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XYLITOL, ERYTHRITOL AS SUCROSE REPLACEMENTS: THEIR EFFECT ON ORAL HEALTH - A NARRATIVE REVIEW

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Abstract

Background: Dental caries is one of the most common chronic diseases worldwide. Sucrose consumption is one of the main causative factors of dental caries due to biofilm acidification, microbial dysbiosis, and enamel demineralization. For this reason, researchers have centered their attention on developing sucrose substitutes with special emphasis on polyols, including xylitol and erythritol, which can reduce cariogenicity without impairing palatability and with additional beneficial qualities.

Aim: This narrative review aims to integrate existing evidence with regard to the mechanism of action, clinical efficacy, and safety usage of xylitol, erythritol, and other sucrose substitutes mentioned in relation to preventing dental caries, maintaining periodontal and overall oral health.

Methods: This narrative review was conducted through structured research of PubMed (2015 - 2025) using keywords related to xylitol, erythritol, oral health, biofilm, dental caries and oral microbiome. Recent clinical trials, in vitro studies, systematic reviews, and mechanistic analyses published the last 10 years were included. Relevant studies were synthesized qualitatively without statistical meta-analyses.

Results: Xylitol demonstrates consistent inhibition effects on Streptococcus mutans, reduced biofilm adhesive properties, and lowered acid production leading to fewer cases of caries and a gradual change in cariogenic oral microbiome. Erythritol is found with similar or better activity levels in most studies, especially with regard to reduced plaque mass, biofilm density, and gingival inflammation. Unlike sucrose, polyols lack the fermentable activity, thereby preventing a lowered pH and subsequent enamel demineralization.

Both compounds are well tolerated, with erythritol exhibiting excellent gastrointestinal safety. Evidence also suggest that there may be a possible relevance to early periodontal changes due to plaque modulating effects.

Conclusions: Sucrose substitutes, especially xylitol and erythritol, have emerged as potential efficacious and biologically credible additions to established prophylactic modalities. Their demonstrated ability to suppress acid forming bacteria, prevent disturbances in oral pH levels, and obstruct the maturation of biofilm formation, makes these substances promising additions to caries prophylaxis and perhaps initial periodontal therapy itself. There is a need for further well-designed clinical studies to establish a precise dosage regimen and comparative efficacy of these substances within established prophylaxis scheme.

Keywords: Xylitol, Erythritol, Sucrose, Caries prevention, Oral microbiome, Sugar substitutes

1. INTRODUCTION

Dental caries remains one of the most widespread chronic conditions worldwide and affects people of all ages. Its development is strongly associated with dietary behaviors, one of the four primary factors contributing to the development of dental caries in the frequent intake of carbohydrates, among which sucrose is considered the most cariogenic. This sugar enhances acid production in dental plaque, supports the maturation of biofilm and promotes a shift in oral microbiota toward highly acidogenic and acid-tolerant bacteria, including Streptococcus mutants [1,2]. As it became clear that standard preventive measures have limitations, attention increasingly turned toward sugar alternatives capable of lowering cariogenic potential without reducing taste acceptability [2].

Among these alternatives, the polyols xylitol and erythritol have gained significant interest due to their anti-cariogenic activity and their ability to influence the oral microbiome. Because their molecular structure resembles that of sucrose, they can be used as sugar replacement in a variety of foods and dental care products, while their metabolic properties prevent oral bacteria from fermenting them, what in short prevents from the drop of ph level and the subsequent demineralization of the tooth's hard tissues [3]. Xsylitol's role in caries prevention is well documented in the literature, whereas erythritol has more recently emerged as a potentially advantageous substitute, offering excellent tolerability and unique effects on the formation and behavior of dental biofilm [4].

The purpose of this narrative review is to integrate current findings concerning sucrose replacements, particularly xylitol and erythritol, and to assess their mechanisms of action, clinical benefits, safety profiles and potential usefulness in preventing both dental caries and periodontal diseases.

2. METHODOLOGY

In this review, narrative review methodology was used to provide a broad spectrum of information about sucrose substitutes and their impact on oral health. Literature searches were conducted using PubMed, including studies published between 2015 and 2025. Search terms included: xylitol, erythritol, sugar alcohol, polyols, sucrose substitutes, oral health, dental caries, oral microbiome and periodontal disease.

