Original Article

Effects of Stevia and Xylitol Chewing Gums on Salivary Flow Rate, pH, and Taste Acceptance

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Abstract

Context: Stevia is a natural sweetener which is used as a sugar substitute. There is limited research regarding the use of stevia chewing gum and its effect on salivary flow rate and pH. **Aim:** The aim of the study was to assess the effect of stevia and xylitol chewing gums on salivary flow rate, pH, and its taste acceptance. **Setting and Design:** A randomized, triple-blinded, clinical study with a crossover design was conducted. **Subjects and Methods:** Twenty children aged 8–13 years with decayed, missing, and filled teeth index score ≥3 were selected. Pretest unstimulated saliva was collected. The children were divided into two groups, and Stevia and Xylitol gums were provided to each group to chew for 15 min. Salivary samples were collected at 15 min and 1 h. Salivary flow rate and pH were measured at baseline, 15 min, and 1 h. **Statistical Analysis:** The collected data were subjected to statistical analysis using Wilcoxon signed-rank test, and $P \leq 0.05$ was considered statistically significant. **Results:** There was an increase in the salivary flow rate from baseline to 15 min in children provided with stevia and Xylitol chewing gums with $P = 0.003$ and 0.001, respectively, in the trial. In the crossover trial, there was an increase in salivary flow rate from baseline to 15 min in children provided with stevia and Xylitol chewing gums with $P = 0.020$ and 0.001, respectively. There was a reduction in salivary pH from baseline to 15 min in children provided with Xylitol ($P = 0.001$) and 15 min to 1 h in stevia ($P = 0.003$) in the trial. In the crossover trial, there was a reduction in pH from baseline to 15 min ($P = 0.020$) and 15 min to 1 h ($P = 0.003$) in children provided with stevia and Xylitol chewing gums ($P = 0.001$). **Conclusion:** Stevia is equally effective to Xylitol chewing gum in increasing salivary flow rate and salivary pH. Stevia due to its bitter aftertaste is less accepted in children as compared to Xylitol.

Keywords: *Chewing gum, flow rate, pH, stevia, xylitol*

Introduction

Saliva is a mixture of secretions in the oral cavity and is the largest secretion in the human body.[1] One of the most important functions of saliva is clearance of bacteria and food debris from the oral cavity. Unstimulated salivary flow rate is at an average of about 0.3 ml/min.[2] Reduction in salivary flow leads to exacerbation of dental caries. Chewing of food leads to salivary stimulation, which has a positive effect on salivary flow rate and pH.[1] The drop in pH below 5.5 is called critical pH at which the enamel is most susceptible to demineralization.[3]

Xylitol, a sugar alcohol, is used extensively as a sweetening agent in several commercially available chewing gums.[2] There is sufficient evidence supporting the use of xylitol chewing gum to increase salivary flow rate and pH. Hegde and Thakkar[4] reported a significant increase in salivary flow rate and pH after the use of xylitol chewing gum when compared to casein phosphopeptide-amorphous calcium phosphate. Kumar *et al*.[5] reported an increase in salivary pH with xylitol chewing gum when compared to other sugar-free chewing gums.

Stevia is a noncaloric sweetener derived from *Stevia Rebaudiana* plant species, used in patients with diabetes and hypertension.[6,7] It is a subject of dental research as it is a natural substance which treats a variety of ailments with its antibacterial and antifungal properties.[8] Stevia is composed of stevioside; rebaudioside A, D, and E; and dulcoside A and B.[9] It is 100% natural, 200–300 times sweeter than sugar, is heat stable, is nonfermentable, and has antiplaque and anticaries activities.[10] Stevia is available in different forms as table

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sugar, drops, hard candy, and cold drinks but is also added recently in mouth rinse, chewing gum, and toothpaste.[10] Recent research has demonstrated that plant extracts of stevia have bitter aftertaste.[11] The effect of stevia chewing gum on salivary flow rate and pH has not been studied.

Hence, the aim of the present study was to assess salivary flow rate, salivary pH, and taste acceptance in children aged 8–13 years with Decayed, Missing and Filled Teeth (DMFT) score >3 after the use of stevia chewing gum in comparison to Xylitol chewing gum.

