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Xylitol and Other Sugar Substitutes in Caries Prevention: A Narrative Review

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ABSTRACT

Dental caries remains the most prevalent chronic disease affecting children worldwide despite significant advances in preventive dentistry. Frequent consumption of fermentable carbohydrates is a major etiological factor in caries development, highlighting the importance of dietary interventions in caries prevention. Sugar substitutes have emerged as valuable alternatives to sucrose because they provide sweetness with little or no cariogenic potential. Among these, xylitol has been the most extensively investigated and has demonstrated the ability to inhibit cariogenic bacteria, reduce plaque accumulation, stimulate salivary flow, and promote enamel remineralization. Other sugar substitutes, including sorbitol, erythritol, mannitol, maltitol, isomalt, and stevia, also exhibit varying degrees of anticariogenic potential. This narrative review summarizes the current evidence regarding the classification, mechanisms of action, clinical effectiveness, safety, and pediatric applications of xylitol and other sugar substitutes. Although xylitol remains the most evidence-based sugar substitute for caries prevention, emerging evidence suggests that erythritol may also provide promising benefits. Sugar substitutes should be considered adjuncts to fluoride therapy, dietary counseling, and effective oral hygiene rather than replacements for established preventive strategies. Further high-quality clinical research is required to establish standardized recommendations for their routine use in pediatric dentistry.

Keywords: Xylitol; Sugar substitutes; Polyols; Dental caries; Early childhood caries; Pediatric dentistry; Caries prevention.

INTRODUCTION

Dental caries is a chronic, biofilm-mediated disease caused by the interaction of cariogenic microorganisms, fermentable carbohydrates, susceptible tooth surfaces, saliva, and host-related factors over time [1]. Despite being largely preventable, it remains the most common chronic disease affecting children worldwide and continues to pose a major public health challenge [2,3]. Untreated dental caries adversely affects nutrition, speech, growth, school performance, and quality of life while imposing considerable economic and healthcare burdens [3].

Early Childhood Caries (ECC) is defined as the presence of one or more decayed, missing due to caries, or filled tooth surfaces in any primary tooth in children younger than six years of age [4]. Children with ECC frequently experience pain, infection, impaired mastication, sleep disturbances, and increased risk of developing caries in the permanent dentition [4,5].

Frequent consumption of free sugars is one of the most important modifiable risk factors for dental caries. Oral bacteria, particularly Streptococcus mutans and lactobacilli, metabolize fermentable carbohydrates to produce organic acids that lower plaque pH below the critical level required for enamel dissolution [1,6]. Repeated acid attacks shift the balance toward demineralization, eventually resulting in cavitated lesions.

Recognizing the harmful effects of excessive sugar intake, the World Health Organization (WHO) recommends limiting free sugar consumption to less than 10% of total daily energy intake and preferably below 5% for additional oral health benefits [7]. However, maintaining these dietary recommendations is challenging, particularly among children because sweetened foods and beverages are widely consumed. Consequently, considerable attention has been directed toward sugar substitutes that provide sweetness without promoting dental caries.

Sugar substitutes are broadly classified into sugar alcohols (polyols) and high-intensity sweeteners. Polyols include xylitol, sorbitol, erythritol, mannitol, maltitol, and isomalt, whereas stevia, sucralose, saccharin, and aspartame are common high-intensity sweeteners [8]. Unlike sucrose, these compounds are poorly metabolized or not metabolized by oral bacteria, resulting in little or no acid production within dental plaque [9].

Among all sugar substitutes, xylitol has received the greatest scientific attention because of its unique biological properties. Besides replacing fermentable sugars, xylitol directly inhibits the growth and metabolism of S. mutans, decreases plaque accumulation, stimulates salivary flow, and promotes enamel remineralization [10]. More recently, erythritol has also demonstrated promising anticariogenic properties, whereas evidence for other sugar substitutes remains comparatively limited [11].

This review summarizes the current evidence regarding xylitol and other sugar substitutes in caries prevention, with particular emphasis on their role in pediatric dentistry.

DENTAL CARIES AND THE ROLE OF DIETARY SUGARS

Dental caries develops through repeated cycles of demineralization and remineralization. According to the ecological plaque hypothesis, frequent exposure to dietary sugars alters the composition of the dental biofilm, favoring acidogenic and aciduric microorganisms that thrive in acidic environments [12]. This ecological shift promotes the progression of dental caries rather than the presence of a single pathogenic microorganism.

Dental plaque is a structured microbial biofilm containing bacteria embedded in an extracellular matrix. Among its microbial inhabitants, Streptococcus mutans plays a central role because of its ability to metabolize sugars rapidly, produce organic acids, synthesize extracellular polysaccharides, and survive at low pH [6]. Lactobacillus species further contribute to lesion progression because of their highly acidogenic nature.

