



Low Caloric Sweeteners for Diabetes and Obesity Care and Their Clinical Inferences for Tackle the Prevalence

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ABSTRACT

Diabetes and obesity are two common human disorders that affecting human health and invite various diseases and disorders in normal body functions. These diseases are very common worldwide. Diabetes occurs when high blood sugar levels develop. This happens when body can't make and use all of the insulin it needs to blood sugar normally to keep blood sugar levels as normal as possible to control diabetes. Diabetic patients will need to follow a diet plan, do exercise and possibly take insulin injections. As part of eating plan, health care provider, and dietitian may ask to limit the amount of carbohydrates eat each day. Low-calorie sweeteners are one easy tool to help for follow eating plan. Obesity is more susceptible and often been associated with frequent ingestion of high energy food in high amount and high intake of sugars such as fermentable sugars such as sucrose, fructose, glucose, and maltose. Both diseases are may be genetically or due to hormonal imbalances. High energy sweeteners may causes caries in the teeth particularly susceptible to the children. Increased calorie intake associated with sugars and carbohydrates, especially when associated with physical inactivity, has been implicated in obesity. Fortunately, low calorie artificial and natural alternatives of sugars have been developed as alternatives to fermentable sugars and have shown promise in these health issues. Although there are only few artificial sweeteners (saccharin, aspartame, acesulfam potassium, sucralose, cyclamate) that have been approved as food additives by the Food and Drug Administration and additional other low-calorie sweeteners (sugar alcohols, neotame, stevia, erythritol, xylitol, tagatose) that have FDA-generally recognized as safe. Given the health impact of sugars and other carbohydrates, professionals should be aware of the marketed available low caloric sweeteners and both their benefits and potential risks.

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Introduction

In the past, avoidance of sugar has been a major focus of nutritional advice for people with diabetes. However, research clearly shows that sugars are an acceptable part of a healthy diet for those with diabetes, particularly sugars obtained from fruits, vegetables and dairy products. Up to 10% of total daily energy requirements may consist of added sugars, such as table sugar and sugar-sweetened products, without impairing glycemic control in people

with type-1 (1) or type-2 (2, 3) diabetes. Foods containing sugars vary in nutritional value and physiological effects. For example, sucrose and orange juice have similar effects on blood glucose but contain different amounts of vitamins and minerals. Consuming whole fruits and fruit juices causes blood glucose concentrations to peak slightly earlier but fall more quickly than consuming an equivalent carbohydrate portion of white bread. This results in a lower glycemic index (GI) for fruits and fruit juices than bread (3, 4). Because refined sucrose produces a lower blood glucose response than many refined starches, some sweetened breakfast cereals produce lower plasma glucose and insulin responses than equal carbohydrate portions of unsweetened cereals (5). Thus,

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undue avoidance of foods containing simple sugars is not necessary. Generally, however, intake of added fructose, sucrose or high-fructose corn syrup in excess of 10% of energy should be avoided, since evidence suggests that this may increase serum triglycerides and/or LDL cholesterol in susceptible individuals (6). The Food and Drug Administration (FDA) has approved five low-calorie sweeteners for use in foods and beverages: Acesulfame potassium (acesulfame K), aspartame, neotame, saccharin and sucralose. Low-calorie sweeteners undergo extensive and rigorous safety testing, which the FDA carefully reviews before approval. The significant body of scientific data developed over the years of testing and study of low-calorie sweeteners shows that low-calorie sweeteners are safe for the entire family and are not linked to adverse health reactions. Low-calorie sweeteners add sweetness without calories to foods and beverages that's similar to table sugar (sucrose). Low-calorie sweeteners eliminate or significantly reduce the calories in foods and beverages such as light yogurt, sugar free pudding and diet or reduced-calorie carbonated soft drinks. The FDA also has approved polyols (sugar alcohols) and tagatose, which are reduced calorie sweeteners that provide some calories, though fewer than table sugar. Moderate use of nutritive (sucrose, fructose, the sugar alcohols (xylitol, mannitol, sorbitol, isomalt, lactitol and maltitol) and aspartame) and non-nutritive sweeteners (acesulfame potassium, sucralose, cyclamate and saccharin) can be part of a well-balanced diet for people with diabetes (7). The energy and/or carbohydrate content of nutritive sweeteners needs to be included in the meal plan, whereas non-nutritive sweeteners do not affect blood glucose levels and provide little or no energy. For example, aspartame is a nutritive sweetener. It provides 16 kJ/g but has a minimal energy contribution to the diet because it is extremely sweet (180–200 times sweeter than sucrose), so only a very small amount is required to sweeten a food product. Sugar alcohols raise blood glucose only minimally (8, 9) and contribute a small amount of energy to the diet. Sugar alcohols are absorbed and metabolized at different rates in the small intestine and can cause flatulence and diarrhea in some individuals (10). During pregnancy and lactation, saccharin and cyclamate are not recommended. In moderation, acesulfame potassium, aspartame and sucralose (11) are acceptable. In individuals with phenylketonuria, the use of aspartame is contraindicated. Nutritive and non-nutritive sweeteners are regulated as food additives. Regulate the amount of food additives that are permitted for use in foods. Acceptable daily intake (ADI) for some common sweeteners is expressed in mg/kg of body weight per day and is defined as the amount of sweetener that can be safely consumed on a daily basis over a person's lifetime without any adverse effects. The ADI amounts are actually much higher than the amounts an individual would consume in a typical diet. However,

