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The Wonders of Xylitol-A Review

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Abstract: ***The irrefutable importance of sugar as the principal dietary substrate that drives the caries process has led to a growing interest in sugar substitutes. Xylitol, a naturally occurring sweetener, is a prime example of the possibilities that the latest generation of sugar substitutes can offer. Xylitol is one of a group of sugar substitutes collectively described as polyols or sugar alcohols, all of which are hydrogenated derivates of fermentable carbohydrates and are classified as "sugar free" ingredients. Clinical trials have proven the role of xylitol in medical and dental field especially in preventing dental caries. Thus, clinicians should consider including xylitol-containing products in their clinical armamentarium for the prevention of tooth decay in high-risk populations.***

Key words: Xylitol, sugar substitutes, caloric/bulk sweeteners, sugar free

I. INTRODUCTION

Dental caries is a bacterial disease in which diet is a major etiologic factor. Given the dominant role that ingestion of sugars plays in caries etiology, caries-control strategies that aim to restrict exposure to sugars have been used for generations. These restrictive strategies often fail because people find them disagreeable. Attempts to quit consuming high amounts of sugar "cold turkey" also fail frequently. Tobacco-use control programs, however, have shown that substitution therapy-replacing a harmful habit with a positive, more culturally acceptable practice can be effective. In dentistry, the application of this principle to a caries-control strategy involves replacing the ingestion of fermentable sugars primarily sucrose with the ingestion of non-fermentable sugar substitutes.[1]

The modern consumer increasingly demands more from than their diet than energy and satiety, as they look to the foods that they eat to provide tangible functional and health benefits. Sugar substitutes offer product developers the opportunity to not only meet, but hopefully to exceed, the expectations of today's better-informed consumer.[2]

A. What is Xylitol?

Xylitol is one of a group of sugar substitutes collectively described as polyols or sugar alcohols, all of which are hydrogenated derivates of fermentable carbohydrates and are classified as "sugar free" ingredients. It is a five-carbon sugar alcohol synthesized from the fibers of many fruits and vegetables, including various berries, plums, lettuce, cauliflower, corn husks, oats, and mushrooms. It can be extracted from corn fibres, birch and coconut shells. About 5-15 grams of xylitol may be formed daily in our body, mostly in the liver cells.[1]

It is metabolized as a carbohydrate by entering the pentose phosphate pathway through the glucoronic acid cycle. Human oral microorganisms and specifically *Streptococcus mutans* do not have the enzymes to utilize xylitol as source of energy for acid production or for synthesis of extracellular polysaccharides.[1]

B. History

Xylitol was discovered almost simultaneously by German and French chemist way back in the late 19th century. In the Soviet Union it has been used for decades as a sweetener for diabetics and in Germany in solutions for intravenous feeding. In China, xylitol has been used for various medical purposes. The dental significance of xylitol was "discovered" in Finland in the early 70's, when scientists at Turku University showed it could prevent caries. Xylitol-Jenkki, the first xylitol chewing gum in the world, was launched by the Finnish company Leaf in 1975.[3]

C. Properties

Xylitol is known as a highly versatile bulk sweetener, with a distinctive combination of functional, organoleptic and health benefits. It is as sweet as sucrose, and has a natural, refreshing cooling effect that can be used to enhance the impact and freshness of most flavour systems.

Organoleptic & Functional Properties	Health Benefits
Intense Natural Cooling Effect	Sugar Free
Equal Sweetness to Sucrose	40% Less Calories Than Sucrose
High Solubility	Low Glycaemic Index (8)
Exceptional Taste Masking Properties	Suitable for Carbohydrate Reduced Diets
Excellent Stability Profile	Non-Cariogenic
Low Water Activity	Cariostatic

II. ROLE OF XYLITOL IN HEALTH

A. Xylitol and Mutans Streptococci

Mutans streptococci (MS), in particular Streptococcus mutans and Streptococcus sobrinus, are considered to be closely associated with dental caries.MS synthesize water-insoluble glucans from sucrose that mediate irreversible adhesion and colonization the teeth. They also produce large amounts of acid, which is involved in tooth demineralization. Another interesting property is that the acid tolerance of these kinds of bacteria is extremely high, thus allowing colonization and persistence under cariogenic conditions.[4]

Microorganisms do not readily metabolize xylitol into energy sources, and its consumption has a minimal effect on plaque pH. Xylitol, however, is absorbed and accumulates intracellularly in S. mutans. Xylitol competes with sucrose for its cell-wall transporter and its intracellular metabolic processes. Unlike the metabolism of sucrose, which produces energy and promotes bacterial growth, S mutans expends energy to break down the accumulated xylitol without yielding energy in return.[4]

Results from biochemical studies suggested that xylitol is transported via the fructose-PTS of S. mutans and the xylitol-5-phosphate created by this pathway is not metabolised. It was believed that the xylitol-5-phosphate may have undergone eventual dephosphorylation and was perhaps exported at the expense of ribitol-5-phosphate. This is the so-called xylitol futile cycle.[5]

