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Review Article

Sweeteners in Human Nutrition

Tanu Jain[1], Kiran Grover[2]

[1]Ph.D. Scholar, [2]Professor,
Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana, Punjab-141004, India.

Corresponding Author: Tanu Jain

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ABSTRACT

Sweeteners or sugar alternatives are sugar substitutes that duplicate the effect of sugar in taste with less food energy. Some sugar substitutes are natural and some are synthetic. Those that are not natural are called artificial sweeteners. They are also called non nutritive sweeteners (NNS) and non-caloric sweeteners. It may be intense or bulk sweeteners. Acesulfame K, aspartame, neotame, sucralose are some intense sweeteners which provide no calories. The mechanism behind its sweet taste depends upon its ability to bind with taste receptors and activate them, which are responsible for the signalling of sweet taste in brain. All sugar alcohols including xylitol, erythritol, sorbitol and mannitol are reduced calorie bulk sweeteners. Unlike all sugar alcohol, erythritol is produced from fermentation process and considered as natural sweetener. Some natural sweeteners are steviol glycosides and Lo-han guo which are extracts of plant leaves and fruit respectively. Applications of these sweeteners are in confectionary, dairy products, chewing gum, chocolates, beverages, medicine, baked foods etc. They are used for weight loss management and diabetes management. USFDA has tested and approved these sweeteners and defined its upper intake limits. Studies showed positive effect of sweeteners on body. They are hypoglycemic, non mutagenic, non carcinogenic in nature and safe for its intended use.

Key words: Artificial sweeteners, Aspartame, Acesulfame-K, Sugar alcohols.

INTRODUCTION

Sugars are inseparable part of our life as these add sweetness in our food, but it cannot be consumed in large amount as it can be one of the potent reasons of many degenerative diseases. So, artificial sugar is the option which provides us sweetness with less or no calories. Due to potently sweetness, sweeteners have been continued to attract consumers as sugar replacer in food, beverages and other applications as flavour enhancer. It has been proven beneficial in weight loss and diabetes management. They are hypoglycaemic, non mutagenic and non-carcinogenic in nature. The US Food and Drug Administration regulate artificial sweeteners as food additives. [1]

Sweeteners

Sweeteners or sugar alternatives are sugar substitutes that duplicate the effect of sugar in taste with less food energy. Some sugar substitutes are natural and some are synthetic. Those, not natural are called

artificial sweeteners. They are also called non nutritive sweeteners (NNS) and non-caloric sweeteners. Classification of Alternative sweeteners [2] has been presented in figure 1 which shows the following categories:

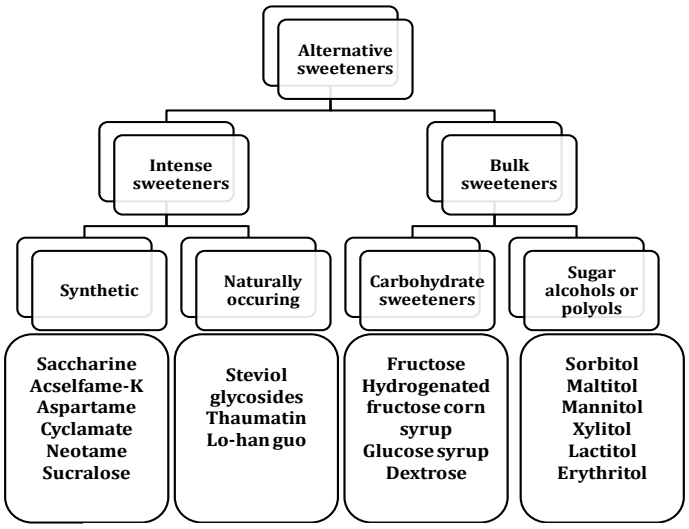

Fig 1: Classification of alternative sweeteners [2]

High potency intense sweeteners- These are the substances that taste hundreds or thousands times sweeter than sugar and provide no calories. It allows for much smaller quantities to be used. These are called artificial sweeteners, non-nutritive sweeteners or synthetic sugar substitutes because it is derived from either naturally occurring substances, including herbs or sugar itself or manufactured chemically. Saccharine, cyclamate, aspartame, neotame, sucralose, acesulfame K etc. fall in this category.