individuals with diabetes should receive individualized counseling on how to include the use of foods containing sweeteners. These foods are often not low in energy due to the fat content of the product. Individuals should therefore be advised on how to evaluate food labels for total fat and sweetener content and on how to substitute these products for other food choices within the meal plan. Individuals should also monitor blood glucose and lipid levels on a regular basis and assess their response to routine sweetener use (12).

Sweetening agents are the substances that are used to sweeten food items, medications, beverages, etc. They divided in to natural sweetening agents which occur in nature as such like sugar, honey, etc and artificial sweetening agents which does not occur as such in products and artificially added to the products to get sweetness (FDA Approved low calorie sweeteners) e.g. saccharin, acesulfame K, aspartame, acesulfam potassium, sucralose, cyclamate etc, synthetic non-caloric or low calorie sweeteners FDA-generally recognized as safe (GRAS) approved low calorie sweeteners-sugar alcohols (sorbitol and mannitol), neotame, stevia, erythritol, xylitol, tagatose. They are also referred as Sugar Substitute or Artificial Sweeteners. Non-caloric sweeteners do not add any extra calories to the products when compared to the natural sweetener which add calories to the products. So, artificial sweetening agents like non-caloric sweeteners are widely used as sweetener by diabetic patients. It is estimated that 16–42% of Americans have untreated dental caries (13). Recently, the prevalence of overweight children and adults has also increased, and diet choices affect both development of caries and contribute to weight gain. Recent prevalence data estimate that overweight among children has more than tripled since 1970 and affects 32% of all children and adolescents (14-19). Excess body fat is the product of ingesting too many calories and reduced physical activity (20). Obesity is a complex issue and no causes have been identified. But, the consumption of high sugar, low-nutrient foods is of particular concern (21, 22). It is generally accepted that sugars and prepared starches in the diet are significant contributors to these two health issues. Frequency of exposure to the teeth and food retention are important considerations when evaluating the caries potential of food products (23-28). Sucrose, fructose, and maltose are sugars commonly used in beverages and food products and add about 4 calories per gram. Consumption in developed countries is reported to be 40–60 Kg/person/year (29). Dentists and other oral health professionals have been active in counseling their patients regarding general health issues, such as monitoring blood pressure, smoking and alcohol cessation, and detection of child abuse/neglect. In addition, dentists have collaborated with medical colleagues in drafting guidelines for referring children with early childhood caries for definitive care, application of fluoride varnish

and sedation. It has now been suggested that the oral health provider become an active participant in screening their patients, especially children, for signs of overweight/obesity and offer appropriate counseling/referral. Other measurement tools, such as waist circumference, may be more accurate indicators of obesity, but the body mass index (BMI) is the most convenient screening means (30, 31). This clinical tool measures body weight adjusted for height. Standardized BMI charts to determine BMI percentiles are available (32). A "healthy weight" is described being below the 85th percentile. Industry and scientists have long searched for alternative sweeteners. The ideal product would have few or no calories, be non carcinogenic or mutagenic, be economical to produce, and would not be heat degradable but would provide sweetness and have no unpleasant aftertaste. Obtaining these properties in a single product has been challenging. Numerous nonnutritive sweetening agents have been developed, but none have possessed all of the preferred properties. Patients and parents/care givers of children often ask oral health professionals about common dietary sugars and alternative sweeteners. The purpose of this paper is to provide the dental professional information that will be helpful in counseling these individuals on diet, caries prevention, and weight control (33).

