Middle-East Journal of Scientific Research 11 (3): 342-346, 2012
ISSN 1990-9233

Role of Low Calorie Sweeteners in Maintaining Dental Health

[1]Charu Gupta, [1]Dhan Prakash, [2]Sneh Gupta and [3]Sudha Goyal

[1]Amity Institute for Herbal Research and Studies, Amity University, Sector-125, Noida-201303, India
[2]Department of Zoology, R.G. (P.G.) College, Chippi Tank, Meerut-250001, India
[3]Department of Chemistry, R.G. (P.G.) College, Chippi Tank, Meerut-250001, India

Abstract: Low-calorie sweeteners (sometimes referred to as non-nutritive sweeteners, artificial sweeteners, or sugar substitutes) are ingredients added to foods and beverages to provide sweetness without adding a significant amount of calories. Their role in weight management is wiy known but their role in maintaining dental health is still hidden. The present article discusses about the well known artificial as well as natural sweeteners and their importance in maintaining dental health. Besides this microbes can also be used as a novel approach for the production of natural sweeteners.

Key words: Natural sweeteners · Dental plaque · Xylitol · Microbes

INTRODUCTION

Low-calorie sweeteners (sometimes referred to as non-nutritive sweeteners, artificial sweeteners, or sugar substitutes) are ingredients added to foods and beverages to provide sweetness without adding a significant amount of calories. In fact, they can also play an important role in a weight management program that includes both good nutrition choices and physical activity [1].

In U.S. the most common and popular low-calorie sweeteners permitted for use in foods and beverages today are

- Acesulfame potassium (ace-K)
- Aspartame
- Neotame
- Saccharin
- Stevia sweeteners
- Sucralose

When added to foods and beverages, these low-calorie sweeteners provide a taste that is similar to that of table sugar (sucrose) and are generally several hundred to several thousand times sweeter than sugar. They are often referred to as "intense" sweeteners. Because of their intense sweetening power, these sweeteners can be used in very small amounts and thus add only a negligible amount of calories to foods and beverages. As a result, they can substantially reduce or completely eliminate the calories in certain products such as diet beverages, light yogurt and sugar-free pudding. In addition, many low-calorie sweeteners do not contribute to cavities or tooth decay.

Acesulfame-Potassium (Ace-K): Ace-K is a combination of an organic acid and potassium and is 200 times sweeter than sugar. It is a popular sweetener used in low-calorie sweetener blends to create an optimal flavor profile in foods and beverages. Ace-K was approved by the U.S. Food and Drug Administration (FDA) in 1988 for use in numerous food products and as a tabletop sweetener. In 1998, the FDA extended its approval to beverages and finally as a general purpose sweetener in 2003. Ace-K is approved for use in nearly 90 countries. Ace-K is not broken down by the body and is eliminated unchanged by the kidneys. It has no effect on serum glucose, cholesterol or triglycerides and people with diabetes may safely include products containing ace-K in their diet.

Aspartame: Discovered in 1965, aspartame is used in foods and beverages in more than 100 countries worldwide. FDA approved aspartame for use in foods in 1981, followed by beverages in 1983. In 1996 it received

Corresponding Author: Charu Gupta, Amity Institute for Herbal Research and Studies, Amity University, Sector-125, Noida-201303, India.

approval as a general purpose sweetener. Aspartame is a molecule consisting of two amino acids-phenylalanine and aspartic acid. People who have a rare hereditary condition called phenylketonuria (PKU) cannot metabolize phenylalanine; therefore, all products containing aspartame must carry a statement warning people with PKU of the presence of aspartame on the label [2,3]. Aspartame provides four calories per gram. However, it is used in very small amounts, contributing negligible calories to the diet. Aspartame is approximately 180 times sweeter than sugar. It is not heat-stable and is not suggested for use in cooking or baking [4].

Neotame: Neotame is also a derivative of aspartic acid and phenylalanine. It is approximately 7,000 to 8,000 times sweeter than sugar, although some report a sweetening power of up to 13,000 times that of sugar [5]. It is partially absorbed, but rapidly metabolized and excreted from the body. Neotame was approved by FDA in July 2002 as a general purpose sweetener. Neotame has also received favorable evaluation by JECFA and is approved for use in other countries, including most parts of Eastern Europe, Australia, Russia, Mexico and several South American countries. Because of the extraordinary sweetening power of a small amount of neotame, the level of exposure to phenylalanine as it is released into the bloodstream is considered clinically insignificant. Therefore, products sweetened with neotame are not required to carry a statement on the label alerting persons with PKU to the presence of phenylalanine.