Natural high potency sweeteners- These are plant-derived substances that have high sweetness potency. They are also non-nutritive in nature. It includes stevia, Lo han, thaumatin, brazzein, monatin etc.

Carbohydrate sweeteners- These are nutritive sweeteners which supply calories in form of carbohydrate but other nutrients like fructose, hydrogenated fructose corn syrup, dextrose, glucose syrup etc.

Reduced calorie bulk sweeteners- These are the substances that provide sweet taste without calories or with very few calories. Erythritol, maltitol, sorbitol, mannitol, xylitol are some examples of bulk sweeteners.

Why do they all taste sweet: Mechanism

Mechanism depends upon the neuroscience of the sweet taste. The gustatory system recognizes chemical stimuli *viz.* sweetness, sour, salty, bitter and umami [3] which occurs through specialized taste cells, clustered together in small groups called taste buds. Activation of these cells releases neurotransmitters which transmit the taste information to brain and brain further processes taste information. [4] Sweet receptors in mouth function in perception of sweet taste. Sweet taste signaling is mediated by T1R2 and T1R3 receptors. [5] Compounds that elicit a sweet taste bind to and activate T1R2 and T1R3 receptor. Natural and artificial sugars (e.g., sucrose, glucose, and sucralose) bind to both T1R2 and T1R3. [6] Dipeptide sweeteners (e.g., aspartame and neotame) bind only to T1R2. [7] Cyclamate binds with T1R3. [8]

Acesulfame K- Acesulfame K was accidently discovered in 1967 by Karl Claub

and Jensen, who was a chemist in Hoechst AG and working in a lab when he noticed an intensely sweet taste on a piece of paper he had touched. The compound was Acesulfame K. It belongs to the class of dihydro-oxathiazinone dioxides. It is approximately 200 times sweeter than sucrose when used at moderate sweetness levels. Sweetness of Acesulfame K is perceived quickly and without any unpleasant delay like aspartame and sucralose, but Ott et al, 1991 reported that it has slight delayed bitter aftertaste. [9] Acesulfame K is approximately one third of as sweet as sucralose, half as sweet as saccharin, about as sweet as aspartame and four to five times sweeter than sodium cyclamate. [10] It is marketted under brand name "Sunett" and "Sweet One". It is used in a wide variety of foods and beverages like dairy products, bakery products, sweets and chewing gum, jams, marmalades, preserve and canned fruit etc.

Aspartame- It is also an intense nutritive sweetener, which is produced by combining the two amino acids L- phenylalanine and L-aspartic acid by a methyl- ester link. [11] It is discovered by accident in 1965 by a Chemist named James Schlatter. He was working on an anti ulcer drug, when he accidently ingested the substance and noticed the sweet taste. It has a clean sweet taste and 180-200 times sweeter than sucrose. Unlike Acesulfame K, Aspartame can be metabolized by the digestive system. Being produced with amino acids, it provides 4 calories per gram. However it is 200 times sweeter than sugar but contains almost zero calories per serving. It is sold under brand name "NutraSweet" and "Equal". It accounts for 32% of the global high intensity sweetener market. Major market for it is soft drinks and table top sweetener. It is also used in confectionary, pharmaceutical tablets and dry syrups, yogurt, dairy products, dry mix products and bars. It does not provide longer stability. This is the reason why it is not used extent in baked products or liquid products that require a long shelf life. Ten grams of Equal sweetener contain 8 g of dextrose and 0.84 g of maltodextrin (starch) to aspartame. Ten grams of Equal provide 36 Calories; an identical weight of sugar provides 39 calories.