Subjects and Methods

A randomized, triple-blind, crossover clinical trial was conducted to evaluate the effect of stevia and xylitol chewing gum on salivary flow rate, pH, and taste acceptance. Dental examination was performed on sixty participants in a residential school in Navi Mumbai, out of which twenty normal healthy controls between the ages of 8 and 13 years with DMFT/dmft >3 were included in the study. Children with DMFT/dmft >3 were included because a higher DMFT results in lower pH levels as compared to no DMFT.[12] We intended to assess possible drop in pH from an existing lower pH. World Health Organization criteria were used for recording caries status.[13] The trial protocol was approved by the university's research committee (Ref no. FRC/2018/Pedo/22). Any participants with special health-care needs, systemic diseases, current or recent use of antibiotics, and undergoing any dental treatment or orthodontic treatment were excluded from this study. Informed written consent was obtained from the participating children, their parents, and school authorities. The sample size was estimated using the following assumptions: alpha error = 5%, beta error = 20%, reading in Group 1 = 4.7377, reading in Group 2 = 4.1537, and common standard deviation = 0.6341. The minimum required total sample size was calculated (http://powerandsamplesize.com/Calculators/Compare-2-Means/2-Sample-Equality) to be 19 (rounded off to 20). The minimum required sample size per group was thus set at 10. The study was conducted between January 2019 and February 2019.

At the start of the clinical trial, the children were instructed not to eat or drink anything 2 h prior to the procedure because pH values are lower for 1–2 h after food consumption.[1] The study samples were divided randomly into two groups, i.e. Group I: stevia-containing chewing gum (Steviadent peppermint-flavored chewing gum) and Group II: Xylitol-containing chewing gum (Trident spearmint-flavored chewing gum). The chewing gums were wrapped in representative color (red and blue for stevia and xylitol, respectively) and were distributed among the children. This randomization procedure was carried out by a secondary assessor, and the results were decoded at the end of the study.

Baseline unstimulated saliva was collected by instructing the children to sit comfortably with eyes open, head tilted slightly forward, and to rest for 5 min to minimize orofacial movements.[14] The spitting method was used to collect saliva.[14] The children were asked to accumulate saliva in the floor of mouth without swallowing for at least 60 s and then to expectorate in a preweighed sterile dispensing cup for 2 min,[14] which was determined gravimetrically.[15] To calculate the weight of the saliva, the containers were weighed before and after gathering saliva, using a digital pocket meter (high-accuracy digital pocket LCD weighing scale). The total volume of the saliva collected was noted and divided by two to obtain the flow rate of saliva in millimeter/minute. One pellet of chewing gum was given to the children in both groups, and they were asked to chew under supervision for a period of 15 min. After 15 min, the chewing gum was discarded. The stimulated saliva was again collected immediately after discarding the chewing gum by the same procedure, and the third salivary sample was collected at an interval of 1 h. The stimulated saliva was also measured for flow rate. The pH was measured with a pocket pH meter (pHep pocket-sized pH meter, Hanna Equipments India Private Limited). The pH was recorded to two decimal places.[4] The children were asked about chewing gum preference after 1 h and were given a questionnaire to answer, which had subjective and objective criteria.[16]

After a washout period of 2 days,[17] the same procedure was repeated by interchanging the group, i.e. Group I: Trident chewing gum and Group II: Steviadent chewing gum.

Statistical analysis

Descriptive statistical analyses were carried out in the present study. Results on continuous measurements were presented as mean ± standard deviation (SD). The level of significance was fixed at $P \leq 0.05$ and was considered to be statistically significant. Based on the results of normality test (Kolmogorov–Smirnov and Shapiro–Wilk test), it was concluded that part of the data was not following the normal distribution, hence nonparametric test was used. Wilcoxon signed-rank test was used to find the significance of the study parameters on a continuous scale between the two groups. The statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data.

Results

The average age of the children was 10.25 years. The average DMFT/dmft was 4.34. Table 1 illustrates intragroup comparison of salivary flow rate for trial and crossover trial. There was a reduction in salivary flow rate from 15 min to 1 h ($P = 0.003$) in the stevia group, while there was an increase in baseline to 15 min ($P = 0.001$) in the xylitol group in the trial. There was an increase in salivary flow rate from baseline to 15 min in the stevia group ($P = 0.001$) and xylitol group ($P = 0.020$),

and a reduction in salivary flow rate was seen from 15 min to 1 h in the stevia group (P = 0.001) and xylitol group (P = 0.003) in the crossover trial.

Table 2 illustrates the intragroup comparison of salivary pH for the trial and crossover trial. There was a reduction in salivary pH seen from 15 min to 1 h (P = 0.003) in the stevia group and baseline to 15 min (P = 0.001) in the xylitol group in the trial group. There was a reduction in salivary pH seen from baseline to 15 min (P = 0.001) and 15 min to 1 h (P = 0.001) in the xylitol group and baseline to 15 min (P = 0.020) and 15 min to 1 h (P = 0.003) in the stevia group.

Table 3 shows intergroup comparison of salivary flow rate where there was no statistically significant difference seen at baseline, 15 min, and 1 h both in the trial and crossover trial. Table 4 shows intergroup comparison of salivary pH where there was no statistically significant difference seen at baseline, 15 min, and 1 h in the trial, while there was lower salivary pH in the xylitol group at 15 min (P = 0.023) and at 1 h (P = 0.005) as compared to the stevia group in the crossover trial.