In addition, xylitol has a number of other effects on S. mutans that may account for some of its clinical effects in caries reduction. Short-term consumption of xylitol is associated with decreased S mutans levels in both saliva and plaque. Long-term habitual consumption of xylitol appears to have a selective effect on S. mutans strains. This results in selection for populations that are less virulent and less capable of adhering to tooth surfaces and, thus, are shed more easily from plaque into saliva.[6,7]

B. Xylitol and Saliva

In terms of dental health, it is good to increase the salivary flow rate as often as possible, i.e. to secrete what is called stimulated saliva. The faster the saliva flow, the greater its buffer capacity, that is, its power of resisting the drops in saliva pH and thus in plaque pH.[8]

Aside from the physical removal of plaque and food debris, which assists in the cleansing of dental occlusal surfaces, the use of chewing gum also increases salivary flow rate and enhances the protective properties of saliva. This is because the concentration of bicarbonate and phosphate is higher in stimulated saliva, and the resultant increase in plaque pH and salivary buffering capacity prevents demineralization of tooth structure. Moreover, the higher concentration of calcium, phosphate, and hydroxyl ions in such saliva also enhances remineralization.[8]

C. Xylitol Reduces Plaque

Xylitol has a clear inhibitory effect on the formation of the experimental biofilms. The growth of Fusobacterium nucleatum and Porphyromonas gingivalis was inhibited in the presence of xylitol. Thus, it confirms the relevance of the use of the polyp for the prevention of oral diseases caused by dental plaque.

Several studies have demonstrated that the consumption of xylitol significantly inhibits the growth of plaque, and with regular consumption, can even reduce overall plaque levels. Xylitol also reduces the proportion of insoluble polysaccharides found in plaque (the adhesive macromolecules that bind the plaque matrix together, and to the surface of the teeth) with a commensurate increase in the proportion of soluble polysaccharides. The resultant plaque is less adhesive, and it is hypothesised that this facilitates its easier removal during brushing and even by the natural washing action of saliva.[9]

D. Xylitol Offers Third Party Decay Protection

A recent study has shown that xylitol can exert positive effects on the dental health of young children, via the maternal consumption of xylitol-sweetened chewing gum. This remarkable study revealed that if the mothers of newborn children consumed xylitol sweetened chewing gum 4 to 5 times per day for the first two years of the child's life, the child exhibited significantly lower oral colonisation by Mutans Streptococci at the age of two, compared to children whose mothers had not consumed xylitol.[10]

Perhaps more significant, is the fact that these children went on to develop over 70% less tooth decay by the age of five years, than the children of mothers who did not receive xylitol. This outstanding result supports the widely accepted theory that oral colonisation by Mutans Streptococci is a reliable indicator of future tooth decay experience, with children who are colonised earlier in life typically exhibiting far higher levels of tooth decay than children who are colonised later in life or not at all.[10,11]

The mechanism of xylitol's effect in this instance again appears to be its specific effects against the Mutans Streptococci, and in particular its effect in reducing the ability of these bacteria to adhere to the teeth. As the bacteria are passed from mothers to their children through every day contact, the mothers who had been consuming xylitol passed on Mutans Streptococci with reduced adhesion characteristics, which were far less effective in colonising the mouth of the child than the "normal" Mutans Streptococci harboured by the mothers who had not consumed xylitol.[12]

E. Ear Infection

One large double-blind, placebo-controlled trial of 857 children investigated how well xylitol (in chewing gum, syrup, and lozenges) could prevent ear infections. The gum was most effective, reducing the risk of developing ear infections by a full 40%. [13]

F. Osteoporosis / Bone Health (Resorption)

Studies have shown that dietary xylitol supplementation diminishes bone resorption in rats, as well as protects against ovariectomy-induced increase of bone resorption during experimental osteoporosis. 10% xylitol combined with 10% ethanol seems to be more effective on diminishing bone resorption and to increase bone mineral density and content in rats.[14]

G. Skin Health / Aging

Dietary xylitol has been shown to increase the amounts of newly synthesized collagen, and to decrease fluorescence of the collagenase- soluble fraction in the skin of both healthy and diabetic rats. As in diabetic rats, a decreased rate of collagen synthesis and increased collagen fluorescence has also been detected in the skin of aged rats.[15,16]

III. XYLITOL DOSE AND FREQUENCY FOR EFFECTIVENESS

Prospective studies at the University of Washington confirmed previous observations and retrospective studies and provide adequate evidence that:

A. The effective daily xylitol dose range is 6 to 10 grams;
B. The effective frequency of consumption is 3 to 5 times per day; and
C. The effectiveness is greater at higher frequency of consumption as well as with a higher dose of xylitol.

