chewing gum sold in Finland is sweetened with xylitol.^[8] Specific brands of sugar free gum containing xylitol include Stride and Trident.



5 - Medical applications:

5 – 1 - Dental care:

Xylitol is a "tooth friendly" non-fermentable sugar alcohol. A systematic review study on the efficacy of xylitol has indicated dental health benefits in caries prevention, showing superior performance to other polyols (poly - alcohols). Early studies from Finland in the 1970s found that a group chewing sucrose gum had 2.92 decayed, missing, or filled (dmf) teeth compared to 1.04 in the group chewing xylitol gums.^[13] In another study, researchers had mothers give xylitol gum to their children 3 months after delivery until they were 2 years old. The

researchers found that children in the xylitol group had "a 70 % reduction in cavities (dmf) ". Recent research confirms a plaque-reducing effect and suggests that the compound, having some chemical properties similar to sucrose, attracts and then "starves" harmful micro-organisms, allowing the mouth to remineralize damaged teeth with less interruption. (However, this same effect also interferes with yeast micro-organisms and others, so xylitol is inappropriate for making yeast-based bread, for instance.)

Xylitol-based products are allowed by the U.S. Food and Drug Administration to make the medical claim that they do not promote dental cavities. A recent study demonstrated that as a water additive for animals, xylitol was effective in reducing plaque and calculus accumulation in cats.

5 – 2 - Diabetes:

Possessing approximately 40% less food energy, xylitol is a low -calorie alternative to table sugar. Absorbed more slowly than sugar, it does not contribute to high blood sugar levels or the resulting hyperglycemia caused by insufficient insulin response.

5 – 3 – Osteoporosis:

Xylitol also has potential as a treatment for osteoporosis. A group of Finnish researchers has found that dietary xylitol prevents weakening of bones in laboratory rats, and actually improves bone density.

5 – 4 - Ear and upper respiratory infections:

Studies have shown that xylitol chewing gum can help prevent ear infections (acute otitis media); the act of chewing and swallowing assists with the disposal of earwax and clearing the middle ear, whilst the presence of xylitol prevents the growth of bacteria in the eustachian tubes (auditory tubes or pharyngotympanic tubes) which connect the nose and ear.^[21] When bacteria enter the body they hold on to the tissues

by hanging on to a variety of sugar complexes. The open nature of xylitol and its ability to form many different sugar-like structures appears to interfere with the ability of many bacteria to adhere.^[22] In a double-blind randomized controlled trial, saline solutions of xylitol significantly reduced the number of nasal coagulase - negative *Staphylococcus* bacteria. The researchers attributed the benefits to the increased effectiveness of endogenous (naturally present in the body) antimicrobial factors.

5 – 5 - Infection:

In rats, xylitol has been found to increase the activity of neutrophils, the white blood cells involved in fighting many bacteria. This effect seems to be quite broad, acting even in cases such as general sepsis.

5 – 6 - Candida yeast:

A recent report suggests that consumption of xylitol may help control oral infections of *Candida* yeast; in contrast, galactose , glucose, and sucrose may increase proliferation.

5 – 7 - Benefits for pregnant or nursing women:

Xylitol is not only safe for pregnant and nursing women, but studies show that regular use significantly reduces the probability of transmitting the *Streptococcus mutans* bacteria, which is responsible for tooth decay, from mother to child during the first two years of life by as much as 80 %.

6 - Safety:

Xylitol has no known toxicity in humans. In one study, the participants consumed a diet containing a monthly average of 1.5 kg of xylitol with a maximum daily intake of 430 g with no apparent ill effects.^[27] Like most sugar alcohols, it has a laxative effect because sugar alcohols are not fully broken down during digestion; albeit ten

times weaker than sorbitol. The effect depends upon the individual. In one study of 13 children, 4 experienced diarrhea when consuming over 65 grams per day.^[28] Studies have reported that adaptation occurs after several weeks of consumption.

Dogs that have ingested foods containing high levels of xylitol (greater than 100 milligram of xylitol consumed per kilo gram of body weight) have presented with low blood sugar (hypoglycemia) which can be life-threatening. Low blood sugar can result in a loss of coordination, depression, collapse and seizures in as soon as 30 minutes.^{[30][31]} Intake of very high doses of xylitol (greater than 500 – 1000 mg / kg bwt) has also been implicated in liver failure in dogs, which can be fatal.^[32] These are points of controversy, however, as earlier World Health Organization studies using much higher doses on dogs for long periods showed no ill effect.