Artificial low calorie Sweetening Agents

People without a sweet tooth are rare. Our preference for sweets is thought to be a basic survival adaptation. Scientists believe that this preference is evolutionary and ensures that infants accept life-sustaining breast milk because of its slightly sweet taste from milk sugar. As we grow older, sweet foods are an important part of birthdays, holidays and family traditions. For most of us, however, indulging in sweets must be done with care. Nowadays numbers of adults are overweight or obese. Obesity substantially increases the chance of developing chronic diseases and conditions like high blood pressure, type-2 diabetes, heart disease, stroke and some cancers. When we think about diet and health, there is no magic formula to lose weight and keep it off. If you want to lose weight, you must eat fewer calories than your body burns. To maintain weight, you need to eat the same number of calories as your body burns. The bottom line is simple. Calories do count and regular physical activity is crucial to maintaining healthy weight or for promoting weight loss. Understanding these facts help you realize that low-calorie sweeteners-and foods and beverages made with them-can play a beneficial role in healthful eating. They can provide sweetness while helping you to the line on calories. Surveys show that many low-calorie sweeteners and the foods and beverages sweetened with them to help with managing their weight, maintaining an attractive appearance and staying in better overall health. Four low-calorie sweeteners are now approved for use in the

USA (31-35). With this variety of sweeteners, more palate pleasing foods and beverages are available to help you achieve your health and nutrition goals.

Low calorie Sweetening Agents and Healthful Eating

It is clear that to lose weight or to maintain a healthy weight you need to pay careful attention to your calorie intake. The use of low-calorie sweeteners and the growing availability of a wider array of good tasting foods and beverages made with low calorie sweeteners can help you keep your calorie intake in line with your needs. Low calorie sweeteners offer the best method to date of reducing calories while maintaining the palatability of the diet." It should be stressed, however, that the use of low-calorie sweeteners alone cannot help people succeed at weight control. They are only a helpful tool. Successful weight control must involve a multi-pronged approach of healthful eating, physical activity, and behavior change. Four low-calorie sweeteners are approved for use in foods and beverages in the United States-acesulfame potassium, aspartame, saccharin and sucralose. Another group of sweeteners, polyols, or sugar alcohols, are reduced-calorie sweeteners and are used primarily in desserts, candy and chewing gum (36, 37). All low-calorie sweeteners-acesulfame potassium, aspartame, saccharin, and sucralose-have undergone extensive safety evaluation and approval as food ingredients by the US Food and Drug Administration (FDA).

Low calorie Sweetening Agents and Control or Lose Weight

The good news is that low-calorie sweeteners have the potential to help people stay on track with a weight loss program and to be more successful in keeping extra weight off. Research has shown that when low-calorie sweetened foods and beverages are substituted for their conventional counter parts people consume fewer calories when they don't know about the substitution. Some studies show that people may make up for eating fewer calories if they are knowingly served or choose lower-calorie foods. For example, if someone chooses to drink a diet or low-calorie beverage, they might feel freer to eat a piece of cake. Low-calorie sweeteners may not stimulate appetite, thereby not increasing calorie intake and not promoting weight gain. Scientists have conducted numerous studies to examine and found LCSs do not to stimulate appetite and cause weight gain (37, 38).

Diabetes and Low-Calorie Sweeteners

Low-calorie sweeteners have long played a role in the food choices of people with diabetes by providing alternatives to sugar-containing foods and allowing reduced consumption of sugars and carbohydrates. The recommendations from the American Diabetes

Association about sugars and carbohydrates have changed greatly over the years. Today's recommendations suggest that people can choose moderate amounts of foods with sugars within the context of healthful eating guidelines. The most important factor in the control of blood glucose levels is to eat similar amounts of carbohydrates at meals and from day to day. Low-calorie sweeteners continue to be important for people with diabetes, especially the many individuals who need to lose weight to help control their blood glucose levels. Low-calorie sweeteners contain almost no calories and no carbohydrates. They do not raise blood glucose or insulin levels. People with diabetes can use foods and beverages with low-calorie sweeteners as tools for making healthful food choices (36-38). Blending of two or more low-calorie sweeteners in a food or beverage has been used internationally for many years and is becoming more common in the United States. Low-calorie sweetener blends are important because they can produce a taste profile very similar to that of sugar-the gold standard for sweetness. Blends commonly used today are aspartame and acesulfame potassium, or acesulfame potassium and sucralose (39).