Sucrose is considered the most cariogenic dietary carbohydrate because it not only serves as a substrate for acid production but also supports the synthesis of extracellular glucans that enhance bacterial adhesion and plaque formation [13]. Following sugar consumption, bacterial metabolism rapidly produces lactic and other organic acids, reducing plaque pH below the critical threshold of approximately 5.5 for enamel [1]. Repeated episodes of acid production eventually result in irreversible mineral loss and cavitation.

The Stephan curve illustrates the rapid fall in plaque pH immediately after sugar intake followed by gradual recovery through salivary buffering [14]. Frequent sugar consumption prolongs the time during which plaque pH remains below the critical level, making the frequency of sugar intake more important than the total quantity consumed.

Extensive epidemiological evidence demonstrates a strong relationship between frequent sugar consumption and caries prevalence in children [15]. Sticky snacks, sugar-sweetened beverages, and bedtime feeding with sugary liquids further increase caries risk because they prolong bacterial acid production.

Replacing fermentable sugars with non-cariogenic sweeteners represents an important preventive strategy. Most sugar substitutes are not fermented by cariogenic bacteria and therefore do not produce sufficient acid to initiate enamel demineralization [9]. In addition, xylitol exerts direct antimicrobial effects, making it particularly valuable in preventive dentistry.

CLASSIFICATION OF SUGAR SUBSTITUTES

Sugar substitutes are divided into bulk sweeteners (polyols) and high-intensity sweeteners according to their chemical structure and sweetening properties [8].

Sugar Alcohols (Polyols)

Polyols are hydrogenated carbohydrates that provide sweetness with lower caloric value than sucrose. The principal polyols include xylitol, sorbitol, erythritol, mannitol, maltitol, and isomalt [8].

These compounds are metabolized slowly or incompletely by oral microorganisms and therefore produce little acid within dental plaque. Consequently, they are regarded as tooth-friendly sweeteners and are widely incorporated into sugar-free chewing gums, confectionery, pharmaceuticals, and oral healthcare products [9].

Among them, xylitol has demonstrated the strongest anticariogenic properties because it directly interferes with bacterial metabolism in addition to replacing dietary sugars [10].

Sorbitol is considerably less cariogenic than sucrose but may be slowly fermented by adapted oral microorganisms following prolonged exposure [16]. Erythritol has recently gained attention because it is not fermented by oral bacteria, possesses excellent gastrointestinal tolerance, and has shown promising clinical results in reducing plaque accumulation and caries progression [11].

Mannitol, maltitol, and isomalt also exhibit low cariogenicity but have been evaluated less extensively in clinical studies.

High-Intensity Sweeteners

High-intensity sweeteners include stevia, sucralose, saccharin, aspartame, and acesulfame potassium [8]. These compounds are several hundred times sweeter than sucrose and are therefore used in very small quantities. They are not metabolized by oral bacteria and consequently do not contribute to acid production or enamel demineralization.

Unlike xylitol, however, they possess little evidence of direct antibacterial or plaque-modifying activity. Their principal benefit lies in replacing fermentable sugars within foods and beverages.

XYLITOL: CHEMISTRY, MECHANISMS OF ACTION AND CLINICAL EVIDENCE

Xylitol is a naturally occurring five-carbon sugar alcohol (pentitol) found in small quantities in fruits, vegetables, and hardwood trees such as birch [10]. It has sweetness comparable to sucrose but provides fewer calories and produces a cooling sensation when dissolved. Unlike fermentable sugars, xylitol is not readily metabolized by oral microorganisms and therefore does not contribute to acid production within dental plaque [10].

The anticariogenic effect of xylitol extends beyond simple sugar replacement. Streptococcus mutans transports xylitol into the bacterial cell through the phosphoenolpyruvate-dependent phosphotransferase system, where it is converted to xylitol-5-phosphate. Since this metabolite cannot be utilized efficiently, it is expelled from the cell, resulting in a futile metabolic cycle that consumes bacterial energy, inhibits growth, and reduces acid production [17]. Consequently, regular xylitol exposure lowers salivary and plaque S. mutans levels, reduces bacterial adhesion, and decreases plaque accumulation [18].

Xylitol also stimulates salivary flow, particularly when administered as chewing gum. Increased salivary secretion enhances buffering capacity, facilitates acid clearance, supplies calcium and phosphate ions for remineralization, and promotes recovery of plaque pH following carbohydrate consumption [14]. Together, these effects create a less favorable environment for cariogenic microorganisms while supporting enamel repair.

