

## The Effect of Different Chewing Gum on pH of Dental Plaque

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### Abstract

**Objective:** Although the most useful method to reduce mechanical dental plaque is brushing and flossing, but due to the lack of adequate effectiveness achieved by these methods, the use of other methods such as replacing sweeteners, including Xylitol and Sorbitol with sucrose in products such as chewing gums have come into the focus of attention. This research was done aimed at examine the effect of gum types containing Xylitol, Calcium and Xylitol or Sorbitol on dental plaque pH changes.

**Methods:** The study was performed as a randomized, single-blind, cross-over clinical trial on 10 female students with an age range of 20 to 30 years old studying in dental school, Azad University. Plaque pH changes were measured using PH Meter device after taking four types of chewing gums containing Xylitol, Sorbitol, Xylitol+ Calcium, Turpentine and 10% sucrose solution as control in the follow-up periods. To compare pH at any time between different materials, the Cried-mann test was used. For group pair comparison, Wilcoxon-signed rank test and Bone-Serroni-Adjusment test were used.

**Results:** Xylitol had the highest average plaque pH during the period time that pH increase at minute 7 was the maximum, and turpentine had the lowest pH at all moments, which reached to its maximum at minute 2 and showed little change in plaque pH increase up to minute 60. The difference between all four types of materials was significant ( $p < 0.001$ ).

**Conclusion:** The use of chewing gum after drinking sugar syrup caused a significant plaque pH increase within 7 minutes up to the initial normal level that the effect of Xylitol chewing gum was significantly higher than the rest.

**Key words:** Decay, Dental plaque pH, Sorbitol, Sucrose, Sugar free gum, Xylitol.

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### Introduction:

Tooth decay is the most common oral diseases, which is caused by metabolic activity in the microbial plaque reducing the microbial plaque pH. The process that occurs during carbohydrates fermentation by decay-producing bacteria (*Streptococcus mutans*) will lead to enamel dissolution and beginning of dental caries process over the time. As a result, microbial plaque is introduces as one of the main reasons of decay (1).

Currently, the most effective method for removing and inactivating dental plaque is the

use of mechanical methods such as brushing and flossing; however, as such methods do not adequately work efficient in removing bacterial plaque and due to bacterial complex etiology, which play an important role in the formation of microbial plaque followed by periodontal diseases and dental caries, the use of other methods have been discussed (2). One of these methods is to use artificial sweeteners as a replacement for sucrose in products such as chewing gums, which has been examined in several studies. These sweeteners belong to a Polyol family that not only is less used by *Streptococcus mutans* microorganisms (the

bacteria that cause tooth decay) but also has a bacteriostatic effect on them. Among them, Xylitol and Sorbitol have come to consideration more than other sugars (3). Some studies were found that replacing ordinary sugar with Xylitol, in addition to reducing the accumulation of decay-producing bacteria, will reduce their adherence to dental plaque, and thereby, leads to decreased dental caries (4-6). Furthermore, it seems that using acceptability of chewing gums containing Xylitol as another strategy to prevent caries is rising. This method is simply accepted by many children (7). Sorbitol is also a sweetener with sweetness equal to 60% of sucrose, but it is less effective in controlling dental caries than Xylitol (8).

Although it has been shown in animal studies that cariogenic microorganisms facing with limited sugar reserves can metabolize Sorbitol as a source of energy (9), however, according to the results of a clinical study performed on children with progressive caries, the use of Sorbitol-containing chewing gum reduces dental decay as 40% (10). Although Sorbitol is known as a anti-decaying substance, but Xylitol actively plays a more effective role in reducing caries by reducing *Streptococcus mutans* and derived lactic acid levels and such an effect increases with increasing dose and its frequency (11). Many research results indicated the effectiveness of sucrose-free gum chewing in reduced the accumulation of dental plaque, reduced streptococcus mutans in saliva and plaque, reduced acid production in saliva and plaque, increased salivation and reduced caries (12). According to the role of gums containing Sorbitol and Xylitol in reducing dental plaque formation and accumulation and reduced decay on the one hand and the unavailability of required information on acid-removing ability of gums containing the sugar substitute for orbit sugar on the other hand, in this study, the effect of pH of a variety of gums containing Xylitol, calcium/ Xylitol and Sorbitol was studied in

Islamic Azad University and Shahid Beheshti University.