Low calorie Sweetening Agents into a Healthful Diet

Whether you are counting calories to reduce or control your weight or counting carbohydrates to control diabetes it is important to know how foods with low calorie sweeteners can fit into your dietary pattern. There is a tendency to think that because a food is sweetened with a low-calorie sweetener, it contains no calories. True, it might be "sugar-free," but sugar free does not mean calorie-free. For example, yogurt or hot cocoa mix sweetened with a low-calorie sweetener does contain calories from other ingredients such as fruit or milk. These foods are not calorie-free. Foods and beverages containing low-calorie sweeteners fit broadly into three groups. Use these guidelines to fit foods with low-calorie sweeteners into your diet.

• Tabletop sweeteners

A packet or package of a low calorie sweetener usually has between zero to 2 calories for the equivalent of sweetness of 2 teaspoons of sugar. The calories are not from the low-calorie sweetener, but from bulking agents (usually dextrose or maltodextrin) used to add volume to the product in order to mimic the same amount as in a packet of sugar. These provide negligible calories.

• Foods with low-calorie sweeteners that contain minimal calories

Examples are diet soda, gelatins, fruit drinks, powdered drink mixes and sugar-free chewing gums. As long as the Nutrition Facts panel on food products tells you that a serving contains less than 20 calories and less than 5

grams of carbohydrate per serving, consider this a calorie-free food. But keep in mind that the calories from many servings of these foods will add up. *Foods sweetened with low-calorie sweeteners that contain other ingredients that contribute calories and carbohydrate:* Examples are hot cocoa mixes, refrigerated yogurts, baked goods, frozen desserts or fruit drinks. Review the Nutrition Facts panel on the product to determine the number of calories and amount of carbohydrate in one serving and how the product fits into your food intake pattern (36-39).

FDA Approved Nonnutritive Sweeteners as Additives

Currently, the Food and Drug Administration (FDA) of the United States has evaluated the data and other information and approved under the conditions of its use only aspartame, acesulfame potassium, saccharin, sucralose, and neotame as noncaloric sweeteners as "food additives," Figure 1. However, the FDA can also approve an agent under *GRAS* (Generally Recognized as Safe). For approval under *GRAS*, supporting data must have been provided and evaluated by qualified experts, and there is consensus that the substance is safe under the conditions of its intended use.

Saccharin

Saccharin, first developed in 1878, is the oldest approved artificial sweetener. Initially granted *GRAS* status, saccharin is now approved as an additive to food and beverages. Saccharin is 300 times as sweet as sucrose by weight, noncariogenic and noncaloric but can have a slightly bitter or metallic after taste. It is available as a tablet, powder, or liquid form and is widely used in food products including diet sodas, pharmaceuticals, and cosmetics. Saccharin has been approved for use in more than 100 countries world-wide. Because saccharin is stable when heated, it is suitable for foods, beverages and in cooking and baking. It is not broken down by the body and is eliminated without providing any calories. Decades ago, there were questions about whether saccharin could cause bladder cancer, based on animal studies. Numerous follow-up studies with animals and humans have shown no overall association between saccharin consumption and cancer incidence. Recently, the federal government removed saccharin from a list of potential cancer-causing agents. For the time being, labels on products with saccharin must include a statement that saccharin has caused cancer in laboratory animals (40).

Aspartame

Aspartame is a very low-calorie sweetener. It is made by joining two amino acids, aspartic acid and the methyl ester of phenylalanine. The components of aspartame are also found naturally in common foods, including meat, dairy products, fruits and vegetables. After ingestion,

aspartame is broken down to its components and utilized by the body in the same way as when derived in much larger amounts from common foods. Although aspartame is widely used in foods and beverages, is not recommended for use in recipes that require lengthy heating or baking time, because of a loss of sweetness. It may, however, be added at the end of the cooking cycle in many recipes. Aspartame was initially approved by the FDA in 1981 for limited use as a table top sweetener and for use in breakfast cereals, gelatins, and puddings. But in 1983, approval was extended to a larger group of food agents, including carbonated beverages. In 1996, the FDA approved aspartame as a general purpose sweetener for use in all foods and beverages. Aspartame is the most widely utilized non-cariogenic artificial sweetener and is 160–220 times sweeter than sucrose (41). It is often the manufacturer's sweetener of choice in formulation of diet soft drinks, yogurt, puddings, gelatin, and snack foods. Prior to approval of aspartame by the FDA, a number of significant issues were raised by concerned individuals relative to aspartame's potential undesirable effects with long term consumption on growth, glucose homeostasis, neurotoxic effects in animals, behavioral reactions, seizure susceptibility and liver functions but these concerns have been largely addressed (42-46). Aspartame is claimed to be safe for type 2 diabetics but should be avoided by people with phenylketonuria (PKU) as they cannot metabolize phenylalanine, a component of aspartame. Persons with a rare hereditary disease known as PKU must control their intake of phenylalanine from all sources, including aspartame. Although aspartame contains only a small amount of phenylalanine, labels of aspartame-containing foods and beverages must include a statement advising PKU of the presence of phenylalanine.