Saccharin: Originally discovered in 1878, saccharin is considered the oldest of the low-calorie sweeteners approved for food and beverage use. Today saccharin is still used safely and widely and often in combination with other sweeteners. Saccharin is 300 times sweeter than sugar, although some reports have indicated it can be up to 700 times sweeter than sugar. It is not broken down by the body and is eliminated without providing any calories. Saccharin is heat stable, therefore making it suitable for cooking and baking.

Stevia Sweeteners: The stevia plant is native to South America and today, it can be found growing in many countries including China, Brazil, Argentina, Paraguay, India and South Korea. Hundreds of foods and beverages consumed around the world are sweetened with stevia sweeteners. Stevia sweeteners are highly purified steviol glycosides, which make up the sweetest part of the stevia plant. In December 2008, the FDA stated it had no questions regarding the conclusion of an expert panel that steviol glycosides are generally recognized as safe (GRAS) for use as general purpose sweeteners. Prior to this, stevia (in its unpurified form) was only permitted for use as a dietary supplement in the U.S. Stevia sweeteners are natural, contain zero calories and are 200-300 times sweeter than sugar. Stevia sweeteners are approved for food and beverage use in several countries and can be found in the U.S. in many food and beverage products, including some juice and tea beverages, as well as some tabletop sweeteners [6].

Sucralose: In 1998, FDA approved sucralose for use in 15 food and beverage categories - the broadest initial approval ever given to a food additive. In 1999, FDA extended the approval to all categories of foods and beverages as a general-purpose sweetener. Six hundred times sweeter than sugar, the intense sweetness of sucralose is made from a process that begins with regular table sugar (sucrose); however, it is not sugar. It is produced through a process whereby three hydrogen-oxygen groups on the sugar molecule are replaced with three chlorine atoms. Sucralose is not recognized by the body as a carbohydrate. It is poorly absorbed and is excreted unchanged from the body. As a result, sucralose provides no calories. Because sucralose is very stable, it can be used almost anywhere sugar is used, including in cooking and baking.

Xylitol: is a natural substance found in fibrous vegetables and fruit, as well as in corn cobs and various hardwood trees like birch. It is a natural, intermediate product which regularly occurs in the glucose metabolism of man and other animals as well as in the metabolism of several plants and micro-organisms. Xylitol is produced naturally in our bodies. Studies suggest that human body can make up to 15 grams daily during normal metabolism. Xylitol tastes and looks exactly like sugar and is really sugar's mirror image. Xylitol is a five-carbon sugar, which means it is an antimicrobial, preventing the growth of bacteria. While sugar is acid forming, xylitol is alkaline enhancing. All other forms of sugar, including sorbitol, another popular alternative sweetener, are six-carbon sugars which feed dangerous bacteria and fungi. It also builds immunity, protects against chronic degenerative disease and has anti-ageing benefits. Xylitol has 40 per cent fewer

Table: Low-Calorie Sweeteners At-A-Glance

Sweetener	Date Approved	Sweeter Than Sugar	Brand Name(s)
Ace-K	1988	200x	Sunett®, Sweet One®
Aspartame	1981	180x	NutraSweet®, Equal®, Others
Neotame	2002	7,000x	n/a
Saccharin	Years prior to 1958	300x	Sweet 'N Low®, Sweet Twin, Sugar Twin®, Others
Stevia Sweeteners	2008	200x	TruviaTM, PureViaTM, Sun Crystals®
Sucralose	1998	600x	Splenda®

Sources: *Comprehensive Reviews in Food Science and Food Safety*, IFT, 2006 *Food and Chemical Toxicology*, 2008

calories and 75 per cent fewer carbohydrates than sugar and is slowly absorbed and metabolized, resulting in very negligible changes in insulin. About one-third of the xylitol that is consumed is absorbed in the liver. The other two-thirds travel to the intestinal tract where it is broken down by gut bacteria into short-chain fatty acids.

Besides these, polyols (or sugar alcohols) are low calorie, but contain carbohydrates and calories and need to be counted as part of meal plan. Examples of sugar alcohols include erythritol, polyglycitol, isomalt, lactitol, maltitol, mannitol, sorbitol and xylitol. Sugar alcohols are found in some sugar-free foods, including sugar-free chewing gum [7].

Unlike other forms of carbohydrates that provide four calories per gram, sugar alcohols provide only about two calories per gram because they are not completely absorbed by the body.