Clinical evidence supporting xylitol is substantial. Early studies, including the Turku Sugar Studies, demonstrated significantly lower caries incidence among individuals consuming xylitol instead of sucrose [19]. Subsequent randomized controlled trials have shown that regular use of xylitol-containing chewing gum, lozenges, and syrups reduces S. mutans counts and lowers caries experience, particularly in children at high caries risk [20]. Maternal xylitol use has also been associated with reduced transmission of S. mutans to infants, thereby delaying bacterial colonization and decreasing the risk of Early Childhood Caries [21].

Systematic reviews generally conclude that xylitol has beneficial effects on plaque microbiology and may contribute to caries reduction. However, they also note variability in study quality, dosage, fluoride exposure, and patient compliance, emphasizing the need for further well-designed randomized clinical trials [22]. Nevertheless, xylitol remains the most evidence-based sugar substitute currently available for caries prevention.

OTHER SUGAR SUBSTITUTES

Although xylitol has the strongest scientific support, several other sugar substitutes contribute to caries prevention by replacing fermentable sugars.

Sorbitol is one of the most commonly used sugar alcohols in chewing gums, toothpastes, and pharmaceutical syrups. It is considerably less cariogenic than sucrose because it is metabolized slowly by oral bacteria. However, certain strains of S. mutans can gradually adapt to ferment sorbitol after prolonged exposure, making it less effective than xylitol [16].
Erythritol has emerged as a promising alternative. This four-carbon sugar alcohol is almost completely absorbed in the small intestine and excreted unchanged in urine, resulting in excellent gastrointestinal tolerance [11]. Oral bacteria are unable to ferment erythritol effectively, and laboratory studies demonstrate reduced bacterial growth, decreased plaque formation, and lower acid production. Long-term clinical studies have also reported reductions in plaque weight, S. mutans levels, and caries progression among children consuming erythritol-containing products [23]. Although the

evidence base is smaller than that for xylitol, erythritol appears to be one of the most promising emerging non-cariogenic sweeteners.

Mannitol, maltitol, and isomalt are also regarded as low-cariogenic polyols because they are metabolized slowly by oral bacteria and produce little acid within dental plaque [8]. However, evidence demonstrating direct anticariogenic effects is limited, and their primary benefit lies in replacing dietary sucrose.

Among high-intensity sweeteners, stevia has attracted increasing interest because of its natural origin. Experimental studies suggest that stevia may inhibit the growth of S. mutans and reduce bacterial adhesion, although clinical evidence remains insufficient to confirm a significant anticaries effect [24].

Other artificial sweeteners, including sucralose, aspartame, saccharin, and acesulfame potassium, are not fermented by oral microorganisms and therefore do not contribute to enamel demineralization [8]. Their principal benefit is indirect, arising from the replacement of dietary sugars rather than direct modification of the oral microbiome.

Overall, available evidence indicates that replacing sucrose with any non-cariogenic sweetener reduces cariogenic challenge. However, xylitol remains the preferred option because of its demonstrated antimicrobial activity, while erythritol appears to be a promising alternative deserving further investigation.

CLINICAL APPLICATIONS IN PEDIATRIC DENTISTRY

Sugar substitutes are increasingly incorporated into comprehensive caries prevention programs in pediatric dentistry. Their principal role is to reduce children's exposure to fermentable sugars while maintaining acceptable taste and improving compliance with preventive measures [15].

Xylitol chewing gum is the most extensively studied delivery system. Chewing stimulates salivary flow, increasing buffering capacity, acid clearance, and remineralization, while xylitol simultaneously suppresses S. mutans metabolism [20]. Regular use after meals has been associated with reduced plaque accumulation and lower caries incidence in school-aged children. However, chewing gum is unsuitable for very young children because of choking risk.

For preschool children, xylitol syrups provide a safer alternative. Clinical studies have shown reductions in S. mutans colonization and Early Childhood Caries following regular use [20]. Xylitol is also incorporated into fluoride toothpastes, mouth rinses, lozenges, oral wipes, and sugar-free confectionery, providing additional preventive support, although evidence for some delivery systems remains less robust than for chewing gum.

Sugar substitutes also play an important role in dietary counseling. Pediatric dentists should encourage families to replace sugar-sweetened beverages, confectionery, and long-term sucrose-containing medications with sugar-free alternatives whenever appropriate [15]. Such substitutions reduce cariogenic exposure while allowing children to maintain acceptable dietary habits.