Table 5 illustrates a comparison of taste acceptance and dryness where there was no statistically significant difference seen in the stevia and xylitol groups in both the trial and crossover trial. Table 6 shows a comparison of burning sensation in the stevia and xylitol groups in the trial and crossover trial. There was a statistically significant difference in the stevia group (P = 0.025) as compared to the xylitol group.

Discussion

Saliva neutralizes pH, thus assisting in demineralization and remineralization process and helping in the removal of bacterial substrates.[2] The use of chewing gums tends to influence the salivary flow rate and pH.

Xylitol is a noncarbohydrate polyol sweetener, predominantly used in chewing gums.[17] It is equivalent in taste to table sugar.[17] It is well established that Xylitol chewing gum increases salivary flow rate and salivary pH.[18,19] Stevia is a natural sweetener which is 200–300 times sweeter than table sugar.[20] It was approved by the FDA as a sugar substitute in 2011.[21] Since its approval, stevia has been used in a range of products including chewing gums. Although sweet, it leaves a bitter aftertaste. Existing analysis of the literature supports the antibacterial role of stevioside on oral bacteria flora.[22-24] However, there is no literature evaluating the effect

Table 1: Intragroup comparison of the salivary flow rate using Bonferroni's *post hoc* analysis

Trial						
	Stevia			Xylitol		
	BL	15 min	1 h	BL	15 min	1 h
BL	-	0.053	1.000	-	<0.001**	0.439
15 min	0.053	-	0.003*	<0.001**	-	0.765
1 h	1.000	0.003*	-	0.439	0.765	-
Crossover trial						
	Xylitol			Stevia		
	BL	15 min	1 h	BL	15 min	1 h
BL	-	<0.001**	0.735	-	0.020*	1.000
15 min	<0.001**	-	<0.001**	0.020*	-	0.003*
1 h	0.735	<0.001**	-	1.000	0.003*	-

*Statistically significant, **Highly significant. BL: Baseline

Table 2: Intragroup comparison of the salivary pH using Bonferroni's *post hoc* analysis

Trial						
	Stevia			Xylitol		
	BL	15 min	1 h	BL	15 min	1 h
BL	-	0.053	1.000	-	<0.001**	0.439
15 min	0.053	-	0.003*	<0.001**	-	0.765
1 h	1.000	0.003*	-	0.439	0.765	-
Crossover trial						
	Xylitol			Stevia		
	BL	15 min	1 h	BL	15 min	1 h
BL	-	<0.001**	0.735	-	0.020*	1.000
15 min	<0.001**	-	<0.001**	0.020*	-	0.003*
1 h	0.735	<0.001**	-	1.000	0.003*	-

*Statistically significant, **Highly significant. BL: Baseline

Table 3: Intergroup comparison of the salivary flow rate in terms of mean±standard deviation at different time intervals among both the groups using unpaired *t*-test in the trial and crossover trials

	Trial					Crossover trial			
	Group	*n*	Mean±SD	*t*	*P*	Group	Mean±SD	*t*	*P*
BL	Stevia	10	0.5917±0.09	0.128	0.900	Xylitol	0.6741±0.07	0.528	0.604
	Xylitol	10	0.5845±0.15			Stevia	0.6478±0.13		
15 min	Stevia	10	0.7060±0.07	0.148	0.884	Xylitol	0.8478±0.07	0.655	0.521
	Xylitol	10	0.6996±0.11			Stevia	0.8220±0.09		
1 h	Stevia	10	0.6148±0.07	1.171	0.257	Xylitol	0.6267±0.07	0.773	0.449
	Xylitol	10	0.6564±0.08			Stevia	0.6601±0.11		

BL: Baseline, SD: Standard deviation

Table 4: Intergroup comparison of the pH values in terms of mean±standard deviation at different time intervals among both the groups using unpaired *t*-test in the trial and crossover trials

	Trial					Crossover trial			
	Group	*n*	Mean±SD	*t*	*P*	Group	Mean±SD	*t*	*P*
BL	Stevia	10	7.380±0.31	1.905	0.073	Xylitol	7.830±0.71	0.708	0.488
	Xylitol	10	7.680±0.39			Stevia	8.010±0.39		
15 min	Stevia	10	7.430±0.26	1.216	0.240	Xylitol	7.640±0.21	2.488	0.023*
	Xylitol	10	7.320±0.11			Stevia	7.830±0.12		
1 h	Stevia	10	7.190±0.08	1.363	0.190	Xylitol	7.230±0.17	3.211	0.005*
	Xylitol	10	7.370±0.40			Stevia	7.440±0.12		

*Denotes highly stastically signifcant values. BL: Baseline, SD: Standard deviation

Table 5: Comparison of the taste acceptance and dryness among both the groups using Chi-square test in the trial and crossover trials