Low Calorie Sweeteners Contribute to Dental Health: Diet plays a major role in dental heath. Excess of sugar in the diet weakens the immune system and creates an acidic environment; thus oral health suffers. Most of oral bacteria are benign, but when sugar enters the scene it feeds the destructive strains, allowing them to proliferate. Periodontal disease is basically caused by bacteria. These deposits permit the growth of bacteria that cause inflammation of the gums. The bacteria also release minute amounts of toxins that break down gum tissue, thereby helping the infection to progress. Plaque is an invisible, sticky film of saliva and food residue that constantly forms on the teeth. Ongoing low-grade bacterial infection also burdens the immune system. Gum infection can also lead to other serious health problems. It doubles the risk of stroke, triples the risk of heart attack, increases the incidence of premature, low-weight babies and also contributes to bronchitis, pneumonia and emphysema.

The main advantage of low calorie sweeteners is in maintaining good oral hygiene [8]. Even if teeth cannot be brushed after every meal, low calorie sweeteners will not cause tooth decay. This is because they are not fermented into harmful acids by oral bacteria. Under neutral conditions, tooth enamel is very durable. All carbohydrates which can be broken down, however, are fermented into acids by the bacteria in plaque, which forms naturally in the mouth [9].

The more we come into contact with carbohydrates, the more active are our oral bacteria. How quickly and thoroughly the acids that the bacteria produce complete their destructive work also depends on the condition of the teeth and on the care they receive, so good dental hygiene remains very important.

Since low calorie sweeteners do not contain fermentable carbohydrates, they do not add to the production of acids by oral bacteria. In fact, low calorie sweeteners are also used to improve the taste of products for dental and oral hygiene, thus contributing to caries prevention. It is well known that toothpastes and mouthwashes with an agreeable taste are used more consistently and frequently than products with a "medical" taste, especially by children.

Xylitol is another low calorie natural sweetener that is effective in preventing tooth decay and maintaining good oral hygiene. Using xylitol helps to raise plaque pH, thereby reducing the time that teeth are exposed to damaging acids as well as starving harmful bacteria of their food source. Xylitol looks, feels and tastes exactly like sugar and leaves no unpleasant aftertaste. It is available in many forms. In its crystalline form, it can replace sugar in cooking, baking or as a sweetener for beverages. It is a mint-flavoured sweetener used in chewing gum, toothpaste, mouthwash, nasal spray and other products. It is used as a sugar substitute because it imparts fewer calories, has a cool mint flavor, helps fight cavity-causing bacteria and can pass through the human gut without involving insulin. Because xylitol is only slowly absorbed and partially utilized, a reduced calorie claim is allowed: 2.4 calories per gram or 40% less than other carbohydrates. Xylitol use reduces tooth decay rates both in high-risk groups (high caries prevalence, poor nutrition and poor oral hygiene) and in low-risk groups (low caries incidence using all current prevention recommendations). Xylitol is not only a safe, natural sweetener without the bad side-effects of sugar and artificial substitutes; it is also good for teeth, stabilizes insulin and hormone levels and promotes good health. Xylitol reverses all these destructive effects of sugar on

oral health. Xylitol is non-fermentable and therefore cannot be converted to acids by oral bacteria, thus it helps to restore a proper alkaline/acid balance in the mouth. This alkaline environment is inhospitable to all the destructive bacteria, especially the worst variety, *Streptococcus mutans*. It also inhibits plaque formation.

Using xylitol right before bedtime, after brushing and flossing, protects and heals the teeth and gums. Unlike sugar, it can even be left on the teeth overnight. With proper use, xylitol actually stops the fermentation process leading to tooth decay. Long-term use suppresses the most harmful strains of oral bacteria, making a long-lasting change in those bacterial communities. Xylitol even has the ability to enhance the mineralization of the enamel. It is most effective in treating small decay spots.

Xylitol stimulates saliva flow and helps keep salivary minerals in a useful form. Its prolonged use increases the buffering capacity and protective factors in saliva. Increased saliva production is especially important for people suffering with a dry mouth due to illness, ageing or drug side-effects.

Since the oral environment becomes less acidic with continued xylitol use, it is advisable to chew xylitol gum or suck a xylitol mint after every meal or after eating sweet snacks. The best thing is that studies have shown that xylitol's effect is long-lasting and possibly even permanent [10].

Microbes

A Novel Approach for Production of Natural Sweeteners: The xylitol can be produced from genetically engineered bacteria that eat hemicellulose in corn fiber and other sources.

In studies at the USDA-ARS Fermentation Biotechnology Research Unit, scientists used metabolic pathway engineering to retool the enzyme-making machinery of *E. coli* bacteria so that they could convert two hemi-cellulose sugars-xylose and arabinose--into xylitol. At the laboratory scale, the bacteria were kept inside special bio-fermentors and fed a broth of corn fibers or other sources of hemicellulose. They excreted xylitol that was later purified from the broth as a white crystalline powder.

