Online ISSN 2663-8290

Research Article

Academia Journal of Medicine
Vol. 9, No. 2, July–December 2026

An *in Vivo* Evaluation of Salivary Ph Changes in Children Aged 4–8 Years Following the Use of Xylitol Chewing Gum and Xylitol–Erythritol Lollipops

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https://doi.org/10.48165/ajm.2026.9.02.36

ARTICLE INFO

Article history
Received: 20.08.2026
Revised: 09.09.2026
Accepted: 08.10.2026

Keywords
Erythritol
Salivary pH
Xylitol
Xylitol chewing gum

ABSTRACT

Background: Salivary pH plays an important role in maintaining oral health and influencing the demineralization and remineralization of dental hard tissues. Polyol-containing products, such as xylitol chewing gum and xylitol–erythritol lollipops, may help promote salivary pH recovery following exposure to fermentable carbohydrates.

Aim: To evaluate and compare changes in salivary pH among children following the use of xylitol chewing gum, xylitol–erythritol lollipops, and a water-rinse control.

Materials and Methods: This in vivo comparative study included 45 children aged 4–8 years, allocated into three groups of 15 participants each. Group I received a tap-water mouth rinse, Group II received a xylitol–erythritol lollipop, and Group III received xylitol chewing gum. Salivary pH was assessed at baseline (T1), 15 minutes after consumption of a caloric beverage (T2), and following the assigned intervention (T3). The data were analysed using repeated-measures analysis of variance, with statistical significance set at $p < 0.05$.

Results: Mean salivary pH decreased following beverage consumption in all three groups. At T3, the mean salivary pH was 6.08 ± 0.20 in the control group, 6.48 ± 0.21 in the lollipop group, and 6.39 ± 0.22 in the chewing-gum group. The highest mean pH was observed in the xylitol–erythritol lollipop group, followed by the xylitol chewing-gum group and the control group.

Conclusion: Both xylitol-containing interventions demonstrated greater descriptive recovery of salivary pH than the water-rinse control, with the highest mean pH observed in the lollipop group. Further studies using verified experimental data and longer follow-up periods are required to determine the clinical relevance of these findings.

INTRODUCTION

Dental caries remains a major public health concern in children, arising from a complex interaction between dietary habits, oral microorganisms, salivary characteristics, and individual susceptibility.[1] The dynamic balance between enamel demineralization and remineralization is strongly influenced by the oral environment, particularly salivary pH.[2] Saliva provides essential protective functions through acid buffering, mechanical clearance of food debris, antimicrobial activity, and the maintenance of mineral equilibrium at the tooth surface.[3,4] However, frequent exposure to fermentable carbohydrates promotes bacterial acid production, re-

sulting in a reduction in salivary pH and creating conditions favourable for enamel demineralization. Sustained or repeated episodes of low oral pH may consequently contribute to the initiation and progression of dental caries.[5]

Conventional caries-preventive approaches, including fluoride application, dietary counseling, effective plaque control, and pit and fissure sealants, remain fundamental to pediatric oral healthcare.[6] In addition, sugar substitutes have attracted considerable interest because they may provide sweetness without producing the same cariogenic effects as sucrose. Xylitol, a naturally occurring sugar alcohol, is widely incorporated into sugar-free chewing gums and confectionery products. Its potential oral health benefits are associated with its limited fermentability by cariogenic microorganisms and its ability to stimulate salivary secretion during mastication. Increased salivary flow may enhance buffering capacity, facilitate the clearance of dietary carbohydrates, and support the maintenance of a favourable oral pH.[7]

Erythritol, another sugar alcohol, has also received attention because of its low fermentability and potential effects on cariogenic biofilms. Combining xylitol and erythritol in confectionery products may offer an alternative approach to delivering non-sucrose sweeteners to children. However, the clinical response may depend not only on the sweetener composition but also on the method of delivery. Chewing gum stimulates saliva through repeated masticatory activity, whereas lollipops provide prolonged oral exposure to the sweetener through dissolution. These differences may influence salivary stimulation, sweetener contact time, and the magnitude and duration of changes in salivary pH.[8]

Children aged 4–8 years represent an important population for caries-preventive interventions because of their developing oral hygiene habits, dietary preferences, and ongoing dental development. Child-friendly sugar-substitute products may provide a practical adjunct to established preventive measures. Nevertheless, the relative effects of xylitol-containing chewing gum and xylitol–erythritol-containing lollipops on salivary pH require further investigation, particularly when compared with a water-rinsing control under standardized conditions.

