Effect of Polyol Gums on Salivary *S Mutans* Levels

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The predominant sugar substitutes used in chewing gum are polyols which are low-caloric substances. The polyols most frequently used in chewing gums are sorbitol and xylitol. ***Aim:****The present study assessed the effectiveness of xylitol and sorbitol chewing-gums on levels of* S mutans *in saliva.* ***Method:*** *The study group consisted of 30 normal and healthy males aged between 13-17 years. A pellet of gum (sorbitol or xylitol) was given to each participant after breakfast (8am), lunch (2pm) and dinner (8pm) for the study period of 3 months. On the first day of the study, baseline salivary samples were collected after breakfast from all participants and assessed for* S mutans *levels. At the end of 3 months, salivary samples were collected and processed in a similar manner.* ***Conclusion:*** *Salivary* S mutans *levels showed a significant reduction after the use of xylitol based chewing gum than with sorbitol based chewing gum.*

Keywords: *xylitol, sorbitol,* S mutans*, polyols, chewing gums*
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INTRODUCTION

Dental caries is a chronic, site-specific, carbohydrate-modified, bio film-mediated, infectious disease. It is a significant public health problem for a large segment of society. Dental caries has a multifactorial etiology and is associated with many risk factors. Out of all possible etiological organisms associated with dental caries; the *S mutans* group has captured the greatest interest over the years, even though they are not the only cariogenic species in oral bio films.[1] For people with caries, the dental health team needs to apply strategy beyond restorative procedures. These include dietary modification, enhancing host resistance through the use of various forms of fluoride and sealants. Another strategy is to suppress the levels of *S mutans*. The principle of substitution therapy involves replacing a harmful habit with a positive and more culturally acceptable practice. This can be applied to a caries-control strategy, wherein the ingestion of fermentable sugars, primarily sucrose is replaced with the ingestion of non-fermentable sugar substitutes. Sugared gum is cariogenic, so all gums used in caries-control regimens need to include a non-sugar sweetener.[2]

The predominant sugar substitutes used in chewing gum are polyols and are low-caloric substances. They are sometimes called "sugar alcohols" because their chemical structure is close to that of both sugar and alcohol. It is well-known that polyols do not promote caries because they are metabolized either slowly or not at all in dental plaque. The polyols most frequently used in chewing gums are sorbitol, a hexatol derived from glucose, and xylitol, a pentatol that occurs widely in nature.[2]

Considered as non-cariogenic, xylitol is incorporated as a sweetener in chewing gums and tablets as well as in oral health care products such as dentifrices and mouth rinses. It is a matter of controversy whether the beneficial effect of these polyols in chewing gums is attributed to the sugar-substitute per se or salivary stimulation[3]. Hence the aim of this study was to assess the effectiveness of xylitol and sorbitol chewing-gums on levels of *S mutans* in saliva.

MATERIALS AND METHODS

The study was carried out at a residential school. The study group consisted of 30 normal and healthy males aged between 13–17 years. For inclusion in the study they had to be residents of the home for a period of at least 4 years. The participants followed similar oral hygiene practices and dietary regime. The other inclusion criteria were: children should be non-phenylketonuric, should not be on antibiotic therapy since 4–6 weeks, and have a DMFT score of ≥ 3.

The nature and design of the study was explained to the teachers of the school. Prior verbal and written consent was taken from the school authorities and participation in the

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study was voluntary. Ethical clearance to conduct the study was obtained from the institution's ethical committee review board. Each participant was provided with a new tooth brush at the start of the study in order to limit the chance of reintroducing *S mutans*. They were asked not to have their teeth professionally cleaned during the study period. No attempt was made to analyze the diet nor modify the oral hygiene practices followed by the study group.