Neotame- Chemical name of neotame is N-[N-(3, 3- dimethylbutyl)- L-aspartyl]-L-phenylalanine-1-methyl ester. [12] It is a derivative of aspartame. It is produced by aspartame and 3,3-dimethylbutyraldehyde via reduction alkylation followed by purification, drying and milling. It is approximately 8000 times as sweet as sucrose and has clean sweet taste. It does not have bitter or metallic tastes. It is not metabolized by oral bacteria and does not affect with glycemic control with NIDDM. Many products like soft drinks, chewing gums, dairy drinks, confectionary bar etc. use combinations of neotame and other sugars and its substitutes.

Saccharine- Saccharin is the oldest chemical sugar substitute. The discovery of the saccharine was reported in 1879 by Remsen and Fahlberg who discovered it by accident, in the research department of John Hopkins University. They were researching toluene derivatives. One of the scientists, Constantin Fahlberg, accidentally spilled some of the compound on his hands and noticed the intense sweet taste. That compound was named saccharin. It has slight bitter aftertaste. [13] Application of saccharine are in beverage like carbonated soft drinks, toothpaste, medicine. Saccharin is not used for baking because it is unstable when heated. It is commonly sold in pink packets under the brand name "Sweet' N Low". 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.

Cyclamate- Sveda and Audrieth in 1937 discovered that that salts of cyclohexylsulfamic acids are sweet. Again he spilled some of the substance and noticed the sweet taste. It is not as sweet as Saccharin, but it has less of a bitter aftertaste and for some reason mixes well with it. These cyclohexylsulfamic acids were prepared by using chlorosulfonic acid as a sulfamating agent. These cyclohexylsulfamates are commonly referred as cyclamic acid salts or cyclamates. Cyclamate was designated as generally recognized as safe (GRAS) in 1958, but was banned in the United States in 1969 because of evidence that high concentrations in the diet were associated with bladder cancer in rats. Cyclamate is converted to a metabolite, cyclohexylamine, which has been reported to be rather toxic. [14] It is used in beverages and table top sweetener.

Sucralose- It is high potency sweetener, made up from sucrose by a process of chemical modification that results in the enhancement of the sweetness intensity, retention of a pleasure sugar like taste and creation of a very stable molecule. It is considered as versatile sweetener used for wide variety of foods and beverages. Credit of discovery of sucralose goes to an Indian scientist Shashikant Phadnis in 1976 in UK. He was working on the production of insecticide. He tasted the compound and reported sweet taste of sucralose. It is manufactured by the selective replacement of three hydroxyl groups on the sucrose molecule by three chlorine atoms to produce 1, 6-dichloro-1, 6-dideoxy-beta-D-fructofuranosyl-4-chloro-4-deoxy-alpha-Dgalactopyranoside. It is approximately 750 times sweeter than sucrose. Pure sucralose is white, free flowing powder, intensely sweet, practically odourless and freely soluble in water. It is most commonly sold under brand "Splenda". It is appropriate for Beverages, canned fruit, chewing gum, dairy, confectionary and baked products. 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), 10 grams of Splenda have 33 Calories compared to 39 Calories for an equal weight of sugar.

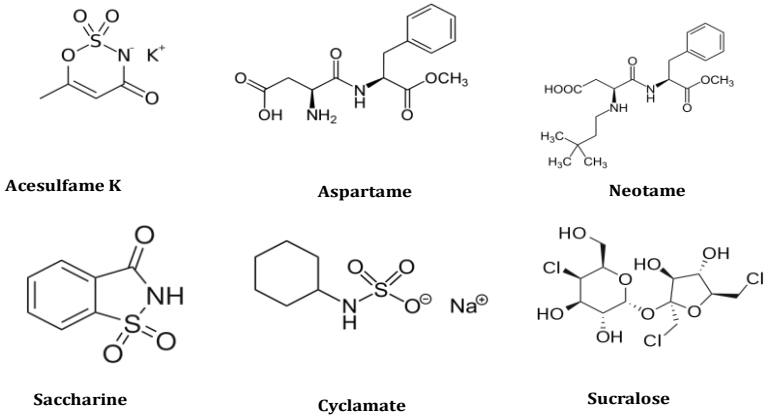

Fig 2: Chemical sructures of different artificial sweeteners

Reduced calorie bulk sweetener-

Sorbitol and mannitol- These are the only polyols which is found in nature in appreciable quantity. Sorbitol was discovered in 1872 in the berries of mountain ash. Mannitol was found in marine