Taste acceptance	Trial		Group	Crossover trial	
	Absent	Present		Absent	Present
Stevia			Xylitol		
Count	8	2		8	2
Percentage within group	80.0	20.0		80	20
Xylitol			Stevia		
Count	9	1		6	4
Percentage within group	90.0	10.0		60	40
χ^2, *P*	0.392, 0.531		χ^2, *P*	0.952, 0.329	
Dryness	**Trial**		**Group**	**Crossover trial**	
	Absent	**Present**		**Absent**	**Present**
Stevia					
Count	7	3	Xylitol	9	1
Percentage within group	70	30		90.0	10.0
Xylitol					
Count	8	2	Stevia	7	3
Percentage within group	80	20		70	30
χ^2, *P*	0.267, 0.606		χ^2, *P*	1.25, 0.264	

BL: Baseline

of stevia chewing gum on salivary flow rate and salivary pH. Hence, we attempted to evaluate the effect of stevia and Xylitol on salivary flow rate, salivary pH, and taste acceptance.

In our study, we selected children between the age group of 8 and 13 years because chewing gum is a well-adopted practice among the preadolescent group.[25] It was conducted in a residential school for girls, thus male students could not be selected. Bansal *et al*.[26] conducted a research on caries prevalence in boys and girls and stated that there is no significant difference in boys and girls at an average age. Children with special health-care needs, systemic diseases, current or recent use of antibiotics, and undergoing any dental or orthodontic treatment were excluded from the study because these conditions may alter the salivary flow rate and pH.[27-29] Because our study was conducted in a residential school, the diet was similar for all the children during the period of investigation, hence, the type of diet could not possibly modify the factors being examined in the present study. The present study adopted a crossover design to eliminate the biological differences between participants in salivary flow rate and chewing habits. A washout period of 2 days prior to the crossover trial was set because the half-life period of Xylitol is 4 h and that of Stevia is 14 h.[17,30] The taste of Xylitol and stevia chewing gums was evaluated in both the groups to determine the taste acceptability. Commercial preparations of chewing gums were used in the present study as they are readily accessible to the general population.

In the present study, the salivary flow rate increased from baseline to 15 min in both groups in the trial and crossover trial, whereas a decrease in flow rate was noted from 15 min to 1 h. The initial increase can be due to gustatory stimulus. After 15 min, there is stimulation of mechanoreceptors,

Table 6: Comparison of the burning sensation among both the groups using Chi-square test in the trial and crossover trials

	Trial		Group	Crossover trial	
	Absent	Present		Absent	Present
Stevia					
Count	3	7	Xylitol	8	2
Percentage within group	30	70		80.0	20.0
Xylitol					
Count	8	2	Stevia	3	7
Percentage within group	80	20		30	70
Total					
Count	11	9	Total	11	9
Percentage within group	55	45		55	45
χ^2, *P*	5.05, 0.025*		χ^2, *P*	5.05, 0.025*	

*Denotes statistically significant

which could lead to decrease in flow rate.[31] Similar results were shown by Karami-Nogourani *et al*.,[19] Vantipalli *et al*.,[31] and Hegde and Thakkar.[4] However, intergroup comparison between the stevia and Xylitol groups did not show any statistically significant difference.

Assessment of salivary pH revealed a drop in pH from baseline to 15 min and 15 min to 1 h in both the groups in the crossover trial. Similar drop in pH of plaque was reported by Wennerholm *et al*.,[32] after the use of chewing gum with a combination of Xylitol and sorbitol when compared with Xylitol alone. Similarly, Burt[33] stated that xylitol–sorbitol mixture was less effective in preventing caries when compared to Xylitol alone. Our study is in contrast to a research conducted by Topitsoglou *et al*.[34] and Dawes and Macpherson,[35] who reported that xylitol–sorbitol mixture had positive effect similar to that of using xylitol alone. Thus, preparations consisting solely of Xylitol and stevia should be researched upon to find their effect on salivary pH.

On assessment of taste acceptability and discoloration, burning sensation was reported in children using stevia chewing gum, which could be due to its bitter taste. However, the overall taste acceptance between both the groups was not statistically significant.

This is the first study evaluating the effect of stevia chewing gum with respect to salivary flow rate and pH. The benefit of stevia is the longer half-life which reduces the number of times it has to be used as compared to Xylitol. The limitation of the present study was that changes in pH and flow rate could not be evaluated till they returned to baseline values because the children were already fasting 2 h prior to the procedure. Hence, further long-term studies with xylitol and stevia alone with larger sample size and longer duration needs to be considered.

Conclusion

From the results of this study, it may be concluded that stevia is equally effective to Xylitol chewing gum in increasing salivary flow rate. A drop in salivary pH was noted after the use of both the chewing gums. Although stevia had burning sensation, the overall taste acceptance was similar to that of Xylitol.

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Conflicts of infterest

There are no conflicts of interest.

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