Review Article

Bulletin of Environment, Pharmacology and Life Sciences

Online ISSN 2277-1808
Bull. Env. Pharmacol. Life Scien. Volume 1 [11] October 2012: 64-67

Website: www.bepls.com

Artificial Sweeteners Beneficial or Harmful: Matter of Thought

Raaz Maheshwari, Sangeeta Parihar[2], Rajnee[3]

[1]Department of Chemistry, SBRMGC, Nagaur, Rajasthan
[2]Department of Chemistry, JNU, Jodhpur, Rajasthan
[3]Department of Physiology, SPMC, Bikaner, Rajasthan

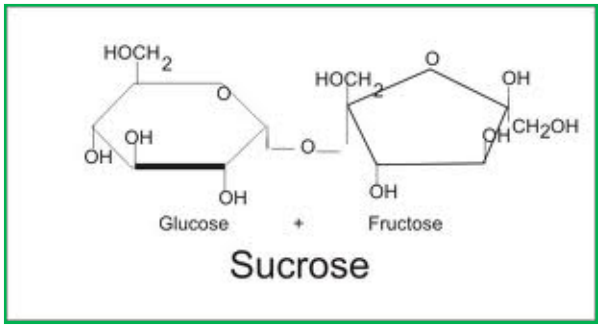
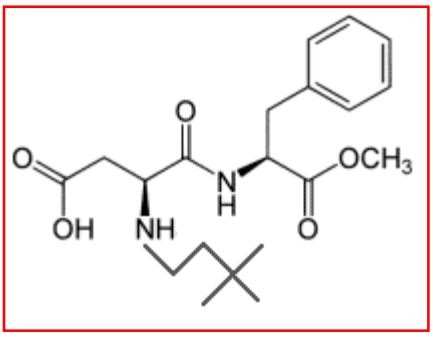


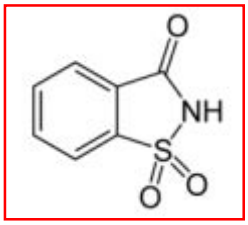
Table sugar (sucrose) has 4 calories per gram. Sugar substitutes are used to limit food energy during dieting, to reduce the formation of dental plaque, and to help regulate blood sugar levels in diabetic individuals.

Sugar substitutes are used to reduce the calories in foods and drinks. Sugar substitutes may be natural products such as sorbitol or xylitol, or they may be artificial sweeteners created in a laboratory like saccharin, sucralose or aspartame. In the United States, the Food and Drug Administration (FDA) has approved the following non-caloric sweeteners: saccharin, aspartame, sucralose, neotame, and acesulfame potassium.



Saccharin

Saccharin was discovered in 1879. It is the oldest nonnutritive sweetener. It is commonly sold in pink packets under the brand name Sweet'N Low. It is 300 times sweeter than sucrose but has a bitter aftertaste. The use of saccharin increased during World War I due to sugar shortages, and during the 1960s because of its use in the production of low-calorie foods. Saccharin is used to sweeten drinks, candies, medicines, and toothpaste. Saccharin is not used for baking because it is unstable when heated. In 1972, the USDA tried unsuccessfully to ban the use of this sweetener after research showed that it increased the rate of bladder cancer in rats. Products were required to carry a warning that saccharin could "cause cancer in laboratory animals". In 2000, the National Institutes of Health (NIH) removed saccharin from its list of carcinogens and the requirement for warning notices was also removed. Saccharin is widely used today. The ingredients of Sweet'N Low are dextrose, 3.6% soluble saccharin, and small amounts of anti-caking agents. Ten grams of Sweet'N Low contain approximately 9 g of dextrose and provide 36 calories. The same weight of sugar provides 39 calories.