algae and mushroom. They are produced when reducing sugar reacts with hydrogen. Both are sold in liquid (syrup) and solid (powder) form. Mannitol is a white crysatalline compound and shares same formula as sorbitol. Both can exist in different polymeric forms. For mannitol, most stable form is beta form. Sorbitol reported to have four forms (alpha, beta, gamma, delta). Different forms have different physical properties. The most stable form is gamma. and sorbitol powder is produced in this form only. Mannitol is one of the least soluble polyols. (22gm/100gm water at 25 degree cel.) while for sorbitol , this figure is 235g/100 gm of water. As described by European Union, calorific values of these sugars are 2.4 kcal per gram. Mannitol is probably the least well tolerated polyol and it is possible to consume on average only about 20 gm per day. Sorbitol syrups are better tolerated than pure sorbitol. Both sorbitol (60% as sweet) and mannitol (50% as sweet) are much less sweet than sugar. Sorbitol is used in foods for diabetics since it does not cause an increase in blood glucose on ingestion. It is also used in toothpaste and mouthwash where sorbitol syrup provides both sweetness and the required sugar free formulation. It include hard candy, tabletting, cooked sausages, baked goods, panning, over the counter products, chocolate etc.

Erythritol- It is the only non caloric bulk sweetener, which is found naturally in many fruits and vegetable. It was first isolated from algae protococcus vulgaris in 1852 by Lamy who named the substance Phycit. [15] Later erythritol was also isolated from algae Trentepohlia jolithus. [16] Erythritol is approved for use in foods in more than 55 countries. Erythritol is a white anhydrous, non hygroscopic, crystalline substance, available in powdered or granular form with a mild sweeteners and similar appearance to sucrose. It is 60-70% as sweet as sucrose. It is 4 carbon sugar alcohol. Being non-caloric in nature, it can be used for a bulk sugar replacer. Due to small molecular size, it is not metabolized in body. It is excreted unchanged in urine as well as in faeces. It is not fermented like other polyols. [17] and does not give any glycaemic/ insulinaemic response. Since it is produced by fermentation process rather than chemical reaction at commercial level, it is considered as natural sweetener. Erythritol can be consumed at relatively high level without side effects, since it is well absorbed and not fermented. It is better tolerated than insulin (many fibres) and lactose. Clinical studies have shown erythritol to be the best tolerated polyol with no undesirable side effect at consumption level 2-4 times higher than other polyols. It is very stable, does not decompose in acid/ alkaline environment. It is heat stable above 180°C. Application includes beverages, chocolates, chewing, candies etc.

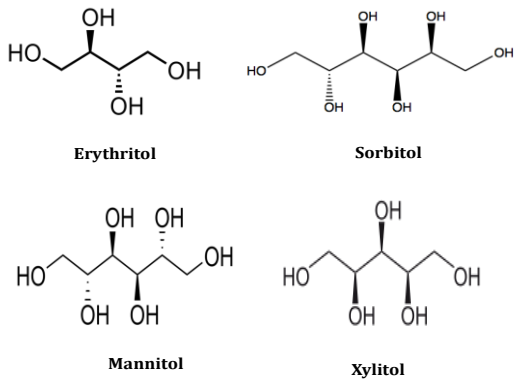

Fig 3: Chemical sructures of different artificial sweeteners

Xylitol - Xylitol is a sugar alcohol that has been used as a food additive and sweetening agent since 1960s. It is a natural constituent of many fruit and vegetables. [18] and found in very minute amount (<1%). It is a five carbon polyol (pentitol). It was first discovered and reported in 1891 by Emil

Fischer. He named the new compound xylit. Xylitol is the sweetest of all of the polyols being the only to exhibit a sweetest intensity equivalent to that sucrose. Xylitol can be combined with all polyols to produce significant sweetness synergy like high intensity sweetener. As it contains no reducing group, it does not take part in Maillard reaction. Applications that require caramelization or non enzymatic browning, the addition of small quantity of reducing sugars or colour may be required. The federation of American societies for experimental biology (FaSeb) has determined the net energy value of xylitol as 2.4kcal/g. It is used in confectionary, chewing gum, chocolate, dairy products and frozen desserts, baked goods.