Acesulfame potassium

Acesulfame potassium (acesulfame K or Ace K) is calorie-free and about 200 times sweeter than sugar. Acesulfame K, non-cariogenic, nonnutritive artificial sweetener, was initially approved by the FDA in 1988 for use as a sweetener in dry food products. In 1994, yogurt, refrigerated desserts, syrups, and baked goods were added to the approved list, and in 2002 it was accepted as a general purpose sweetener. Acesulfame K is highly stable and has been approved for use in a wide variety of foods, beverages and baked products. Acesulfame K is not broken down by the body and is eliminated without providing any calories. More than thirty countries have approved the product to be used in foods, beverages, cosmetics, and pharmaceutical products. Like saccharin, acesulfame K, has a slightly bitter aftertaste and is often blended with other sweeteners to mask this property. Acesulfame K stable at high cooking/baking temperatures, even under moderately acidic or basic conditions, which

permits it to be used in baking or in products requiring a long shelf life. Although considered safe by the FDA for general consumption in food, there have been some concerns raised relative to dose-dependent cytogenetic toxicity (47, 48).

Sucralose

Sucralose is approximately 600 times sweeter than sugar but is not metabolized by the body. It is made from sugar through a patented, multi-step process. Sucralose is highly stable and can be used in foods, beverages and in cooking and baking. Sucralose is not recognized by the body as sugar or carbohydrate. Sucralose is a nonnutritive, noncaloric trichlorinated derivative of sucrose. It was first accepted by the FDA as an eating table-top sweetener in 1998 and followed by acceptance as a general purpose sweetener in 1999. Sucralose is considered safe for use by diabetics and has been shown not to be metabolized into acids by oral microbiota. It is heat stable during cooking and baking and is widely used in many food products such carbonated and noncarbonated beverages, as a tea and coffee sweetener, and in baked goods, chewing gum and frozen desserts. To date no health issues have been established concerning the general dietary use of sucralose (49).

Neotame

Neotame is a relatively recent approved noncaloric food product. It received FDA approval in 2002 for use as a general purpose sweetener in selected food products (except not in meat and poultry) and flavor enhancer. Neotame is an intense nonnutritive sweetener that is not fermentable by the oral microbiota and possesses a crisp, clean taste with no detectable aftertaste. It is reported to be greater than 7,000 times more potent than sucrose on a weight basis depending on the food product and how it is prepared (50). Neotame is a derivative of a dipeptide and has a similar chemical structure to aspartame. However, unlike aspartame, it is safe for consumption by people with phenylketonuria. It is also heat stable in baking applications and can be safely used by diabetics and pregnant women. Neotame is stable in carbonated soft drinks, powdered soft drinks, yellow cake, yogurt, and hot-packed still drinks (51).

Cyclamate

This is a calorie free artificial sweetening agents which is about 30-50 times sweet than sugar and metabolized in the gut.

FDA GRAS Approved Nonnutritive Sweeteners

The FDA has approved as "Generally Recognized as Safe" (*GRAS*) several additional nonnutritive non-/low caloric calorie sweeteners, Figure 2.

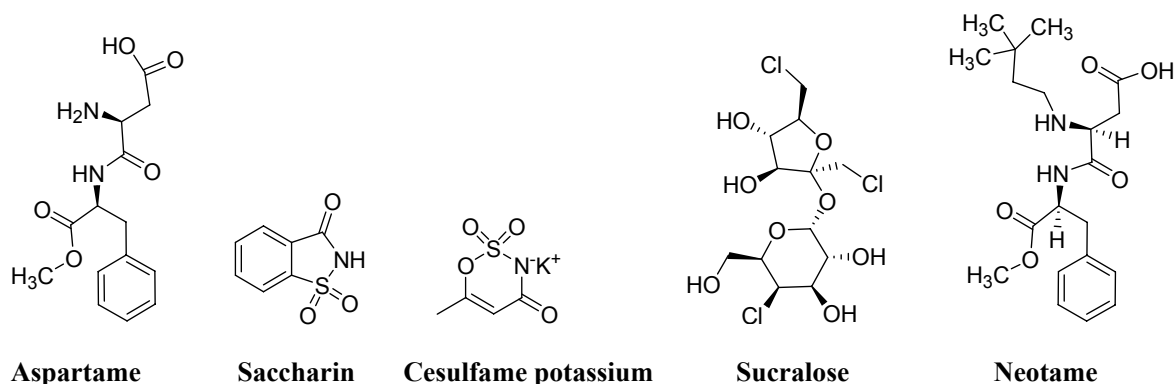


Figure 1: Chemical structure of FDA approved non-/low caloric sweeteners as food additives.