There appears to be a ceiling effect, however, where effectiveness is not enhanced for xylitol dose beyond 10 grams per day.[7]

IV. XYLITOL SIDE-EFFECTS

Xylitol appears to be safe. Limited xylitol side effects have been reported. In general inhalation of aerosolized iso-osmotic xylitol is well-tolerated by naive and atopic mice, and by healthy human volunteers. However, overdose of xylitol may cause serious side effects such as stomach discomfort, diarrhoea, oral erosive eczema or even acute renal failure. Infusion of xylitol may cause renal oxalosis.[17] Oral consumption of a large quantity of xylitol-containing gum was found to induce severe hypoglycemia, collapse and seizures in a 9 month old neutered male Labrador Retriever. In dogs, xylitol is a strong promoter of insulin release and can cause severe hypoglycemia with ataxia, collapse and seizures. In humans, xylitol has little to no effect on plasma insulin or glucose levels.[17]

V. CONCLUSION

In the face of the continuing high rate of caries in some populations in the presence of current dental caries prevention modalities, xylitol offers a potent tool that can have a significant impact. The evidence is sufficient for clinicians to consider including xylitol -

containing products in their clinical armamentarium for the prevention of tooth decay in high-risk populations. Clinicians, consumers, and dental public health agencies should advocate for:

A. Clear labeling of the xylitol content in products to help consumers make well-informed decisions when using these products for the prevention of tooth decay; and

B. Clear recommendations of efficacious dose and frequency of xylitol use.

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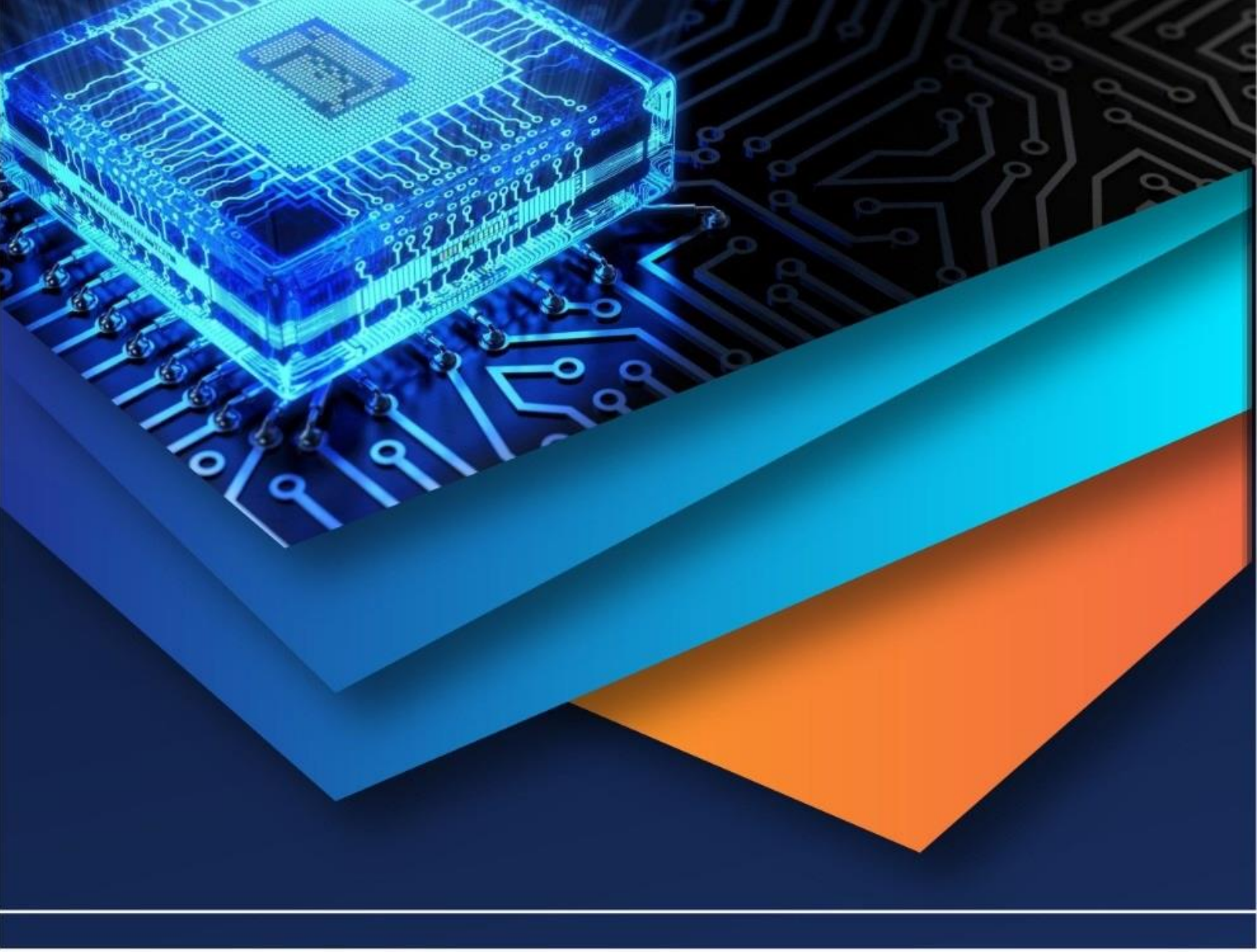

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