The chewing gums were dispensed at the beginning of every month to the teachers, during the scheduled visit. Written instructions for administering and monitoring the use of chewing gums were given to the teachers. A pellet of gum was given to each participant after breakfast (8am), lunch (2pm) and dinner (8pm). The participant gathered in a room for the chewing period, during which they were not allowed to jump or play. They were instructed to chew for 10 minutes, and chewing was supervised by a teacher who ensured proper disposal of the used gum. The teachers were asked to return all the used wrappers and/or unused gums at the next visit in an attempt to verify compliance.

On the first day of the study, baseline salivary samples were collected after breakfast from all participants and assessed for *S mutans* levels. During the first 3 months of the study, a Sorbitol based chewing gum (Orbit, Wrigley India Pvt Ltd, Bangalore, India) was dispensed. At the end of 3 months, salivary samples were collected and processed in a similar manner. In the following 3 months, participants were instructed to abstain from chewing any gum. After this interval of 3 months, saliva was collected from each participant of the same study group and analysed for S mutans levels. This served as a baseline prior to dispensing of the xylitol based chewing gums (Happydent, Perfetti India Ltd, Mumbai, India). In the microbiological laboratory all salivary samples were handled each time in an identical fashion and were processed on the same day of collection. Salivary samples were vortexed, sonicated and 10^{-3} dilutions were prepared and inoculated onto Mitis Salivary Agar plates. The plates were incubated in an sanaerobic chamber at 37ºC for 48 hours, and the CFUs were enumerated.

The data obtained was subjected to statistical analysis using paired t-test and wilcoxin signed rank test.

RESULTS

Salivary *S mutans* levels showed a significant reduction after the use of xylitol based chewing gum (50.2%). With sorbitol chewing gum, a lesser reduction in salivary *S mutans* levels (13.8%) was observed (Table 1).

Table 1. Salivary *S Mutans* Levels Before And After Chewing Xylitol And Sorbitol Based Chewing Gums

Chewing gum	Salivary S mutans level		P value
	Before	After	
Xylitol	28.87±4.57 (18-36)	14.37±3.72 (8-22)	0.0060**
Sorbitol	32.07±3.69 (24-40)	27.63±3.08 (20-32)	
P ≤ 0.01** = is highly significant			

DISCUSSION

Polyol sweeteners, commonly known as sugar alcohols, have been used as substitutes for sucrose and fructose in sugar free food and confectionary products, as well as in pharmaceutical and nutraceutical products.[2] Sugar substitutes replace highly fermentable carbohydrates and thus reduce the frequency of cariogenic impulses.[4]

Both xylitol and sorbitol based gums were assessed for their antimicrobial effect in this study. Although both gums contain polyol sweeteners, it was observed that the effect of the chewing gums on *S mutans* differed. Since the polyol content of the gums was the only variable, it may be concluded that it was not the chewing of gum per se, but rather the selective effect of xylitol that caused the reduction in the numbers of *S mutans*. A Finnish study demonstrated the effectiveness of xylitol in lowering *S mutans* counts in children aged 11 to 12 who chewed xylitol-sweetened gum three times *per* day.[5] In another study, preschool – aged children who chewed xylitol-sweetened gum three times daily for three weeks also showed significant reduction in salivary *S mutans*.[6] Use of chewing gum containing xylitol (a sugar alcohol of the pentitol type) over a 6 month period was associated with a significant reduction in the plaque levels of *S mutans* in a cohort of 5 year old children.[7]

S mutans does not readily metabolize xylitol into energy however; xylitol is absorbed and accumulated intracellulary. Xylitol competes with sucrose for its cell wall transporter and its intracellular metabolic processes. Unlike the metabolism of sucrose, for which net energy is produced and *S mutans* growth is promoted, the metabolic process for xylitol does not yield energy but instead creates a net energy loss.[3] Xylitol is transported and phosphorylated as xylitol 5-phosphate (X5P) by a phosphoenolpyruvate-xylitol phosphotransferase system (PEP-xylitol PTS) into *S mutans* cells in the presence of glucose. X5P inhibits the activity of glycolytic enzyme resulting in the inhibition of acid production and the growth of *S mutans*. In addition, the accumulated X5P is dephosphorylated to xylitol by an intracellular phosphorylase and then xylitol is expelled outside the cells. This phosphorylation- dephosphorylation cycle of xylitol is called a futile cycle, where PEP is wasted. Since PEP is a phosphoryl donor for ATP synthesis and an energy source for PEP-sugar PTS, the existence of the futile cycle can also decrease bacterial growth and acid production.[8]