Polyols

Polyols (or sugar alcohols) are another group of reduced-calorie sweeteners that contain some calories. Polyols are found naturally in berries, apples, plums, and other foods, but are manufactured from carbohydrates for use in sugar-free candies, cookies, chewing gums and other reduced-calorie foods. Familiar names of polyols include sorbitol, mannitol and isomalt. Since polyols are partially, but not completely broken down by the body, they provide, on average, half the calories of sugar and other carbohydrates. Some polyols, such as sorbitol, may produce gas and discomfort in the stomach and may cause diarrhea in some people when large amounts are consumed. As a result, foods with a significant amount of certain polyols bear the statement, "Excess consumption may have a laxative effect."

Sorbitol

Sorbitol is a 6-carbon sugar alcohol that occurs naturally in many fruits and berries. Although rather expensive to manufacturer, sorbitol is often used as a "bulk" sweetener in a variety of food substances such as chewing gum, chocolates, cakes and cookies, toothpaste, and mouthwash. On a weight basis, sorbitol is only half as sweet as sucrose. It is generally considered non-cariogenic, but sorbitol can be fermented slowly into acid by *S. mutans*. Research has shown sorbitol to possess mild cariogenic potential when used over an extended period of time by patients with reduced salivary gland function, and it normally supports the formation of dental plaque and the growth of mutans streptococci (52). Specific remineralization-enhancing effect of sorbitol has not been shown (53). It remains debatable among some authorities whether sorbitol should be consumed by diabetics. Sorbitol is not easily digested or absorbed from the gastrointestinal tract, and diarrhea is a potential side effect if ingested in large quantities (54).

Xylitol

Xylitol, a five-carbon naturally occurring, nonfermentable, sugar alcohol, was first discovered in 1890 in birch and other hardwood tree chips, in wheat and oat straw in 1891, and later in various fruits and vegetables (55). It was approved by the FDA in 1986 for limited use. Xylitol is as sweet as sucrose and possesses a pleasant taste but is relatively expensive to manufacture. Although not as calorie heavy as sucrose, xylitol does possess a calorie burden when consumed and has some potential for increasing blood glucose. It is used primarily in mints, chewing gum, and toothpaste but is also available for table use. Studies have suggested that the regular use of xylitol containing chewing gum reduces the quantity of dental plaque, significantly reduced *S. mutans* levels, and increases saliva production (56). Reduction of caries incidence and remineralization of caries lesions have been reported in caries susceptible individuals when chewing gum containing xylitol was regularly used (57-60). Xylitol has also been shown to inhibit cytokine expression by a lipopolysaccharide from one of the suspected periodontal pathogen bacteria, *Porphyromonas gingivalis* (61). Thus, its regular use could possibly aid in preventing periodontal disease and gingival inflammation. Xylitol has been credited in lowering the risk of cariogenic bacteria transmission from mother to infant when compared to chlorhexadine and fluoride varnish treatments and reducing the incidence of ear infections among children at day-care centers (62-65). However, excessive use of xylitol can aggravate symptoms of Crohn's disease and irritable bowel syndrome resulting in diarrhea (66, 67).

Erythritol

Erythritol, a four-carbon sugar alcohol, has similar characteristics of sorbitol, mannitol, and xylitol. It is manufactured by a process that begins with fermenting glucose. But, it is only slightly more than half as sweet