Yacón



Roots of Yacón

Scientific classification

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Asterids
Order: Asterales
Family: Asteraceae
Genus: *Smallanthus*
Species: ***S. sonchifolius***

Binomial name

Smallanthus sonchifolius

1 – Introduction :

The **Yacón** is a perennial plant grown in the Andes of Perú for its crisp, sweet - tasting tubers. The texture and flavour have been described as a cross between a fresh apple and watermelon which is why it is sometimes referred to as the apple of the earth. The tuber is composed mostly of water and fructo - oligosaccharides. It has recently been introduced into farmer's markets and natural food stores in the US.

Although sometimes confused with jicama, yacón is actually a close relative of the sunflower and Jerusalem artichoke. The plants produce propagation roots and storage tubers. Propagation roots grow just under the soil surface and produce new growing points that will become next year's aerial parts. These roots resemble Jerusalem artichokes. Storage tubers are large and edible.

These edible tubers contain inulin, an indigestible sugar, which means that although they have a sweet flavour, the tubers contain fewer calories than would be expected.

Yacón plants can grow to over 2 meters in height and produce small, yellow inconspicuous flowers at the end of the growing season. Unlike many other root vegetables domesticated by the Indigenous Peoples of the Andes (olluco, oca), the yacón is not photoperiod sensitive, and can produce a commercial yield in the tropics.

Yacón provides for two nutritional products the yacón syrup and yacón tea. Both products are popular among diabetic people and dieters who consume these products because of its low sugar properties. The low sugar characteristic is due to the fact that the tuber is made up of FOS (fructooligosaccharides), a special type of fructose that the human body can not absorb thus it leaves the body undigested. The syrup is also a prebiotic which means that it feeds the friendly bacteria in the colon that boosts the immune system and helps digestion.

2 - Yacón culture:

Yacón can easily be grown in home gardens in climates with only gentle frosts. It grows well in southern Australia, Tasmania and New Zealand, where the climate is mild and the growing season long. It has recently been introduced to the Philippines, and is now widely available in markets.

Propagation roots with growing points can be planted in a well-dug bed in early spring, near the time of the last expected frost. While aerial parts are damaged by frost, the roots are not harmed unless they freeze solid. Yacón is a vigorous grower much like Jerusalem artichokes. The plants grow best with fertilization.

After the first few frosts the tops will die and the plants are ready for harvest. It is generally best to leave some in the ground for propagating the following spring. Alternatively, the propagating roots can be kept in the refrigerator or buried away from frost until spring. While usable-sized tubers develop fairly early, they taste much sweeter after some frost.

3 - Yacón leaves:



Yacón Leaves.

The leaves of the yacón contain quantities of proto catechuic, chlorogenic, caffeic and ferulic acids, which gives tea made from the leaves prebiotic and antioxidant properties. As a result, some researchers have explored the use of yacón tea for treating diabetes and for treating diseases caused by radicals, e. g., arteriosclerosis.

4 - Religious usage:

In colonial times yacón consumption was identified with a Catholic religious celebration held at the time of an earlier Inca feast. In the Moche era, it may have been food for a special occasion. Effigies of edible food may have been placed at Moche burials for the nourishment of the dead, as offerings to lords of the other world, or in commemoration of a certain occasion. Moche depicted these yacón in their ceramics .

5 - Yacon syrup:

Yacón syrup is a sweetening agent extracted from the tuberous roots of the yacón plant indigenous to the Andes mountains.

It was used by the Incas. In Peru people eat yacon because of its nutritional properties - few calories and low sugar levels. In Bolivia yacón roots are eaten by people with diabetes or other digestive and renal disorders. Where as In Brazil the dried leaves are used to make yacón tea, said to be anti diabetic.

The syrup contains up to 50 % of FOS (fructo oligo sacharides). The consumption of FOS does not increase blood glucose. However, since any inulin - derived sweetener has large amounts of fructose, the same concerns about the health effects of fructose apply.

It is usually made with an evaporator, like the ones used to make maple syrup.^[1] It has a taste similar to molasses or caramelized sugar.^[3] In a study by Yoshida et al. (2002), an enzyme solution of yacon was determined to be a better antioxidant than enzyme solutions of potato, mushroom, eggplant and edible burdock.