Articles were limited to English and Polish languages. Inclusion criteria encompassed randomized controlled trials, in situ studies, in vitro investigations with clinical relevance, observational studies, systematic reviews, and meta-analyses. Exclusion criteria involved studies unrelated to oral health, animal studies lacking translational value, and reports with insufficient methodological details. As a narrative review, formal PRISMA criteria were not applied, instead, emphasis was placed on synthesizing mechanistic insights and clinically relevant findings across diverse study designs

3. RESULTS

Overview of the Evidence Base

Collected evidence demonstrates a consistent pattern: sucrose substitutes, particularly the polyols xylitol and erythritol, exert measurable, biologically meaningful effects on several key determinants of dental caries and periodontal diseases formation. Across randomized controlled trials, in vitro experiments, in situ enamel models and systematic reviews, the same conclusion emerges - polyols interfere with acidogenicity, biofilm maturation and microbial compositions within the oral cavity [1-5].

The strongest body of research concerns xylitol, which has been examined for over three decades. Meta-analyses and long-term clinical studies confirm that habitual xylitol exposure reduces Streptococcus mutans levels and contributes to moderate but significant reduction in caries incidence [1,6]. Erythritol, while supported by more recent pool of studies, shows equally compelling effects and in several domains appears superior to xylitol, especially in terms of early biofilm inhibition and gastrointestinal tolerability [4].

Importantly, nearly all reviewed studies converged on one central mechanism: replacement of fermentable sucrose with non-fermentable polyols disrupts the progressive fall in plaque pH, thereby preventing the onset of acid-driven enamel demineralization [3,4]. This effect is fundamental because low pH is the primary ecological factor driving caries progression.

Types of sucrose substitutes

Sucrose substitutes include several categories of compounds that mimic sweetness while reducing or eliminating cariogenic potential. Among these, sugar alcohols (polyols) are the most extensively studied within dentistry [7]. Xylitol and erythritol ate the primary polyols with well-documented oral health effects.

Xylitol is a five carbon polyol naturally present in some fruits and vegetables. Its sweetness is comparable to sucrose but offers lower caloric content and unique metabolic properties that disrupt bacterial carbohydrate metabolism [8]. Erythritol, a four-carbon polyol produced industrially via fermentation, is nearly calorie free and distinguished by superior digestive tolerance [9].

Other polyols such as sorbitol and mannitol are widely used in sugar free products but are less effective in caries prevention due to partial fermentability by oral bacteria [10]. High intensity sweeteners (e.g, aspartame, sucralose, stevia) provide sweetness without cariogenicity but lack direct antimicrobial or biofilm modulating effects [11].

Mechanism of action

Sugar alcohols such as xylitol and erythritol exert multiple beneficial effects within the oral cavity, primarily due to their unique biochemical properties and their interaction with cariogenic and periodontal bacteria [12]. Unlike sucrose, polyols cannot be efficiently metabolized by S.mutans and related acidogenic microorganisms. As a result, they do not contribute to acid production, thereby maintaining more neutral pH in dental plaque [3].

Xylitol additionally interferes with the intracellular metabolism od S.mutans through the so-called "futile cycle" [13]. Once transported into the bacterial cell via the fructose phosphotransferase system, xylitol is phosphorylated to xylitol-5-phosphate, which cannot be further metabolized. The cell then expels the compound at an energetic cost, ultimately reducing bacterial growth, acid production and adhesion [13].

Erythritol, a smaller four-carbon polyol, appears to display a somewhat different spectrum of activity. In vitro research demonstrates that erythritol can inhibit the formation and maturation of dental biofilm by reducing bacterial cloaggregation and interfering with extracellular polysaccharide (EPS) synthesis [14]. Emerging evidence suggests erythritol may also influence bacteria associated with periodontal disease [15].

Effects on plaque pH, biofilm maturation and demineralization

Frequent sucrose exposure provides the substrate necessary for acidogenic and aciduric bacteria to proliferate, leading to a sustained decrease in plaque pH and a shift in the microbial ecosystem toward cariogenic species. Substituting sucrose with polyols interrupts this cycle. Unlike sucrose, xylitol and erythritol cannot be metabolized into lactic acid, meaning that acidification does not occur despite similar sweetness profiles [3].

The studies by Loimaranta et al. demonstrates that both xylitol and erythritol significantly reduced the rate of real time biofilm formation by S.mutans, resulting in a more stable plaque environment and diminished EPS production [5]. Because extracellular polysaccharides promote biofilm architecture and adhesion, this interference weakens the structural integrity of plaque and lowers its cariogenic potential. In situ studies confirm these laboratory findings.