### Methods:

The present study was conducted by a randomized, single-blind and cross-over clinical trial during four one-day periods with one week break between the sessions. Study participants included 10 dental female students of Azad Dental University with an average age of 25 3/8 years old. The participants' DMFT was determined and those with DMFT between 8 and 12 were selected. The subjects had no certain systemic diseases, and at least from two weeks before the study had not used any drug (especially antibiotics). They also had no history of periodontal disease and dry mouth and did not smoke. In addition, they had no history of restoration at the location of study (proximal surfaces of second premolar, mesial surface of first molar and distal surface of the first premolar).

At study baseline, the stimulating salivary flow and the number of salivary *Streptococcus mutans* and *Lactobacillus* bacteria in participants were determined by Caries Risk Test (CRT-Bacteria-Ivoclar vivadent AG). Then, saliva buffering power was determined using CRT Buffer Kit (13). The subjects with stimulating salivary flow rate of 1 ml per minute and normal or alkaline saliva were selected (14). Before beginning the research, the procedure was fully explained to the patients and their written and informed consents were obtained. To make the oral conditions similar regarding microbial plaque, the volunteers were asked to brush their teeth in the usual way with Crest toothpaste for 3 weeks (15) and not to use any fluoride-containing products or antimicrobial mouthwashes (16). Then, in the first session, complete oral prophylaxis was performed for all the subjects. To provide the conditions for dental plaque to reach the capability of adequate

acid production as well as avoiding any conflicts with dental and periodontal health, in the first session, complete oral prophylaxis was done by the researcher, and then, the volunteers were asked to avoid performing of oral hygiene procedures, including brushing - flossing and using antimicrobial mouthwashes for 48 hours and not to eat at least 2 hours before the test and to drink only water so that the plaque thickness can reach to a level to determine the pH by the electrodes.

The patients randomly and according to material used including Xylitol (Wrigley's Factory/ Netherlands), Sorbitol (Wrigley's Factory/ Netherlands), Xylitol+ Calcium (Wrigley's Factory/ Netherlands), Turpentine and 10% sucrose syrup (as control group), divided into 5 groups. The amount of gum used in all groups was equal to 10 g. All materials were coded from 1 to 5. At this time, the basic dental plaque pH (at rest time before the intervention) was measured by Metrohm microelectrode (Metrohm/ Switzerland/ LL micro glass electrode), thus, the reference electrode connected to a pH meter was placed within the interproximal plaque under the contact point between the first molar and second premolar in each of the four quadrants of the mouth. In case of dental restoration in this area, the microelectrode was placed between the first premolar and the second premolar. All figures after being fixed on pH meter were read for 30 seconds. At this stage, the patients were asked to keep 10% sucrose syrup in their mouth for 2 minutes and then spit out. In the following, the plaque pH values were measured at 2, 5 and 10 min after washing with 10% sucrose solution. Then, the studied gum was chewed for 10 minutes. The plaque pH was measured after chewing gum at intervals of 2, 5, 7, 10, 15, 20, 30, 40, 50 and 60 minutes.

Plaque pH measurements were performed in all 4 quadrants in similar sites. The microelectrode was calibrated with 20% KCL solution with pH

range of 4-5 before beginning of each experiment and between the interval of each reading, and the electrodes were rinsed with a gentle stream of distilled water. The 2% glutaraldehyde solution for 20 min was used for electrodes disinfection.

After doing one step, the next steps were repeated exactly as the first stage about other gum types with one week rest period intervals. Then, the pH curve (the mean pH of 4 quadrants) for each material tested in all subjects was plotted for specified time intervals. The Cried-mann test was used to compare pH at any time and between different materials considering the type of the study. For group paired comparison, the Wilcoxon-signed rank test and Bone-ferroni-Adjustment test were used.