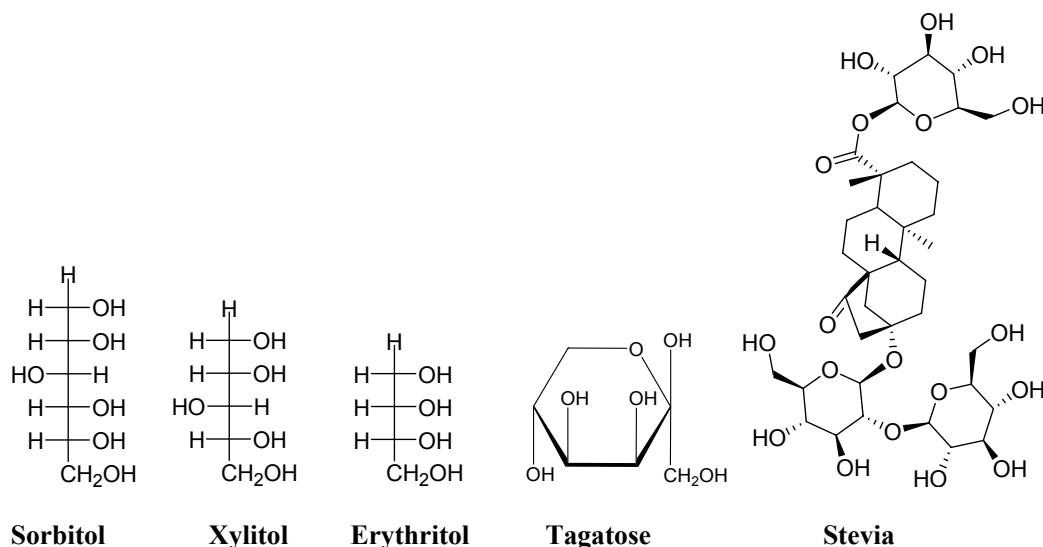


Figure 2: Chemical structure of FDA approved non-/low caloric sweeteners as GRAS (Generally Recognized as Safe).

(70%) as sucrose and does not dissolve in water as well, but has significantly fewer calories by weight (0.2 calories per gram versus 4 calories per gram). Erythritol has been used in Japan since 1990 as a component of candies, soft drinks, chewing gum, jams, and yogurt. It was given *GRAS* recognition by the FDA in 1997. Erythritol is heat stable and can be used in baking and as a sweetener in low carbohydrate/calorie diets. It is almost completely absorbed by the small intestine (and excreted unchanged in the urine within 24 hours), has shown no toxic or carcinogenic effects, and is considered safe for consumption by diabetics. No long-term human caries trial on erythritol has been completed. However, the daily use of erythritol has been shown to reduce mutans streptococci levels in plaque and saliva (68). Erythritol does not cause bloating, flatulence, or diarrhea at normal consumption levels but may have a laxative effect in both children and adults if consumed in excess (69).

Tagatose

Tagatose, a low-calorie natural sugar, has all the good qualities of erythritol plus it has about the same (92%) sweetness as sucrose, performs better in cooking, and has been shown to actually improve blood sugar control in diabetics. It has about 1/3 the number of calories as sucrose by weight. It was granted *GRAS* status in 2001 and is used in a variety of drugs, foods such as chocolates, chewing gum, cakes, ice cream and frosted cereals, beverages, and dietary supplements. Tagatose has been shown to have benefits treating noninsulin-dependent type-2 diabetes as it attenuates the rise of serum glucose after oral glucose

intake (70). No significant adverse health effects have been associated with the ingestion of this product when consumed in reasonable amounts. Excessive consumption can lead to mild intestinal discomfort, flatulence, and diarrhea (71).

Stevia

Stevia, a heat stable sweetener with little or no aftertaste, is an extract from the herb *Stevia rebaudiana* Bertoni (72). The extracted active ingredient is a white crystalline material. Its sweetness potency is many times greater (200–300) than sucrose. Stevia is calorie-free and non-cariogenic. The herb is native to Central and South America and has been used by the indigenous peoples of this area for centuries as a sweetener (73). It has been used extensively in China, Brazil, and Japan, and to a lesser extent in Germany, Malaysia, and Israel, for many years as a sweetener in numerous food categories (74). Originally banned by the FDA, the use of stevia was approved in 1995, as a *dietary supplement* but not as an *additive*. The argument to approve stevia as a *food additive* was heated, and it remained approved only as a *food supplement* for an extended period of time. However, in December 2008, the FDA responded favorably to *GRAS* status for the chemically refined derivative of stevia, the extract Rebaudioside A (Rebiana), to be used as a general purpose sweetener (75). Rebiana is also available in combination with dextrose and as an extract from stevia leaves. Stevia has been shown to be safe for use by diabetics and has not been shown to be mutagenic (76, 77).

Sweeteners and Health

All low-calorie sweeteners contribute no or very few calories to foods and beverages. Each has undergone extensive safety testing which has been carefully reviewed by the Food and Drug Administration. The scientific data clearly demonstrate that low-calorie sweeteners are not linked to any adverse health reactions. In the United States, the FDA investigates complaints from consumers. It has stated that there are no causal relationships between dietary use of low-calorie sweeteners and alleged adverse reactions (78-80).