Aspartame

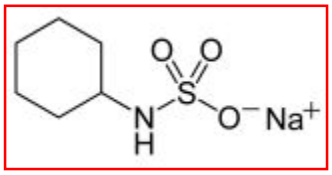
Aspartame is 200 times sweeter than sugar. It is marketed under the brand names NutraSweet and Equal. Aspartame is the methyl ester of the dipeptide of the amino acids aspartic acid and phenylalanine (aspartyl-phenylalanine-1-methyl ester). Aspartame is used as a tabletop sweetener, and it is added to a wide variety of foods, including breakfast cereals, soft drinks, desserts, candy, and chewing gum. Aspartame loses its sweetness when

Bulletin of Environment, Pharmacology and Life Sciences

heated and it is usually not suitable for baking. Aspartame is metabolized into its component amino acids. People with the rare disorder phenylketonuria (PKU) cannot metabolize phenylalanine, so they should avoid aspartame. There have been some reports of headaches and dizziness from consuming aspartame, but no scientific studies have shown a definite association. Ten grams of Equal sweetener contain 8 g of dextrose and 0.84 g of maltodextrin (starch), in addition to aspartame. Ten grams of Equal provide 36 Calories; an identical weight of sugar provides 39 calories.

Neotame

Neotame is between 8,000 and 13,000 times sweeter than table sugar. Neotame is chemically similar to aspartame, but sweeter and more stable. Neotame is hydrolyzed to produce methanol (wood alcohol) and de-esterified neotame residue, but since neotame is used only in very small amounts, the amount of methanol produced is less than what is found in fruit juices. The 3,3-dimethylbutyl group attached to the amino group of the aspartic acid portion of the molecule blocks the enzymes which would break the peptide bond between the aspartic acid and phenylalanine moieties. The Food and Drug Administration approved neotame for general use in July 2002.

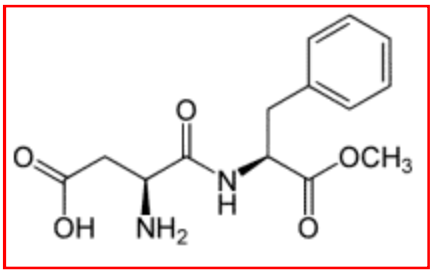


Acesuflame Potassium

Acesuflame Potassium (Acesulfame K, Ace K) is a nonnutritive sweetener 200 times sweeter than table sugar marketed under the brand name Sunett. At high concentrations, it has a slight bitter aftertaste like saccharin. Its chemical structure is the potassium salt of 6-methyl-1,2,3-oxathiazine-4(3H)-one 2,2-dioxide. Some test results have hinted that acesulfame potassium may increase the occurrence of breast tumors in laboratory animals, but the FDA has not required additional safety testing.

Sucralase

Sucralose is marketed as Splenda. It is available as a tabletop sweetener and as an ingredient in food processing. Sucralose is about 600 times sweeter than table sugar. Sucralose is stable at hot and cold temperatures and can be used in cold and hot drinks, as well as baked goods. Although Splenda is marketed as a no calorie sweetener, it is a mixture of dextrose, maltodextrin, and sucralose. Ten grams of Splenda contain 9.00 g of carbohydrates consisting of 8.03 g of sugars (dextrose) and 0.96 grams of starch (maltodextrin). For this reason, 10 grams of Splenda have 33 Calories compared to 39 Calories for an equal weight of sugar. The calories of Splenda come from the carbohydrates. Recent formulations of Splenda use resistant maltodextrin which can be categorized as fiber.

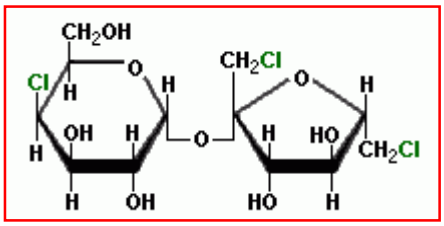


Cyclamate

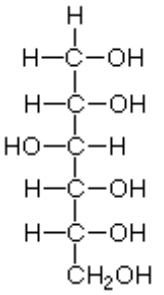
Cyclamate is 30 to 50 times sweeter than sugar and is sold under the trade names Sucaryl and Sugar Twin. Cyclamate is the sodium or calcium salt of cyclamic acid (cyclohexanesulfamic acid). Cyclamate was banned in the United States in 1970 because large doses caused bladder cancer in rats, but it is still approved as a sweetener in more than 55 countries.