Children receiving long-term medications deserve particular attention because many pediatric syrups contain sucrose. Where possible, sugar-free formulations should be recommended to minimize medication-associated caries risk [25].
Overall, sugar substitutes should be regarded as adjunctive preventive agents that complement fluoride therapy, dietary counseling, effective plaque control, fissure sealants, and regular dental care rather than replacing these established preventive measures.

SAFETY AND LIMITATIONS

Sugar substitutes have been extensively evaluated for safety and are generally recognized as safe when consumed within recommended limits [26]. Their widespread use in foods, beverages, pharmaceuticals, and oral healthcare products reflects decades of toxicological evaluation and clinical experience. In pediatric dentistry, they are considered safe adjuncts to preventive care when used in age-appropriate forms and under parental supervision.

Among sugar alcohols, xylitol has one of the best-established safety profiles. Clinical studies have shown no evidence of carcinogenicity, mutagenicity, or significant systemic toxicity in humans [10]. However, excessive consumption of polyols may produce gastrointestinal symptoms such as bloating, flatulence, abdominal discomfort, and osmotic diarrhea because they are incompletely absorbed in the small intestine [26]. These effects are usually mild, dose dependent, and diminish with regular consumption.

Erythritol demonstrates the best gastrointestinal tolerance among polyols because it is almost completely absorbed in the small intestine and excreted unchanged in the urine, resulting in minimal colonic fermentation [11]. Sorbitol, mannitol, maltitol, and isomalt are more likely to cause gastrointestinal symptoms when consumed in large quantities [8].

High-intensity sweeteners, including stevia, sucralose, aspartame, saccharin, and acesulfame potassium, have also been evaluated extensively by international regulatory agencies and are considered safe within their established acceptable daily intake (ADI) levels [26].

An important safety consideration is that xylitol is highly toxic to dogs, causing profound hypoglycemia and, in severe cases, acute liver failure. Although this toxicity is species-specific and does not occur in humans, parents should be advised to keep xylitol-containing products away from household pets [26].

Despite their advantages, sugar substitutes have several limitations. Their effectiveness depends on regular use and patient compliance, and the concentration of active ingredients varies considerably among commercial products. Furthermore, although xylitol has substantial clinical evidence supporting its anticariogenic effects, evidence for many other sugar substitutes remains limited. Most importantly, sugar substitutes cannot replace comprehensive preventive measures such as fluoride exposure, effective oral hygiene, dietary modification, and regular dental visits [15].

FUTURE PERSPECTIVES

Research on sugar substitutes continues to evolve with advances in preventive dentistry, oral microbiology, and food science. While xylitol remains the gold standard, newer compounds such as erythritol have shown encouraging results and warrant further investigation [11].

Future studies should focus on developing sugar substitutes with stronger antimicrobial activity, improved taste, better patient acceptance, and enhanced clinical effectiveness. Advances in oral microbiome research may facilitate the development of sweeteners capable of selectively suppressing cariogenic bacteria while preserving beneficial microbial communities [12].

Another promising area is the development of novel delivery systems, including sustained-release varnishes, bioadhesive films, controlled-release chewing gums, biodegradable patches, and restorative materials capable of gradually releasing xylitol or other anticariogenic agents. Such technologies could improve patient compliance and prolong therapeutic effects.

Future research should also investigate combinations of sugar substitutes with established preventive agents such as fluoride, casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), probiotics, and calcium phosphate technologies to determine whether synergistic effects can further reduce caries risk.

Although numerous clinical trials have evaluated xylitol, methodological differences regarding dosage, delivery systems, fluoride exposure, and outcome measures continue to limit direct comparisons among studies [22]. Large, multicenter randomized controlled trials with standardized protocols and long-term follow-up are required to establish evidence-based recommendations for routine clinical use.

From a public health perspective, replacing dietary sugars with non-cariogenic sweeteners may contribute to reducing childhood caries at the population level. However, these interventions should complement broader strategies promoting healthy diets, reduced free sugar intake, fluoride use, and access to preventive dental care.

CONCLUSION

Dental caries remains one of the most prevalent chronic diseases in children, and frequent consumption of fermentable sugars is a major contributor to its development. Replacing dietary sugars with non-cariogenic sweeteners represents an effective adjunctive strategy for reducing cariogenic challenges and supporting comprehensive caries prevention.

Among currently available sugar substitutes, xylitol possesses the strongest scientific evidence supporting its anticariogenic properties. In addition to replacing fermentable sugars, xylitol inhibits Streptococcus mutans, reduces plaque accumulation, decreases acid production, stimulates salivary flow, and promotes enamel remineralization. These unique biological effects distinguish it from most other sweeteners and explain its prominent role in pediatric preventive dentistry.