Discussion

New nonnutritive sweeteners have been introduced into human diets over the past few decades. Oral health care professionals are often called upon to provide knowledgeable advice regarding the importance of diet and the role of sugars and nonnutritive sweeteners in caries formation and weight control. As such, they must be familiar with alternatives to sugar and the types of food products that are available with substitute non-/low caloric, non-cariogenic sweetening agents. Although nonnutritive sweeteners do not generally promote dental caries, a program to prevent dental decay and promote oral health must also include good oral hygiene habits, regular dental professional care, and exposure to fluoride (81-84). Whether the use of nonnutritive sweeteners has a positive impact on weight loss by consumers remains controversial. It has been postulated that nonnutritive sweeteners encourage sugar craving and dependency because of their sweet nature, and flavor preference occurs with repeated exposures to sweet tasting foods and beverages (85-89). Several studies have shown an increase in BMI with consumption of nonnutritive sweeteners. But, others have found the evidence less compelling and more equivocal. Whether nonnutritive sweetener use has a role in the current obesity and diabetes epidemic, whether beneficial, neutral, or not remains undetermined. In addition, consumption of two or more servings of nonnutritive sweetened sodas has been associated with 2-fold increased odds for kidney function decline in women as measured by the eGFR (estimated Glomerular Filtration Rate). However, it is well established that a reduction of fermentable sugars and carbohydrates in the diet coupled with good oral hygiene practices will reduce the incidence of dental decay. While it is difficult to totally avoid sugar in the diet, as it is often added to processed food to enhance the taste, reducing the amount and frequency of dietary exposure to sugar is an important adjunct in preventing caries and reducing calorie intake although not without some potential health concerns as previously described (90). However, nonnutritive sweeteners offer an attractive alternative to sugar in caries prevention and a possible adjunct in weight control when used appropriately and in concert with a balanced diet and

exercise. The identification of safe, palatable, heat stable, non-/low-caloric, nonnutritive/noncariogenic sweetener substitutes for the more dental decay promoting and calorie heavy sugars such as sucrose, glucose, fructose, and maltose continues to be actively pursued. In addition to annually updating the health history, dental professionals should determine annually the BMI percentile of their patients and refer those on unhealthy trajectories to their physician or a dietitian for additional counseling. It also behooves the dental professional to stay attuned to current information relative to alternative sweetener products that exist or are being developed and approved for dietary consumption by the FDA and be prepared to be a source of counseling for their patients and families as they relate to reducing the incidence of caries and possible overweight (91-93).

The low-calorie sweeteners don't raise blood sugar or insulin levels, with diabetes, to include sweet-tasting foods and beverages in their meal plans. Low-calorie sweeteners also provide flexibility with making food choices. For example, choosing a yogurt or soft drink flavored with a low-calorie sweetener makes it possible to include another carbohydrate source such as bread or fruit in your meal plan. Naturally occurring and added sugars should be included as part of the daily carbohydrate allowance and as part of a healthy eating plan. For many people with diabetes, losing weight is a big part of their diabetes treatment. Many times losing weight helps your body cells use insulin better. The best way to lose weight is to adopt a healthy eating plan and to increase physical activity. Many weight loss diets only change your eating habits for a short time and take low calories food. Often when you go back to your old eating habits you will regain the weight lost. With a diabetic meal plan, you are eating fewer calories because you are filling up with good, healthful foods, not foods high in fat. A diabetic meal plan also emphasizes portion sizes. Sometimes, just a 5-10 kg weight loss can bring blood glucose into control. Slow weight loss is healthier. No more than a one- to two-pound weight loss per week is recommended. Regular physical activity also helps with weight loss, as well as helps control blood glucose, blood cholesterol, and blood pressure. Most people with diabetes can include added sugars up to 10% of daily energy requirements without deleterious effects on blood glucose or lipid control. Individuals with diabetes should be educated on the appropriate use of nutritive and non-nutritive sweeteners. The impact of nutritive sweeteners on the individual's blood glucose levels and lipid profiles should be assessed on a regular basis. According to the FDA, consumption of low-calorie sweeteners is safe for the general public. If you need to lose weight, consult your physician to discuss how the use of foods and beverages made with low-calorie sweeteners can help you trim calories. Always consult health care provider, diabetes educator or registered

dietitian for specific dietary advice. There is no cure for diabetes. However, you can manage or delay diabetes through diet, exercise, weight control and, if necessary, medication (94-97).

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