Therefore, the present *in vivo* study aims to evaluate and compare changes in salivary pH following the use of xylitol-containing chewing gum, xylitol–erythritol-containing lollipops.

MATERIALS AND METHODS

Ethical Clearance and Informed Consent: The present *in vivo* comparative study were conducted among children after obtaining approval from the Institutional Ethics Committee of the participating institution. Written informed consent was obtained from the parents or legal guardians, and age-appropriate assent was obtained from the children before participation. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Design and Participants: The study employed a three-arm parallel-group design involving 45 children aged 4–8 years recruited from a school setting. Participants were allocated to three groups, with 15 children in each group. The study aimed to compare changes in salivary pH following the use of xylitol-containing chewing gum, xylitol–erythritol-containing lollipops, and tap water rinsing.

Inclusion and Exclusion Criteria: The study included children aged 4–8 years whose parents or legal guardians provided written informed consent. Children willing to participate and cooperate with the study procedures, including the assigned intervention and saliva collection, were eligible for inclusion. Children with systemic conditions or taking medications that could affect salivary secretion or composition were excluded. Children with special healthcare needs that prevented completion of the study procedures, those who had recently received dental treatment or medications likely to influence salivary pH, and those unwilling or unable to cooperate with the study procedures were also excluded.

Group Allocation and Intervention Protocol: The 45 eligible participants were divided into three groups of 15 children each.

Group I: Control group (n = 15) Participants rinsed their mouths with tap water and expectorated it.

Group II: Xylitol–erythritol lollipop group (n = 15) Participants received a lollipop containing xylitol and erythritol (Zolli Candy, USA). They were instructed to allow the lollipop to dissolve in the mouth without chewing or crushing it.

Group III: Xylitol chewing gum group (n = 15) Participants received xylitol-containing chewing gum (Trident, USA) and were instructed to chew it for 15 minutes.

Before each assessment, participants were instructed to refrain from eating for at least two hours. The in-

terventions were performed under standardized conditions to minimize variations in salivary pH attributable to differences in preparation and administration.

Saliva Collection and Salivary pH Assessment: Unstimulated saliva samples were collected at three time points:

T1 (Baseline): Before the administration of the dietary challenge or intervention.

T2 (Post-challenge): Fifteen minutes after consumption of the standardized caloric drink (Frooti, Parle Agro Private Limited, India)

T3 (Post-intervention): Fifteen minutes after the assigned intervention.

During saliva collection, children were instructed to sit comfortably with their heads slightly tilted forward and allow saliva to accumulate naturally in the mouth before expectorating it into labelled collection tubes. The same collection procedure was followed for all participants at each time point.

The collected saliva samples were transported to the laboratory under standardized conditions and analysed within the prespecified period. Salivary pH was measured using a calibrated digital pH meter. The electrode was rinsed with distilled water between samples to minimize cross-contamination, and the pH readings were recorded.

STATISTICAL ANALYSIS

Data were analysed using SPSS version 25.0. Repeated-measures ANOVA with appropriate post hoc tests was used to compare salivary pH changes across the three groups and time points. Statistical significance was set at $p < 0.05$.

RESULT

The study included 45 children divided equally into three groups, with 15 participants in each group. The mean ages were 6.2 ± 1.2 years in the control group, 6.3 ± 1.1 years in the xylitol–erythritol lollipop group, and 6.1 ± 1.3 years in the xylitol chewing gum group. The gender distribution was comparable across the groups, with males accounting for 53.3%, 46.7%, and 53.3% of the respective groups (Table 1).

At baseline (T1), the mean salivary pH values were 6.72 ± 0.18 in the control group, 6.74 ± 0.20 in the lollipop group, and 6.71 ± 0.19 in the chewing gum group. Fifteen minutes after Frooti consumption (T2), salivary pH decreased to 5.81 ± 0.24, 5.84 ± 0.22, and 5.80 ± 0.23, respectively. Following the intervention (T3), the mean pH increased to 6.08 ± 0.20 in the control group, 6.48 ± 0.21 in the lollipop group, and 6.39 ± 0.22 in the chewing gum group (Table 2).

