Review article

Sugar Substitutes - A Dental Perspective

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Abstract

The most acceptable sweetening agent used is sugar (sucrose) and it is considered the "Arch Criminal" in dental caries initiation. For decades, a look out for a substitute for sugar which possess all the characteristics of sugar but without any cariogenic effect has been on. However, at present there is no such substitute which can replace sugar in all aspects, but the cariogenic potential can certainly be reduced by using certain sugar substitutes. Recently, few sugar substitutes were even considered to have antimicrobial property against caries producing microbes in oral cavity.

Introduction

Dental caries is one of the oldest diseases of both prehistoric and modern times. Initiation of the caries disease process is brought about by an interaction between the host tissue, i.e. the tooth, cariogenic microflora and suitable local substrate, i.e., the diet. From time to time, various studies have been carried out to prove the indispensability of each of the contributory factors of caries process. It has been proposed that out of the major contributory factors, even if one is barred, the dental disease process can be restricted.

Gustafsson et al. in 1954, in Vipeholm study, summarized that amongst the dietary components, "sugar" is the major culprit causing dental caries. It was also noticed that refined and sticky carbohydrates are very dangerous to the teeth.[1]

In light of these studies, it was thought that to limit the cariogenic potential, we either need to restrict the consumption of sucrose or replace sucrose with a substitute that provides sweetness but limits the adverse effects. For this reason, various investigators have searched for alternative sweeteners orsugarsubstitutes. One of the oldest sugar substitutes that came into being was xylitol.

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A large number of sugar substitutes are available these days. These can be categorized as artificial or natural, and also as calorigenic or non calorigenic as shown in the table 1.

Review of various available sugar substitutes and their effect on oral ecology

Sorbitol: The phenomenon involved in the preventive nature of sorbitol on caries rate is that most of oral microorganisms lack the enzymatic makeup to utilize sorbitol. The utilization of sorbitol by microorganisms provides them with a substrate that may contribute to their survival, but does not directly contribute to their cariogenicity

A study by Burt BA compared sugar-sweetened gum with sorbitol-sweetened gum and found that sorbitol has low carcinogenicity when it was chewed at least three times per day.[2]

Xylitol: Scheinin and Makinene et al. in 1975 in Finland were the first to report the anti- cariogenic potential of xylitol. In their landmark study, the effects of sucrose, fructose and xylitol were compared for plaque formation, plaque flora and dental caries increment. At the end of two years, the patients in the xylitol group showed a reduction in the incidence of caries, less plaque and lower colony counts of S mutans.

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Isokangas P et al. conducted a study to evaluate that maternal use (in expecting mothers) of xylitol chewing gum can prevent dental caries in their children.[3] The results showed that young children had 70% fewer cavities when their mothers chewed xylitol gum, even though the children themselves did not chew the gum.

Xylitol reduces the proportions of mutans streptococci in plaque through non-specific and specific effects as stated by Maguire A, Rugg-Gunn AJ. [4]

Lycasin: Lycasinhas beenfound to be non-cariogenic from rat experiments. A combination of lycasin and xylitol also has found to have anticariogenic properties.

Palatinit: Some strains of S.mutans, A.israelii, A.viscosus, and L.caesei are able to ferment palatinit in-vitro, lowering the pH to levels less than 5.5. Strains of S.mutans are unable to produce extracellular polysaccharides from palatinit

Sorbose: The experiments of Muhlemann, in 1977 showed that sorbose also reduces dental plaque. The present knowledge, based on results from microbiological studies indicate that sorbose should be taken into consideration as a possible low-cariogenic sugar substitutes. [5]

Palatinose: Palatinose in specific pathogen free (SPF) rats infected with S.mutans or S.sobrinus did not develop dental caries. The rats were fed with 56% palatinose.[6] This palatinose and other sucrose isomers have been found not to be utilized by most oral bacteria. It was found that strains of MS did not ferment palatinose significantly even after 48 hours incubation of the organisms.