Natural high potency sweeteners-

Thaumatin- Thaumatin is a common name for a mixture of potently sweet proteins that can be extracted from West African perennial plant *Thaumatococcus daniellii* (Bennett). This plant produces fruit, arils of which contain the sweet proteins. The "Katemfe" fruit contains mixture of intensely proteins thaumatinI and thaumatinII which have similar amino acid sequence differing only in five residues. It is not a synthetic sweetener and is extracted from source using only aqueous extraction process followed by physical separation processes to remove unwanted material. The resulting product is a light tan coloured powder.

The sweetness potency of thaumatin is normally described as being approximately 2000 times the sweetness of sucrose not much data are published on the solubility of thauatin, but the sweetener is prepared as a freeze dried powder that is readily soluble in water. It is anticipated that thaumatin should be metabolized the same as other plant protein. It is used as a flavour enhancer in many food and beverages, soft drinks, chewing gum, fortitied food and liquid medicines to mask bitter and astringent tastes.

Lo han guo (mogroside)- Lo han guo is a native fruit of China. Plant, Siraitia *grosvenorii* belongs to cucurbitaceae family. Common name of the plant include *lo han guo, lo han kuo*. The sweet constituents of the plant are triterpene glycosides known as mogrosides. [19] Mogroside V is a polar compound readily soluble in water and stable. It is 150 times as potent as sucrose. There is not much reported about it. Structurally, it resembles with steviol glycosides in its structure that are known to exhibit excellent stability. So it is also considered as a stable compound. It is said to be soluble in water. [20] It has been used as a food, beverage and traditional medicine. [21] The extract of lo han guo fruit have long been indigenously to treat colds, sore throats and minor stomach and intestinal complaints. [19] Recent reports suggest that it has anti-oxidant characteristics. [22] and helpful in cancer treatment mogrosides may exhibit anti cancer properties. [23,24] It is not much used in application other than traditional use. Although there are some minor beverages [25] in US that contained lo han fruit extract. In addition, there are now some breakfast cereal products.

Steviol glycosides- Stevia leaves were used by indigenous peoples in Paraguay and Brazil since before recorded history. [26] In the 1887, M. S. Bertoni, a Botanist was the first European to document stevia and later on in 1931, French chemists extracted stevioside, the main sweet component in the form of an extremely sweet, white crystalline compound. *Stevia rebaudiana* Bertoni is a plant name which is the source of the potently sweet stevioside, rebaudioside A and several other steviol glycosides. It belongs to compositae family. It is a perennial shrub. It is often referred to as "the sweet herb of Paraguay". It is also known as "honey yerba" and "hiney leaf".

The mature plant grows up to 65-centimetres (26 inches) to as tall as 180 cm (72 inches). It is a short day plant. [27] The plant also has medicinal value. It has also been reported that *S. rebaudiana*, as a non-calorie first natural sweetener used in medicinal green teas for treating heart burn and other ailments, [28] even though there are more than 200 species of the genus *Stevia*, only *S. rebaudiana* gives the sweetest essence. [29]

It is a first non caloric natural sweetnener, showing, medicinal properties. It is used in medicinal green teas for treating heart burn and other ailments. The leaf is a main source of stevioside. [30] It also has bitter aftertaste due to the presence of some essential oils, tannin and flavonoides. USFDA [31] approved JECFA [32] found steviol glycosides safe for use. The component of stevia is stevioside, which is a diterpenoid glycoside, contains steviol, an aglycone. Along with stevioside, some other sweet compounds such as steviobioside, rebaudioside A, B, C, D, E and dulcoside A were also found in the leaf of stevia. Stevia and its products has been used by Japanese in cooked or baked goods, processed foods and beverages, fruit juices, pastries and chewing gums and sherbats. These include pickles, seafood, meat, fish, soy, ice-cream and table top sweeteners.