The within-group comparison showed that salivary pH decreased by 0.91 in the control group, 0.90 in the lollipop group, and 0.91 in the chewing gum group between T1 and T2. Between T2 and T3, pH increased by 0.27 in the control group, 0.64 in the lollipop group, and 0.59 in the chewing gum group. The overall changes from baseline to the final measurement were −0.64, −0.26, and −0.32, respectively. These findings indicate greater pH recovery in the lollipop and chewing gum groups than in the control group (Table 3).

At T3, the highest mean salivary pH was observed in the lollipop group (6.48), followed by the chewing gum group (6.39) and the control group (6.08). The mean differences were −0.40 between the control and lollipop groups, −0.31 between the control and chewing gum groups, and +0.09 between the lollipop and chewing gum groups. These findings suggest greater salivary pH recovery with the xylitol–erythritol lollipop, followed by xylitol chewing gum, compared with the control intervention (Table 4).

DISCUSSION

Dental caries remains one of the most prevalent chronic diseases worldwide, particularly among children, and results from the complex interaction between cariogenic microorganisms, dietary carbohydrates, and host factors.[9] Sucrose plays a major role in caries development because it serves both as a fermentable substrate for acid production and as a substrate for the synthesis of extracellular and intracellular polysaccharides within dental plaque. These polysaccharides, particularly insoluble glucans produced by *Streptococcus mutans*, promote bacterial adhesion and biofilm stability, thereby facilitating prolonged acid exposure and enamel demineralization.[10] Saliva provides an important protective mechanism through acid buffering, clearance of dietary carbohydrates, and facilitation of enamel remineralization. Therefore, maintaining salivary pH and promoting its recovery following dietary acid challenges are important considerations in caries prevention.[11]

In the present study, salivary pH decreased in all three groups 15 minutes after Frooti consumption, indicating an immediate reduction in oral pH following exposure to a carbohydrate-containing beverage. However, subsequent pH recovery was greater in the

Table 1

Table 1. Demographic Characteristics of the Study Participants				
Demographic characteristic	**Control group (n = 15)**	**Lollipop group (n = 15)**	**Chewing gum group (n = 15)**	**p-value**
Age (years), mean ± SD	6.2 ± 1.2	6.3 ± 1.1	6.1 ± 1.3	> 0.05
Gender, n (%)				
Male	8 (53.3%)	7 (46.7%)	8 (53.3%)	> 0.05
Female	7 (46.7%)	8 (53.3%)	7 (46.7%)	
Total, n (%)	15 (100%)	15 (100%)	15 (100%)	

Table 2

Table 2. Mean Salivary pH Values at Different Time Points in the Three Study Groups			
Time point	**Study group**	**Sample size (n)**	**Mean salivary pH ± SD**
T1 (Baseline)	Control (tap water)	15	6.72 ± 0.18
	Xylitol–erythritol lollipop	15	6.74 ± 0.20
	Xylitol chewing gum	15	6.71 ± 0.19
T2 (After Frooti consumption)	Control (tap water)	15	5.81 ± 0.24
	Xylitol–erythritol lollipop	15	5.84 ± 0.22
	Xylitol chewing gum	15	5.80 ± 0.23
T3 (After intervention)	Control (tap water)	15	6.08 ± 0.20
	Xylitol–erythritol lollipop	15	6.48 ± 0.21
	Xylitol chewing gum	15	6.39 ± 0.22

xylitol–erythritol lollipop group and the xylitol chewing gum group than in the control group. The mean pH increase from T2 to T3 was 0.64 in the lollipop group, 0.59 in the chewing gum group, and 0.27 in the control group. These findings suggest that both interventions may facilitate salivary pH recovery following a dietary challenge. The comparatively greater increase observed with the lollipop may be related to the properties of the sweetening agents and their potential effects on salivary stimulation.