Sugar Alcohols

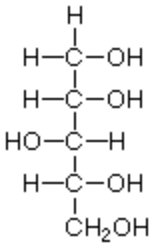
Sorbitol, **xylitol**, and **erythritol** are natural sugar alcohols found in fruits and vegetables. They can be made commercially by catalytic hydrogenation from the corresponding sugars. Xylitol is produced from xylose. Sorbitol, also known as glucitol, is produced from glucose. Erythritol is produced commercially by fermentation of glucose with the yeast *Moniliella pollinis*. Xylitol is absorbed slowly and only partially utilized by the body, it contains 40% fewer calories than sugar, about 2.4 calories per gram. Sorbitol and xylitol are common ingredients in "sugar-free" candies and chewing gum. Other sugar alcohols include mannitol, maltitol, lactitol, and erythritol. Sugar alcohols are not well absorbed in the intestinal tract, and they are fermented by microflora that may produce bloating, gas, and diarrhea. Just 10 grams of sorbitol may be enough to cause gastrointestinal distress. Xylitol appears to be safe for humans, but it can cause seizures, liver failure, and death in



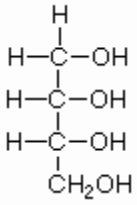
dogs in relatively small doses.[4] Erythritol is 60 to 70% as sweet as table sugar and has a caloric value of 0.2 calories per gram. Erythritol does not promote tooth decay, and does not cause gastric side effects like other sugar alcohols.



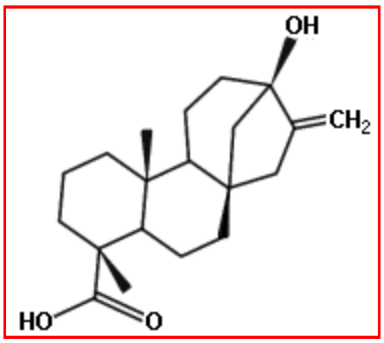
Sorbitol



Xylitol



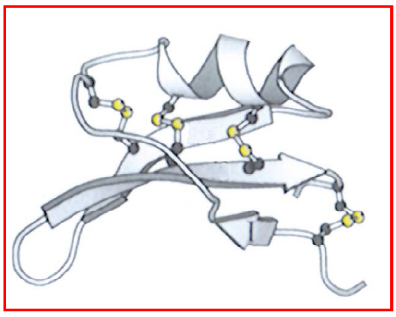
Erythritol



Steviol

Stevia is the name of a bush (*Stevia rebaudiana* Bertoni) whose leaves are used to produce extracts having up to 300 times the sweetness of sugar. Stevioside and rebaudioside are two of the sweet steviol glycosides in the stevia leaf. Stevioside has one beta-D-glucose molecule replacing the bottom hydrogen atom of steviol and two beta-D-glucose molecules replacing the top hydrogen site. Stevia had been marketed in the U.S. as an herbal supplement because there was not enough scientific data to certify it as a food additive. Experiments on rats and hamsters have shown that high doses of stevioside decrease the production of sperm in males and that females had fewer and smaller offspring. In December 2008, the FDA approved the use of purified rebaudioside A from *S. rebaudiana Bertoni*, and classified it as Generally Recognized as Safe (GRAS). Rebaudioside A, also called **Reb-A** and **rebiana**, has one beta-D-glucose molecule replacing the bottom hydrogen atom of steviol and a chain of three beta-D-glucose molecules replacing the top hydrogen site of steviol.
Stevia products are marketed under the brand names Truvia and PureVia, but the packets are not just rebiana. Both Truvia and PureVia contain erythritol, a low-calorie sugar alcohol sweetener. One packet of Truvia (3.5 grams) contains 3 grams of erythritol, and "natural flavors" of undisclosed chemical composition.