The end result is *S mutans* cellular death, and a reduction in S.mutans levels. In addition to reducing *S mutans* levels, long term habitual consumption of xylitol appears to have a selective effect on *S mutans* strains, which result in the selection for *S mutans* strains that are able to use xylitol but are less virulent.[3]

Salivary *S mutans* counts drop with consistent use of xylitol-sweetened gum, probably because replacing sucrose with xylitol starves the cariogenic microorganisms.[9-11] Evidence also suggests that consistent use of xylitol-sweetened gum reduces plaque accumulation.[12,13] The concentrations of ammonia and basic amino acids increase when plaque is exposed to xylitol, resulting in neutralization of plaque acids.

Chewing gum is not considered to be a safe practice for small children by the American Academy of Pediatrics because it presents a choking risk.[14] Chewing of gums is discouraged in day care and schools by teachers and school authorities because of concern for classroom disruption and indiscriminate disposal of the chewing gum.[3]

In our study, chewing was performed safely, since the participants gathered in a room during the chewing period and was supervised by the teacher. The compliance of chewing was also excellent. No study participants discontinued chewing and there was no report of refusal to chew or occurrence of side effects.

The main adverse effect associated with consumption of xylitol, as well as with other polyol sweeteners, is osmotic diarrhea, which occurs when xylitol is consumed in quantities four to five times that needed for dental caries prevention.[3]

There is great controversy on the xylitol dosage needed for a microbial and a caries-protective effect. Recently, it has been suggested that 5 to 10g/day of xylitol is needed for the microbial benefits,[15] although other studies showed a positive microbial effect of xylitol at a dose of 3.9g/day[16] and a positive caries clinical effect at a dose as low as 4.3g/day, with 8.5g/day being significantly better.[17] According to Akerblom, children can tolerate daily doses up to 45g.[18]

Xylitol is safe for use in children when it is consumed in quantities appropriate for dental caries prevention.[18,19] In the planning of a caries-prevention program involving the use of xylitol, it would benefit participants if xylitol were introduced slowly and at increasing doses to allow for their bodies to acclimate to the polyol because many people, especially young children, are not accustomed to consuming several grams of xylitol per day. It is also important in the initial phase to monitor young children closely for loose stools or diarrhea, which may lead to dehydration and require that the children undergo hydration therapy.[3]

The oral biologic effects of xylitol support the suggestion that the use of the xylitol gum can be considered a valuable tool in caries prevention.[20] A xylitol chewing gum program may provide an additional method to be used in situations where other preventive methods are difficult to implement. Also, it provides an easy and inexpensive distribution mechanism, since no specific equipment, health care facilities or personnel are needed. It is important to note that chewing of gum can never replace the sound oral hygiene practices of brushing with fluoride toothpaste and flossing.[20]

The cost/benefit ratio of a polyol chewing gum prevention program should be considered.[7] Habitual chewing of xylitol gum may have a long-term preventive effect by reducing the caries risk for several years after habitual chewing has ended.[21]

Demand by consumers and dental professionals for less expensive xylitol-containing products should make it more accessible. Development and distribution of xylitol based products routinely to high risk populations should be seriously debated and implemented.[15]

CONCLUSION

Both polyol chewing gums showed a reduction in salivary *S mutans* levels. Xylitol based chewing gums resulted in a significantly higher reduction in salivary *S mutans* levels in comparison to sorbitol based chewing gums.

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