Next study showed that the addition of xylitol and erythritol to low-fluoride toothpaste significantly reduced enamel demineralization compared with fluoride alone, suggesting synergistic effects between fluoride and polyols [16]. Subsequent studies further revealed that polyols disrupt dual species biofilm formation, especially when combined with sodium trimetaphosphate, indicating a promising future direction for multipurpose formulation [17].

Antimicrobial activity and microbiome modulation

One of the core findings of the chosen studies in that polyols have both direct and indirect impacts on the oral microbiome.

Direct effects include:

- inhibition od S.mutans growth and adherence [1,18]
- reduction of EPS synthesis [19]
- suppression of bacterial cloaggregation within early biofilm layers
- Inhibition of periodontal relevant pathogens such as Porphyromonas gingivalis in erythritol treated environments [20].

Indirect effects result mainly from ecological changes. By preventing the decrease in pH, polyols make the environment less favorable for aciduric species. Since microbial communities adapt to ecological forces, rather than to individual substances, even minor ecological changes can shift the dominant bacterial populations toward less cariogenic profiles.

Several clinical studies demonstrate a reduction in the counts of mutans streptococci in plaque and saliva following daily exposure to xylitol [1,8]. Erythritol has also exhibited significant antimicrobial activity against both experimental biofilms and the viable loads of bacteria established clinically [6]. Taken together, these represent not only metabolic inhibition but also ecological modification and structural disruption of biofilm as the polyols' mechanisms of action.

Xylitol vs. Erythritol - comparative effectiveness

Although xylitol has traditionally been considered the gold standard polyols in dentistry, emerging evidence indicates that erythritol may possess certain advantages.

Table 1. Comparison of both polyols

Feature	Xylitol	Erythritol
Molecular size	5-carbon polyol	4-carbon polyol
Fermentability	Non-fermentable	Non-fermentable
Effect on biofilm	Moderate disruption	Strong disruption [3,4]
GI tolerance	Mild side effects possible at >10g/day	Highly tolerated - absorbed and excreted unchanged [6]
Effect on periodontal pathogens	Mainly indirect	Direct anti-inflammatory and anti-Pg effects [6]

Various head-to-head studies demonstrate that erythritol is more effective than xylitol in reducing plaque weight, bacterial load, biofilm thickness, especially in long-term clinical trials [9]. The small molecular size of erythritol favors diffusion into deeper layers of the biofilm, which explains its greater capacity to destabilize the biofilm structure.

However, the evidence for xylitol remains robust and clinically validated across decades of research, particularly regarding reduction of S.mutans transmission from mother to child and long-term caries prevention in pediatric populations [1,8].

Effects on periodontal tissues

A particularly interesting area of new research involves potential periodontal benefits of polyols. While the strongest periodontal effects are attributed to erythritol, xylitol also plays a supporting part.

ERYTHRITOL: Recent studies illustrate erythritol lowering inflammatory markers, inhibiting cellular senescence in gingival fibroblasts, and virulence of periodontal pathogens [7]. Air polishing with erythritol powder resulted in an improvement in bleeding on probing - BoP, plaque scores and patient comfort compared to traditional powders [10].

XYLITOL: Evidence supporting direct periodontal benefits are weak. However, reduction in plaque mass indirectly contributes to improved gingival health [3,7]. Because plaque accumulation is the main driving force behind gingivitis, it's expected that xylitol would exert its periodontal maintenance through its mechanical and microbiological effects. Taken together, the periodontal data indicate promising but preliminary clinical benefits and further long-term trials are needed.

Safety and tolerability

Polyols are generally considered safe for daily consumption. The main drawback of xylitol is that high doses induce osmotic gastrointestinal distress. In contrast erythritol is absorbed quickly in the small intestine and excreted unchanged in the urine, thus resulting in excellent gastrointestinal tolerance [14].

Neither xylitol or erythritol raises blood glucose levels, hence, both are appropriate for diabetics. The safe profile of the two has been repeatedly validated through toxicological assessments, clinical trials, and regulatory reviews.

Practical implications for clinical dentistry

Based on the reviewed evidence, the following clinical recommendations can be drawn:

- Xylitol gum, 1-2 g per piece, used 3-5 times a day, reduces S.mutans levels [1,8]
- Erythritol lozenges may be preferred for patients with GI sensitivity or orthodontic appliances [6]
- Polyol-enhanced fluoride toothpaste provides improved protection of enamel compered to fluoride alone [16]
- Erythritol powders are suggested for supportive periodontal therapy based on comfort and anti-inflammatory potential [7].
- High risk caries patients are best served by integrated polyol exposure several times a day.