## Results:

The present study was conducted in a cross-over method on 10 female dental students in School of Dentistry. The plaque pH was measured before and after chewing three gums, turpentine and 10% sucrose solution in mentioned periods in four quadrants of the mouth. All samples used the tested materials in a cross-over manner. The mean pH changes based on follow-up time and chewing gums type are presented in Table 1. According to these results, the differences in plaque pH during different period times were significant among four studied substances ( $p < 0.001$ ). The plaque pH levels at baseline time and after 2 minutes were similar, and the difference at baseline time ( $p = 0.299$ ) and in time 2 ( $p = 0.147$ ) was insignificant. At fifth minute, the maximum and minimum plaque pH levels were respectively related to Xylitol gum (7.14 (.10)) and turpentine (6.75 (.17)) that the difference was estimated significant with ( $p < 0.001$ ). At seventh minute, the maximum and minimum plaque pH levels were respectively related to Xylitol gum (7.20 (.10)) and turpentine (6.74 (.19)) with ( $p < 0.001$ ). At tenth

minute, the maximum plaque pH levels was related to Xylitol gum (7.08 (.15)); but, Sorbitol (6.67 (.16)) further reduced the plaque and maintained this trend to the end, and this difference was significant ( $p<0.001$ ). At fifteenth minute, the maximum and minimum plaque pH levels were respectively related to Xylitol gum (6.92 (.15)) and Sorbitol (6.46±.16) with a significant difference ( $p<0.001$ ). At twentieth minute, the maximum and minimum plaque pH levels were respectively related to Xylitol gum (6.83 (.14)) and Sorbitol (6.42 (.15)) with ( $p<0.001$ ). At 30th minute, despite the lowest plaque pH levels was of Sorbitol (6.34 (.17)), but the maximum plaque level was related to Xylitol + calcium (6.79 (.15)) that the difference was also estimated significant. Form minute 40 and thereafter, the highest rate of plaque was related to Xylitol gum and the lowest level was related to Sorbitol, which are significantly different from each other ( $p<0.001$ ). The curves of changes in pH due to

chewing studied gums after consumption of sugar syrup at baseline time and after 2, 5 and 10 minute are shown in figure 1. According to this figure, plaque pH levels after consumption of 10% sucrose syrup in different experimental groups (3 types of chewing gum and turpentine) were not significantly different ( $p>0.05$ ), while there were significant differences between follow-up period times among various ingredients ( $p<0.001$ ).

According to this diagram, plaque pH had a significant reduction in the first minute, and then reached to its maximum at seventh minute that the maximum and minimum rates are related to Xylitol and turpentine, respectively.

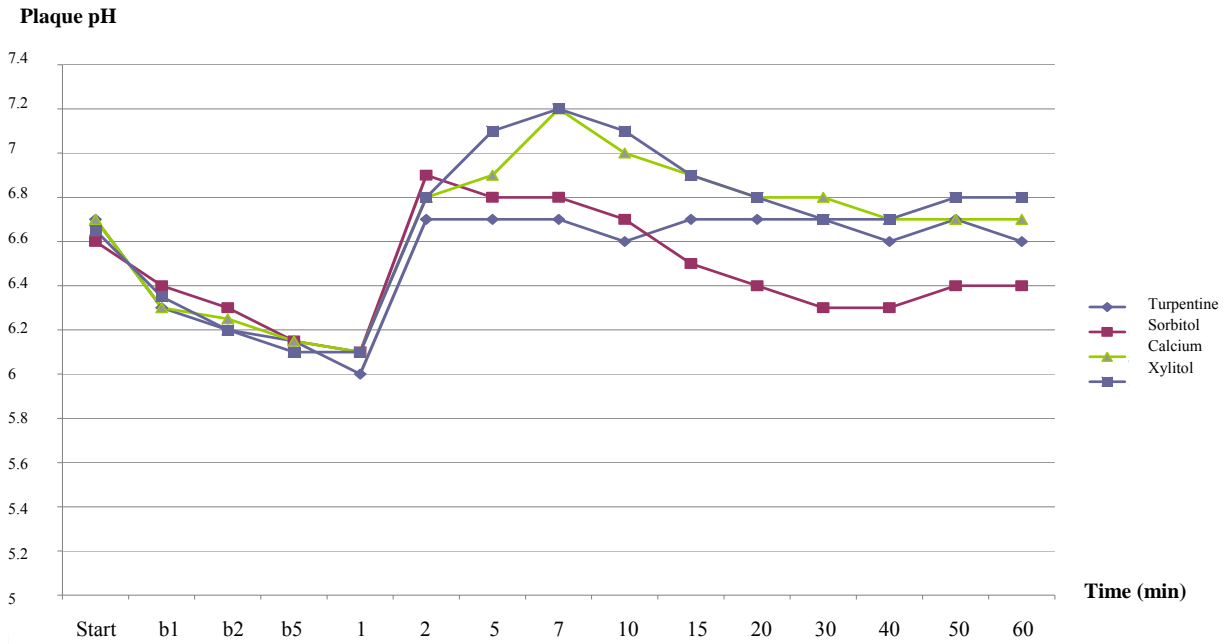
The curve experiences the downward trend up to minute 60 and remains constant thereafter, which is higher than basic pH in all cases. Also, the highest and lowest final pH levels are related to Xylitol and Sorbitol, respectively. There were no significant differences between plaque pH levels in different quadrants ( $p> 0.05$ ).