Metabolism

Acesulfame K is a chemical and in human body, it is absorbed and similarly excreted rapidly and completely unchanged in the urine. Therefore it is non- caloric. No metabolism is observed in human and other species [33] Aspartame is broken down to aspartic acid, phenylalanine and methanol. Amino acids are digested, following the same pattern of as they would if generated from food, giving glucose and fumarate from aspartic acid and phenylalanine respectively as end products and utilized in the body in this form. The end product of methanol is formic acid and in this form it is eliminated out of the body. Neotame also contains phenylalanine in its molecule but it does not produce phenylalanine after hydrolysis. It is broken down into de-esterified neotame and methanol in equimolar quantities. De-esterified neotame is excreted in the urine. In case of saccharin only five percent was recovered in the faeces according to the study conducted by Renwick(1985). [34] In another study conducted on rats, absorption was found to be dose dependent. But it is not metabolized in humans or rats. It goes into the circulation and excreted by the kidneys with the balance recovered in faeces. Cyclamate also slowly and incompletely absorbed from small intestine and not metabolized in the body and excreted unchanged in the urine. In case of sucralose, most of it is eliminated in faeces. All polyols are very low digestible carbohydrates. It is partially absorbed in small intestine and passes to large intestine where it is available for microbial fermentation, which results in short chain fatty acids. All polyols supply a few calories. But fate of erythritol is different. It is absorbed in small intestine. Absorbed erythritol is rapidly distributed in the body. But it is neither metabolized in body nor fermented in large intestine. [35] so it provides no calories.

Table 1: Physical properties of sweeteners

Sweetener	Appearance	Colour	Solubility	Temperature
Acesulfame K	Solid, crystalline	Colourless to white	Water soluble	Stable at high temperature
Aspartame	Crystalline	Colourless to white	Water soluble	Unstable at high temperature
Neotame	Crystalline	White/ off white	Water soluble	Unstable at high temperature
Saccharin	Solid	White	Water soluble	Highly stable
Cyclamate	Solid	Colourless	Water soluble	Stable at room temperature
Sucralose	Crystalline powder	White	Water soluble	Stable at room temperature

Table2: Comparison of different sweeteners:

Sweeteners	Caloric value / serving	Relative sweetness	Molecular structure
Maltitol	3.2Cal/gm	0.8-0.9	Disaccharide alcohol (maltose + maltose)
Xylitol	2.4	0.8-1	monosaccharide alcohol
Erythritol	0.2	0.6-0.8	4 carbon sugar alcohol
Lactitol	2.3	0.35	Disaccharide alcohol (galactose + sorbitol)
Sorbitol	2.4	0.6	Monosaccharide alcohol
Mannitol	1.9	0.5-0.6	Monosaccharide alcohol
Lo-han kuo Extract	0	250-300	Terepenes glycosides
Aspartame	0	200	Amino acid methyl esters
saccharine	0	200-700	Saccharine
Ascelfame K	0	130-200	Ascelfame Potassium
Stevia	0	200-400	Steviol glycosides
Sucralose	0	600	Chlorinated sucrose

Table3: Toxic potential of sugar alternatives [57]

Common Name	Metabolites	ADI (mg/kg/day)	Acute	Chronic
Acesulfame-K		15	Headache	Clastogenic, genotoxic at high doses, thyroid tumors in rats
Aspartame	Methanol, aspartic acid and phenylalanine	50	Headache, dry mouth, dizziness, mood change, nausea, vomiting, reduced seizure threshold, thrombocytopenia	Lymphomas, leukemias in rats
Neotame	cyclohexylamine	2	Headache, hepatotoxic at high doses	Lower birth rate, weight loss
Saccharin	O-sulfamoylbenzoic acid	5	Nausea, vomiting, diarrhea	Cancer in offspring of breastfed animals, low birth weight, bladder cancer, hepatotoxicity
Sucralose	Chlorinated sucrose	5	Diarrhea	Thymus shrinkage