Other sugar substitutes, including erythritol, sorbitol, mannitol, maltitol, isomalt, and stevia, also demonstrate low cariogenic potential and provide useful alternatives to sucrose. Among these, erythritol appears particularly promising because of its excellent safety profile and encouraging clinical evidence. Nevertheless, further high-quality clinical studies are required to confirm its long-term effectiveness and determine its comparative efficacy with xylitol.

Current evidence indicates that sugar substitutes should not be viewed as stand-alone preventive agents but rather as components of a comprehensive caries prevention program that includes fluoride therapy, twice-daily toothbrushing with fluoridated toothpaste, dietary counseling, fissure sealants where indicated, and regular dental examinations.

When used appropriately, they offer a practical and evidence-based approach to reducing sugar exposure while maintaining patient acceptance, particularly in children at increased risk of dental caries.

Continued research into novel sweeteners, innovative delivery systems, and personalized preventive strategies will further clarify the role of sugar substitutes in pediatric dentistry and may enhance future approaches to caries prevention.

REFERENCES

1. Fejerskov O, Nyvad B, Kidd EAM. Dental Caries: The Disease and Its Clinical Management. 3rd ed. Oxford: Wiley Blackwell; 2015.
2. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, et al. Dental caries. Nat Rev Dis Primers. 2017;3:17030.
3. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. Lancet. 2019;394:249–60.
4. American Academy of Pediatric Dentistry. Policy on early childhood caries. Pediatr Dent. 2023;45(Special Issue):79–82.
5. Tinanoff N, Baez RJ, Diaz Guillory C, Donly KJ, Feldens CA, McGrath C, et al. Early childhood caries epidemiology. Monogr Oral Sci. 2018;27:16–23.
6. Loesche WJ. Role of Streptococcus mutans in human dental decay. Microbiol Rev. 1986;50:353–80.
7. World Health Organization. Guideline: Sugars Intake for Adults and Children. Geneva: WHO; 2015.
8. Grenby TH. Advances in sweeteners and sugar substitutes. Int Dent J. 1991;41:161–9.
9. Hayes C. The effect of non-cariogenic sweeteners on the prevention of dental caries. J Dent Educ. 2001;65:1106–9.
10. Mäkinen KK. Sugar alcohol sweeteners as alternatives to sugar. Int J Dent. 2010;2010:981072.
11. de Cock P, Mäkinen K, Honkala E, Saag M, Kennepohl E, Eapen A. Erythritol is more effective than xylitol and sorbitol in managing oral health endpoints. Int J Dent. 2016;2016:9868421.
12. Marsh PD. Microbial ecology of dental plaque and its significance in health and disease. Adv Dent Res. 1994;8:263–71.
13. Bowen WH, Koo H. Biology of Streptococcus mutans-derived glucosyltransferases. J Dent Res. 2011;90:1277–86.
14. Stephan RM. Changes in hydrogen-ion concentration on tooth surfaces and in carious lesions. J Am Dent Assoc. 1940;27:718–23.
15. American Academy of Pediatric Dentistry. Best Practices: Caries-risk Assessment and Management. Latest edition.
16. Edgar WM. Sugar substitutes, chewing gum and dental caries. Br Dent J. 1998;184:29–32.
17. Trahan L. Xylitol: a review of its action on mutans streptococci. J Dent Res. 1995;74:1027–31.
18. Söderling E. Xylitol, mutans streptococci and dental plaque. Adv Dent Res. 2009;21:74–8.
19. Scheinin A, Mäkinen KK. Turku Sugar Studies. Helsinki: Acta Odontol Scand; 1975.
20. Milgrom P, Ly KA, Rothen M. Xylitol and its vehicles for public health needs. Adv Dent Res. 2009;21:44–7.
21. Isokangas P, Söderling E, Pienihäkkinen K, Alanen P. Occurrence of dental decay after maternal xylitol consumption. J Dent Res. 2000;79:1885–9.
22. Riley P, Moore D, Ahmed F, Sharif MO, Worthington HV. Xylitol-containing products for preventing dental caries. Cochrane Database Syst Rev. 2015;(3):CD010743.
23. Honkala S, Runnel R, Saag M, Olak J, Nõmmela R, Russak S, et al. Effect of erythritol on dental caries. Caries Res. 2014;48:482–90.
24. Gamboa F, Chaves M. Antimicrobial potential of Stevia rebaudiana. J Oral Biosci. 2012;54:203–6.
25. Durward C, Thou T. Dental caries and sugar-containing medicines. N Z Dent J. 1997;93:124–9.
26. European Food Safety Authority. Scientific opinions on the safety of polyols and intense sweeteners. EFSA Journal. Various publications.