**Table 1- Mean plaque pH of subjects (±SD) of different groups at different time intervals**

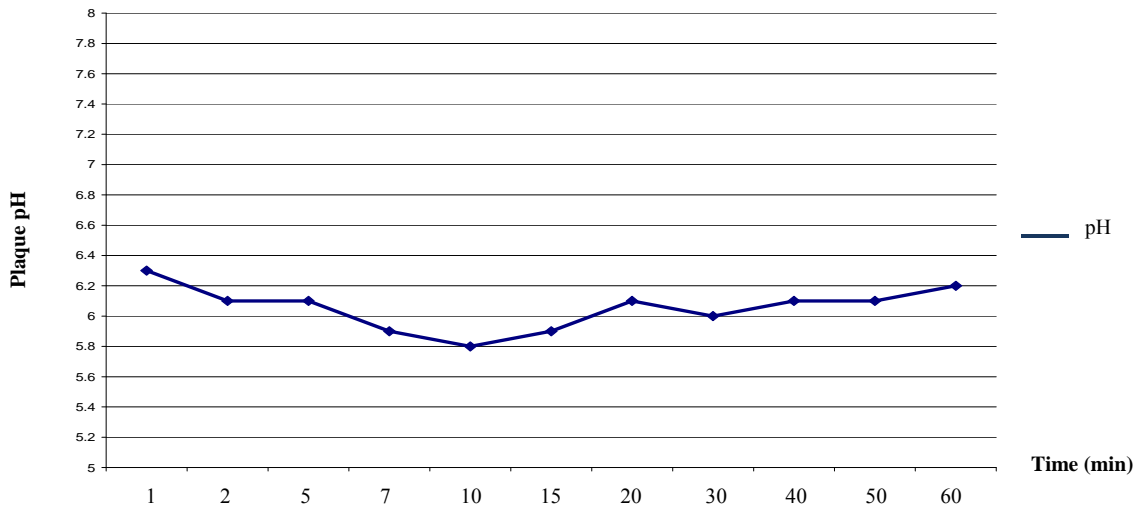
Tested Materials Time (min)	Turpentine	Sorbitol	Calcium+Xylitol	Xylitol	Result
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
0	6.04 (0.14)	6.08 (0.11)	6.11 (0.09)	6.10 (0.09)	(0.299)
2	6.75 (0.17)	6.86 (0.13)	6.82 (0.13)	6.81 (0.12)	(0.147)
5	6.75 (0.17)	6.82 (0.15)	6.85 (0.15)	7.14 (0.10)	(<0.001)
7	6.74 (0.19)	6.83 (0.17)	7.17 (0.14)	7.20 (0.10)	(<0.001)
10	6.63 (0.18)	6.67 (0.16)	7.04 (0.13)	7.08 (0.15)	(<0.001)
15	6.74 (0.15)	6.46 (0.16)	6.90 (0.14)	6.92 (0.15)	(<0.001)
20	6.67 (0.13)	6.42 (0.15)	6.82 (0.14)	6.83 (0.14)	(<0.001)
30	6.73 (0.14)	6.34 (0.17)	6.79 (0.15)	6.74 (0.10)	(<0.001)
40	6.56 (0.09)	6.34 (0.14)	6.73 (0.10)	6.74 (0.09)	(<0.001)
50	6.73 (0.14)	6.35 (0.13)	6.74 (0.08)	6.78 (0.12)	(<0.001)
60	6.64 (0.16)	6.34 (0.13)	6.69 (0.11)	6.84 (0.11)	(<0.001)

Figure 2 shows the plaque pH changes after consumption of 10% sucrose alone. According to this chart, plaque pH after 10% sucrose solution consumption by in 4 quadrants had a

significant decline in pH up to tenth minute after sucrose intake, and then took an upward trend up to minute 60.