Brazzein is a sweet-tasting protein extracted from Oubli, the fruit of a West African vine (Pentadiplandra brazzeana Baillon). The chemical structure of brazzein consists of 54 amino acid residues arranged in one alpha-helix and three strands of anti-parallel betasheets (peptide strands running in opposite directions held together by hydrogen bonds between the strands). The amino acid sequence of brazzein is:
On weight basis, brazzein is about 1000 times sweeter than sugar. The taste of brazzein is similar to sucrose but with lingering sweet aftertaste. Brazzein is stable over a broad pH range from 2.5 to 8, and it is heat stable at 98°C for 2 hours. This makes it practical for many commercial applications.



Large scale extraction of the sweetener from its natural source is not feasible, but brazzein has been produced from genetically engineered corn. The protein from the modified corn contains 4% brazzein, which when purified is up to 1200 times sweeter than sucrose on a weight basis.[3] In addition, brazzein-containing maize germ flour can be used directly to sweeten food products. The company Natur Research Ingredients expects to make brazzein commercially available in 2009 under the brand name Cweet.

General Observations

Most non-caloric sweeteners are mixed with dextrose and maltodextrin to provide bulk, but unfortunately, these bulking agents are digestible carbohydrates that add calories. As we have seen for Sweet'N Low, Equal, and Splenda, ten grams of these sweeteners provide from 33 to 36 calories compared to 39 calories for sugar. On a weight basis, these sweeteners can reduce the number of

calories only by 10 to 15 percent when compared to sugar, which is not significant. However, these sugar substitutes allow the calories of sweetener to be reduced by approximately 80 percent because, in the case of Splenda, one packet containing 1 gram of product (3.3 Calories) has the same sweetening power as one teaspoon of sugar weighing 4.2 grams (16.3 Calories). Manufacturers purposely package these sweeteners in small packets with less than 5 calories per serving, thus meeting the FDA standards for "no calorie" foods. The small serving size allows the products to be marketed as zero-calorie sweeteners.

One would expect that drinks with non-caloric sweeteners would promote weight loss, but epidemiological studies have found that consumption of diet soda is associated with the development of metabolic syndrome.[1] The ingestion of non-caloric sweeteners dissociate the sensation of taste as a predictor of the caloric or nutritive content of food. Experiments have found that reducing the correlation between sweet taste and the caloric content of foods using artificial sweeteners in rats resulted in increased caloric intake, increased body weight, and increased adiposity.[2] The results suggest that consumption of products containing artificial sweeteners may lead to increased body weight and obesity by interfering with the fundamental equilibrium of physiological processes mediated by taste receptors.

REFERENCES

1. Lutsey, P. L. Steffen, L. M. and Stevens, J. 2008. Dietary Intake and the Development of the Metabolic Syndrome. The Atherosclerosis Risk in Communities Study, *Circulation*, PMID 18212291
2. Swithers, S. E. and Davidson, T. L. 2008. A Role for Sweet Taste: Calorie Predictive Relations in Energy Regulation by Rats, *Behavioral Neuroscience*, **122** (1), pp.161-173, PMID 18298259
3. Lamphear B. J. Expression of the sweet protein brazzein in maize for production of a new commercial sweetener,*Plant Biotechnol J.* 2005 Jan;**3**(1), pp. 103-114. PMID: 17168903
4. Dunayer E. L. Gwaltney-Brant SM, Acute hepatic failure and coagulopathy associated with xylitol ingestion in eight dogs. *J Am Vet Med Assoc.* 2006 Oct 1;**229**(7),pp. 1113-1117. PMID: 17014359