Xylitol has been approved by the US Food and Drug Administration (FDA) in 1963, so it has no known toxic levels. The only discomfort that some sensitive people may notice initially when taking large amounts is mild diarrhoea or slight cramping. Since the body makes xylitol daily, as well as the enzymes to break it down, any discomfort usually disappears within a few days as the body's enzymatic activity adjusts to a higher intake.

Another sweetener aspartame found in thousands of products worldwide, can also be created using genetically modified (GM) bacteria. Monsanto, the largest biotech corporation in the world, uses GM bacteria to produce aspartame in their US production plants. The process in which aspartame is created involves combining an amino acid known as phenylalanine with aspartic acid. The bacteria require aspartame for the sole purpose of producing phenylalanine. Monsanto discovered that through genetically altering the bacteria, phenylalanine could be created much more quickly. They have two strains of bacteria - one is traditionally modified and the other is genetically modified. The genetically modified bacteria have a modified enzyme with one amino acid different.

CONCLUSION

Since the safety and efficacy of genetically modified organisms (GMOs) is still controversial, the best way is to choose natural alternatives such as palm sugar, xylitol or stevia. Thus it can be safely concluded that low calorie sweeteners can make a significant contribution to dental health.

REFERENCES

1. Blackburn, G.L., B.S. Kanders, P.T. Lavin, S.D. Keller and J. Whatley, 1997. The effect of aspartame as part of a multidisciplinary weight-control program on short- and long-term control of body weight [abstract]. Am. J. Clin. Nutr., 65: 409-418.
2. Soffritti, M. and F. Belpoggi, F. Tibaldi, E.D.D. Esposti and M. Lauriola, 2007. Life-Span Exposure to Low Doses of Aspartame Beginning during Prenatal Life Increases Cancer Effects in Rats. Environ Health Perspect, 115: 1293-1297.
3. Soffritti, M., F. Belpoggi, D.D. Esposti and L. Lambertini, 2005. Aspartame induces lymphomas and leukemias in rats. Eur. J. Oncol, 10: 107-116.
4. De la Hunty, A., S. Gibson and M. Ashwell, 2006. A review of the effectiveness of aspartame in helping with weight control. Nutrition Bulletin, 31: 115- 128.
5. Kant, R., 2005. Sweet proteins- Potential replacement for artificial low calorie sweeteners. Nutrition J., 4: 5.
6. Carakostas, M.C., L.L. Curry, A.C. Boileau and D.J. Brusick, 2008. Overview: The history, technical function and safety of rebaudioside A, a naturally occurring steviol glycoside, for use in food and beverages. Food and Chemical Toxicol., 46: S1-S10.

7. Kemp, S.E., 2008. Low calorie sweeteners. Every bit as sweet, but are they safe? 12: 7.
8. Grenby, T.H., 1991. Update on low-calorie sweeteners to benefit dental health. International Dental J., 41: 217-224.
9. Swithers, S.E. and T.L. Davidson, 2007. A Role for Sweet Taste: Calorie Predictive Relations in Energy Regulation. Behavioral Neuroscience, 122: 161-173.
10. Beiswanger, B.B., A.E. Boneta, M.S. Mau, B.P. Katz, H.M. Proskin and G.K. Stookey, 1998. The effect of chewing sugar-free gum after meals on clinical caries incidence. J. Am. Dent. Assoc., 129:1623-6.

Useful Links:

- U.S. Food and Drug Administration. FDA Consumer Magazine. Artificial Sweeteners: No Calories…Sweet!. July-August 2006. http://www.fda.gov/fdac/features/2006/406_sweetners.html
- International Food and Information Council. Facts about Low-Calorie Sweeteners. May 2006. hhttp://www.ifc.org/publications/factsheets/lcsfs.ctm?renderforprint=1
- U.S. Food and Drug Administration. FDA Consumer. Sugar Substitutes: Americans Opt for Sweetness and Lite. November-December 199, Updated February 2006. http://www.csfan.fda.gov/~dms/fdsugar.html
- Nutrition Fact Sheet Polyols: Sweet Benefits J Am Diet Assoc. 108(5): 909-10. 2008.
- Hayes, Catherine, DMD, DMSc. The effect of non-cariogenic sweeteners on the prevention of dental caries: A review of evidence. Harvard School of Dental Medicine. See http://www.lib.umich.edu/dentlib/nihcdc/abstracts/hayes.html
- J. Am. Geriatrics Soc. 2002; 50. See http://www.globalaging.org/health/world/medgum.htm
- How Xylitol-containing Products affect Cariogenic Bacteria. *J. Am. Dent. Assoc*. April 2000.