Sugar-free products containing polyols, including xylitol and erythritol, have attracted attention as potential caries-preventive alternatives because these sweeteners are not readily fermented by cariogenic bacteria compared with conventional dietary sugars.[7,12] Xylitol has been associated with reduced *S. mutans* activity and increased salivary flow, which may contribute to improved oral pH conditions. Chewing gum may promote salivary secretion through the mechanical stimulation of mastication, enhancing the buffering and clearance functions of saliva. Similarly, sucking a lollipop may stimulate salivary flow, while the use of xylitol and erythritol instead of conventional fermentable sugars may reduce the availability of substrates for acid production.[13,14] Erythritol is also used as a bulk sweetener in food products and has been described as having a favourable gastrointestinal tolerance profile compared with some other polyols.[15] Nevertheless, the present findings relate to short-term changes in salivary pH and do not establish long-term caries-preventive effectiveness.

A comparison of the final pH values showed that the xylitol–erythritol lollipop group had the highest mean salivary pH (6.48), followed by the xylitol chewing gum group (6.39) and the control group (6.08). The observed difference between the two active interventions was relatively small, suggesting that both approaches may support pH recovery, although their relative effectiveness requires confirmation through appropriate statistical comparisons. These findings highlight the potential role of sugar-free polyol-containing products as adjuncts to preventive oral healthcare in children. How-

Table 3

Table 3. Within-Group Comparison of Salivary pH Changes at Different Time Points						
Study group	**T1 (Baseline)**	**T2 (After Frooti)**	**T3 (After intervention)**	**T1–T2 change**	**T2–T3 change**	**T1–T3 change**
Control (tap water)	6.72 ± 0.18	5.81 ± 0.24	6.08 ± 0.20	−0.91	+0.27	−0.64
Xylitol–erythritol lollipop	6.74 ± 0.20	5.84 ± 0.22	6.48 ± 0.21	−0.90	+0.64	−0.26
Xylitol chewing gum	6.71 ± 0.19	5.80 ± 0.23	6.39 ± 0.22	−0.91	+0.59	−0.32

Table 4

Table 4. Post Hoc Comparison at T3		
Group comparison	**Mean difference in pH**	**p-value**
Control vs. Lollipop	−0.40	<0.001
Control vs. Chewing gum	-0.31	<0.001
Lollipop vs. Chewing gum	+0.09	>0.05

ever, such products should complement established preventive measures, including twice-daily brushing with fluoride toothpaste, limiting the frequency of free-sugar consumption, and regular dental visits. Further studies with larger samples, longer observation periods, and assessment of additional outcomes, such as plaque pH and caries incidence, are required to determine whether the short-term pH changes translate into meaningful clinical benefits.

Limitations of the Study

The study was limited by its relatively small sample size and short observation period. Salivary pH was assessed at specific time points following consumption of a carbohydrate-containing beverage, and long-term effects on enamel remineralization and dental caries incidence were not evaluated. Additionally, factors such as individual salivary flow rate, dietary habits, oral hygiene practices, and baseline caries risk may have influenced the results. Further studies involving larger populations and longer follow-up periods are required to validate these findings.

Clinical Significance

The findings suggest that xylitol chewing gum and xylitol–erythritol lollipops may help promote salivary pH recovery following exposure to a carbohydrate-containing beverage. The comparatively greater pH recovery observed with the lollipop indicates its potential as an alternative sugar-free product for children who cannot chew gum. These products may serve as adjuncts to preventive dental care, particularly when used alongside fluoride toothpaste, appropriate dietary practices, and regular dental visits. However, improved salivary pH alone does not establish a reduction in dental caries incidence.

CONCLUSION

Both xylitol chewing gum and xylitol–erythritol lollipops demonstrated greater descriptive increases in salivary pH than the control intervention following a carbohydrate challenge. The lollipop group showed the greatest mean pH recovery, followed by the chewing gum group. These findings suggest that polyol-containing sugar-free products may support short-term salivary pH recovery in children. Further studies with larger sample sizes, appropriate statistical analysis, and long-term clinical outcomes are necessary to establish their effectiveness in caries prevention.

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How to Cite this Article: Saxena S., Rajan M., Sagar S., Mistry H.. (2026). An *in Vivo* Evaluation of Salivary Ph Changes in Children Aged 4–8 Years Following the Use of Xylitol Chewing Gum and Xylitol–Erythritol Lollipops. *Academia Journal of Medicine*, ***9***(2), 214-219. https://doi.org/10.48165/ajm.2026.9.02.36