ADI- Acceptable Daily Intake

Health benefits-

Blood glucose regulation

Artificial sweeteners limit the use of sugars. They do not release energy and provide an option as sugar replacer while sugar alcohols release energy, but are metabolized more slowly in body, allowing blood sugar levels to remain more stable over time.

John C de Ruyter (2011) [36] reported the effect of sugar sweetened beverages on body weight of children of 4-11 years. Mixture of sucralose and Acesulfame K in cane beverage is given against sugar for 18 months and found that there was more weight gain and increased body mass index in sugar group than artificial sweetener group. Same result was reported by Reid et al (2002) [37] who saw the effect of artificial sweetener on 20-50years male and females. Other studies [38,39] supported the above studies, concluding that artificial sweeteners decreased body weight, fat mass, body mass index and waist circumference of different individuals. But in a experiment, [40] rats given artificial sweetener have steadily increased caloric intake, increased body weight, and increased adiposity.

Foods containing sorbitol and mannitol can be used by diabetics to manage their blood glucose levels since it does not require insulin for metabolism. The GI of both sorbitol and mannitol are very low at about 10 and 0 respectively. Xylitol also represents an ideal sweetener for use in diabetic diets. It exhibits a very low relative glycaemic response (RGR) of 8 to glucose with a value of 100. It also provides fewer calories and a number of additional health related benefits without any reported negative impact on metabolic condition.

Effect of chronic consumption of steviol glycosides was seen in diabetics [41] and found that it did not alter gluose homeostasis. Mixed results were found in case of effect of steviol glycosides on blood pressure. Study conducted by Chan *et al* [42] reported decrease in systolic and diastolic blood pressure in hypertensive patients after consumption of 250mg steviol capsule daily

for one year. While another study [43] reported no significant changes in blood pressure after consumption of 1000mg steviol glycoside per day for 4 weeks in normal individuals. So it can be said that duration also play an important role with consumption of sweeteners.

Dental aspects

All polyols are tooth- friendly and do not promote tooth decay, provides a poor substrate for oral bacteria, such as streptococcus mutans (causes dental caries), helps in reduction of dental plaque.

Xylitol and other polyols are increasingly utilised as replacements for fermentable carbohydrates in a wide range of foods, due to having non cariogenic nature. The USFDA has also approved the use of a "does not promote tooth decay" health claim in labelling for sugar free foods that contain xylitol or other polyols. In addition to prevention of demineralization, the regular consumption of xylitol is also associated with the enhanced remineralization of teeth already affected by caries. Honkala et al (2006) [44] studied the efficacy of xylitol candies in preventing caries and found low DMFS scores in xylitol group. Xylitol containing tooth wipes were also prepared to prevent dental caries in children. [45] Sorbitol and mannitol are also non cariogenic and not fermented by oral bacteria.

Thaumatin shows zero glycemic index, which is suitable for diabetics. It is not fermented in mouth, does not harm teeth. It is a natural product.

Satiety effect

The studies demonstrated that consumption of xylitol, alone or in combination with other sugars, can induce satiety and thereby reduce caloric intake. [46]

Food products

Many products *viz Besan laddu,* cake pudding, *halwa, kulfi* etc has been prepared for diabetics patients using different brand of artificial sweeteners and concluded artificial sweeteners as good option for providing sweet taste with less calories. [47] Homemade cookies were also prepared using xylitol as sugar replacer. [48] In other study stevia powder was used to replace sucrose in preparation of sweet products viz custard, *pinni*, sandesh for diabetics. [49] Some more products, including chenna kheer [50] and sweet bread [51] were also developed using artificial sweeteners.