Saccharin JM: Saccharin and fluoride in a combination have been shown to cause maximum reduction in dental caries. Tanzer in 1988 compared the combination of saccharin and fluoride on inhibition of dental caries associated with S.mutans in rats to topical fluoride and the use of de-ionized water, wherein better reduction of caries was observed in the saccharin group.[7] Saccharin is pharmacologically inert and is widely used in diet soft drinks, dietetic foods, mouth washes, medicinal preparations and as a sweetener for table use. [8]

Aspartame: Being similar to table sugar and approximately 180 times as sweet as sugar, aspartame is widely used. In a study by Das S et al. in 1991, it was found that in rats that were fed with aspartame alone showed reduction in S.mutans count and dental caries.[9]

Sucralose: Sucralose, marketed as Splenda was first approved for use in Canada in 1991. The non-cariogenic potential of sucralose was demonstrated by Steinberg LM (1995)[10] and Mandel ID, Grotz VL.[11] Steinberg LM (1995).[10] Their study compared the effect ofaqueous solution of sucralose and aqueous solutions of sucrose on in-vivo plaque pH. They concluded that sucralose-based sweeteners may be useful in the dietary management of caries.

Sugar substitutes derived from plant sources[12]

Natural products and sweeteners are easily derived from plant sources and considered to be better than chemically derived sweeteners, as they are free from any chemical mutagen, carcinogen or toxic by-product.

1. **Monellin:** This natural product is derived from thegrape like red berry cluster of serendipity plant indigenous to Africa. It has monellin protein as its active principle, and it is said that the relative sweetness of monellin varies from 800 to 2000 times sweeter than sucrose.

2. **Licorice:**This is a well-known flavouring agent that is obtained from the roots of a small shrub grown in Central Asia and Europe. The roots contain glycyrrhizin, the active sweetener in the form of salts of glycyrrhizin acid. It has excellent foaming, flavouring-reinforcement properties and is used in beverages, desserts, dentifrices and pharmaceutical preparations.

3. **Stevia:** The species Stevia rebaudiana Bertoni, commonly known as sweet leaf, sugarleaf or simply stevia, is widely grown for its sweet leaves. As a sugar substitute, stevia's taste has a slower

onset and longer duration than that of sugar, although some of its extracts may have a bitter or licorice-like aftertaste at high concentrations.

Trade names: Rebiana, truvia

Synthetic or artificial sweeteners

These generally include the non-nutritive/non-caloric sweeteners.

Sugar substitutes, chewing gum and dental caries

Chewing gums are the most widely used sugar substitutes. The use of chewing gum is prevalent among children, teenagers and adults alike. Important defining aspects are the ability to use sugar substitutes in gum manufacture and the prolonged stimulation of a protective flow of saliva. The increased salivary flow enhances the self-cleansing action of saliva and also reduces caries. Xylitol and sorbitol are majorly used sugar substitutes in chewing gum. Xylitol in chewing gum is reported to reduce not only the proportions of mutans streptococci in plaque or saliva, but also the amount of plaque present.

Future prospectives of sugar substitutes

It is an established fact that sugar contributes to formation of dental caries, and to prevent it from occurring, sugar consumption needs to be restricted. Therefore, there is a need to replace dietary sugars with substances which provide sweetness, but lack the cariogenic effects, and hence the search for alternative sweeteners or sugar substitutes.

A large number of sugar substitutes are available in the market and are fast replacing sugars. These are being added to chewing gums, puddings, ice-creams, desserts, fruit spread, soft-drinks and also being used as a table top sweetener.

Sugar substitutes have marked their role in the dental industry also, as they are being frequently used in tooth-pastes, mouthwashes, mouth-fresheners and chewing gums. The future trend also includes introducing sugar substitutes in dental floss and tooth-picks (xyli-floss and xyli-pick available in some countries).

The future prospects are bright for sugar substitutes accounting to the fast pace with which they are replacing natural sugars. However, the use should be within limitation after fully analysing their side-effects.

Classification of sugar substitutes

1. **Classification based on sugar substitute providing calories or not:**

(a) **Caloric/Nutritive sweetener**	(b) **Non-caloric/ Non-nutritive sweetener**
(i) Poly alcohols/sugar alcohols • Xylitol • Sorbitol	(i) Cyclamate
(ii) Hydrogenated starch hydrolysate • Lycasin • Palatinit	(ii) Saccharin
(iii) Coupling sugar • Sorbose • Palatinose	(iii) Aspartame
	(iv) Sucralose
	(v) Neotame

2. **Classification based on sugar substitute providing calories or not:**

Natural (derived from plant origin)	**Artificial**
1. Monellin	1. Aspartame
2. Licorice	2. Saccharin
3. Stevia	3. Sucralose

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