Limitations of the evidence

Despite positive findings, several limitations exist:

- There is considerable heterogeneity between study designs
- Various dosing and delivery methods
- Limited long-term RCTs for erythritol
- Variability in outcome measures: plaque, weight, pH, CFU count, caries incidence
- Reliance on in vitro models, which do not fully replicate oral conditions

4. DISCUSSIONS

The aggregate evidence brought out under this narrative analysis trends to establish the importance of polyol sugars and the role of xylitol and erythritol, in particular, in being key ingredients for a new prevention oriented oral healthcare strategy.

Besides the established anticariogenic effects, these substances have the potential to bring about an influence on other aspects related to oral ecology, giving rise to a favorable microbes-to-tissue ratio, thereby establishing an important shift from the previously exclusive pathogenic concept of prevention in oral healthcare.

From a clinical standpoint, the use of polyols provides a wide array of advantages. This is because these substances can be used in a variety of delivery methods, including chewing gum, lozenges, toothpaste and professional prophylaxis preparations. This helps in providing options in dental care for the patient giving room for flexibility in delivering dental care according to patient-centered approach. Even with a favor safety and tolerance profile, polyols can be accepted better by a wide array of clients, including pediatric and geriatric clients, and those with specific food restrictions, including diabetics.

However, despite these promising findings, a few points must be addressed with caution. There is a substantial variability in the present research carried out with regard to design, dosage regimens, and duration, making it rather difficult to develop clinical practice guidelines based on these aspects. Moreover, the long-term effects in terms of oral microbial variability, compliance rates, and cost-effectiveness have remained untouched in most of these research papers available currently. There is a lack of evidence with regard to the use of polyols in combination with other preventives.

Future research needs to concentrate on conducting longitudinal researches with a view to analyzing clinical outcomes and ecological markers within the oral microbiome. Comparative researchers related to the efficacy of xylitol versus erythritol, dosages, frequency of administration, and synergistic effects in relation to other prevention methods will be essential for incorporating research outcomes into evidence based dental practice.

Xylitol and erythritol appear to be valuable, scientifically supported tools for enhancing oral health, both individually and in combination, due to the proposed beneficial effects on oral microbial homeostasis, cariogenicity reduction, and synergistic effects with other established prevention modalities. With further scientific evaluations aimed at establishing optimal use guidelines, these polyols hold much potential to contribute significantly to the reduction of global oral disease burden and may be a step forward in maintaining and supporting oral health across diverse populations.

5. CONCLUSIONS

The cumulated evidence makes clear the pragmatic and strategic importance of adding polyol-based sucrose replacements, especially xylitol and erythritol, to oral disease prevention regimens. Contrary to the discussion section, where explanatory views and limitations were considered, now we focus on the general implications of these findings for clinical practice and future prevention regimens.

Indeed, polyols represent a form of universally available, safe, and user-friendly intervention, which may be added to existing prevention regimens, such as topical fluoride treatment and professional plaque control, thus providing a multimodal strategy for the prevention of oral disease.

Clinically, the use of xylitol and erythritol is versatile, and targeted treatment can be designed according to specific requirements. Its use in common products such as chewing gum, lozenges and toothpaste increase compliance, and professional products such as air polishing powders containing erythritol can be used for periodontal treatment and prevention. This makes polyols a useful tool for implementing both individual and mass-level treatment because of its potential effects within the scope of public health programs related to a decrease in caries rates and improvement in oral hygiene practices.

Notably, however, available evidence shows the feasibility of polyol-based approaches with minimal harmful effects and high-level tolerance in terms of age and among people with systemic diseases such as diabetes. Thus, with regard to safety and usability, polyols represent viable alternatives for long-term preventives, especially among those who are most at risk or those who lack regular dental care access.

While the preliminary evidence is promising, implementing these approaches into evidence based clinical practice will require additional research. Longitudinal outcomes research concerning compliance and cost effectiveness will be key for defining clinical guidelines and recommendations policies. Moreover, the potential within the investigation of an established approach incorporating polyols with fluoride and mechanical methods may hold promise for enhancing oral outcomes.

In conclusion, xylitol and erythritol can be concluded as efficacious additives for the field of modern day preventative dental care. Implementation of these substances within existing oral hygiene regimens can significantly impact the suppression of caries, improvement of periodontal conditions, and promotion of a stable oral ecosystem. Using these polyols is an effective strategy for maximizing oral healthcare outcomes, especially within a clinical setting due to the required expertise and specific equipment needed by dental professionals.

DISCLOSURE

Author contribution statement

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