Safety and regulatory status

Five artificial sweeteners have been FDA have been tested and approved by USFDA. These are Acesulfame K, aspartame, neotame, saccharin and sucralose. 15 mg per kg body weight acceptable daily intake has been prescribed for Acesulfame-K and sucralose while for aspartame it is 50mg/kgBW (FDA) and 40 mg/kgbw(EFSA). For Neotame and saccharin, FDA has defined ADI as 2mg/kgBW and 5 mg /kg body weight. ADI established by JECFA for cyclamate is 11.0 mg/kg BW. Cyclamate levels in cola soft drinks are limited to 250ppm. It has also been suggested that the components of aspartame can lead to a number of health problems. Heavy artificial sweetener use (>1680 mg per day) leads to an increased relative risk of 1.3 for bladder cancer in humans. [52] Cyclohexylamine caused High amount of testicular atrophy and impairment in spermatogenesis in rats and dogs. [53,54] Acesulfame K can cause headache.

Xylitol has been shown to have a very low order of toxicity via all routes of administration. JECFA and the Scientific Committee for Food (SCF) of the EU have approved it as safe for consumption. In the EU both sugars mannitol and sorbitol are considered as food additives. Sorbitol is considered as GRAS with limitations under good manufacturing practices. Mannitol is a food additive allowed in food products at a maximum level of 2.5%. As far as erythritol

is concerned, JECFA assigned ADI as "not specified" but the reported data confirm that it is totally safe for use. Polyols can cause gastric distress like nausea, laxation, gas or bloating when taken in excess amount.

No carcinogenicity and mutagenacity [55] has been shown by stevia and it is safe for use. It is found that stevioside at a dose of 15 g/ kg body weight was not lethal to mice, rats and hamsters. JECFA temporarily granted 2 mg/kg body weight ADI for steviol glycosides. Long history of use in China suggests that mogroside should be a safe compound. It showed no mortality when administered to mice at doses up to 2g/kg body weight. It has been shown to be non mutagenic. In US market, FDA issued a no objection letter and it achieved GRAS status. Thaumatin showed no mutagenic, teratogenic effects and allergenic effects. The results of researches indicate that thaumatin when used as flavour, modifier and extender and partial sweetener is found to be unhazardous at the anticipated level of consumption. [56] It was accorded as GRAS as a flavour adjunct for chewing gum in1984. ADI has not been specified by JECFA.

Controversy

Although artificial sweeteners especially high potency intense sweetener are safe in use, they do not raise blood glucose or insulin, completely non-toxic and cause no distress or any other adverse side effects but some toxic effects of sweeteners has been reported by Whitehouse et al. (2008) [57] Scientists speculate that artificial substitutes may actually contribute to obesity. People often think of foods containing these substitutes as low calorie or low fat when they often are not. They use in very minute quantities. So to provide them bulk, maltodextrin is used, which provide same calories as sucrose or other carbohydrate does. The addition of NNS to diets poses no benefit for weight loss or reduced weight gain without energy restriction. [58] Some scientists believe that sweet tastes prompt body's digestive system to get ready to process caloric food. But when calories don't arrive because sweetness was artificial, body learns not to crank up metabolic furnace. Over time that adjustment makes it harder to burn calories and shed weight.

CONCLUSION

Sweeteners or sugar alternatives replace traditional sugars from our diet. It is an attractive alternative to sugar because they add virtually no/low calories to diet. It may be intense or bulk sweetener. Popular under many brands like 'Spleda', 'Truvia', 'Sweet N' Low' etc. A person need only a fraction compared with amount of sugar would normally use for sweetness. Artificial sweeteners are widely used in processed foods, including baked goods, soft drinks, powdered drink mixes, candy, puddings, canned foods, jams and jellies, dairy products and other foods and beverages. Studies show that consumption of these substitutes decreased calorie intake, weight gain, maintains blood sugar levels without any adverse effect on hunger. However it is perfectly safe to consume, But if it is consumed more than the suggested dose, it can lead to headache, nausea, vomiting and diarrhea.

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