**Diagram 1- Mean changes in plaque pH of subjects at different time intervals due to chewing studied gums after consumption of 10% sucrose solution.**



**Diagram 2- Mean plaque pH of subjects at different time intervals following consumption of 10% sucrose solution.**

**Discussion:**

The current study showed that Xylitol gum has the maximum impact on increased dental plaque pH among tested gums, and chewing gum containing Xylitol and calcium is in the next ranking. Also, Xylitol gum had the highest pH

level in the final minutes. In comparison between Sorbitol and turpentine, which placed in next rankings, Sorbitol chewing gum increased pH to a greater degree up to minute 10; but after tenth minute, turpentine raised the pH more, and at the end, it also maintained the pH at a higher level. The maximum increase in plaque pH level

was in gums containing Xylitol and gums containing Xylitol and calcium, and the minimal rate in maximum of increased pH was related to turpentine ( $p < 0.001$ ) (Diagram 1). In recent years, numerous studies have been conducted on the effects of different gums on oral cavity in different areas that the results of many of them are similar to the present study.

Akay, *et al.* (2007), Park, *et al.* (1993), Wennerholm, *et al.* (1994) and Lif Hologerson, *et al.* (2005), all examining the effects of various gums on dental plaque pH came to the conclusion that chewing gum increases dental plaque pH (15, 17-19). According to Akay, *et al.* (2007) study, the maximum plaque pH was seen after consumption of paraffin and calcium gum at minute 5 after their chewing, and had a gradual decline up to minute 60 (15). According to Park, *et al.* study (1993), after chewing Sorbitol gum for 10 minutes in the following of different snacks ingestion, the plaque pH increased and experienced a gradual decline up to 2 hours, which varied due to the content of different snacks (17). The results of this study and Park's study (1993) were somehow different. The difference may be attributed to using different snacks in Park's study and different times of gum chewing (after 5 and 15 minutes). In a study by Akay, *et al.* (2007) on calcium - fluoride containing chewing gum, the maximum plaque pH level reached to 7.3 at minute 15 (15). However, in the present study, the maximum plaque pH caused by calcium-containing Xylitol gum reached to 7.2 at about minute 7. In the present study, the maximum plaque pH caused by Xylitol chewing gum containing calcium reached to 7.2 at about minute 7, which was similar to the above study. The difference in time to reach the maximum level can be attributed to factors such as gums ingredients and individual differences of the participants of the study as well as slight differences in the initial stages of studies, since the presence of fluoride of chewing gum does

not make tangible change in plaque fluoride content (18). The results showed that after ingestion of sucrose (initial pH = 6.3), there will be a gradual decrease in plaque pH up to minute 10; however, in none of the samples, the plaque pH reached below 5.8 after its consumption, and then gradually increased up to minute 60 (final pH=6.2).

In the present study, plaque pH did not reach below 5.5 (critical pH in Stephen curve) after sucrose ingestion during the first 10 minutes, while such a result has been shown in many other studies. This can probably due to an increase in the stimulatory effect of sucrose syrup on salivary flow rate that could reach the plaque pH to a neutral level (20).

Lif Hologerson, *et al.* (2005) showed that the pH of saliva decreases immediately after washing with sucrose (19). The reason may be due to the release of acid from the plaque and bacterial masses on the tongue; since, acid production by *in vivo* salivary bacteria requires more time (21), and considering that all studied subjects were selected from dentistry students, which were considered of tooth brusher population, not reaching to pH below the critical level can be justified. According to Exelson studies in tooth brusher population, the marked drop in pH level is only seen in 3-day plaque following sucrose ingestion (14). In this study, all studied subjects used the same type of toothpaste for 3 weeks. They were matched regarding salivary pH, absence of decay, salivary bacteria and studied regions, and thereby, the initial pH of plaque in all cases had no significant difference, which according to Sonmez and Aras (2007), Akay, *et al.* (2007), Koparal, *et al.* (1998) and Akay indicated the reliability of study design and micro touch electrode method of study (13, 15, 20). In the present study, all studied subjects were selected from dentistry students that are in an age range. Based on Exelson studies, age has no effect on plaque pH variation (14), while according to Koparal, *et al.* (1998), plaque pH

response is different in children compared to adults (20), and according to Toumba and Duggal (1999), the drop in pH in children after consumption of sucrose is less tangible (22). Among factors affecting plaque pH, saliva characteristics, genetic and nutritional factors can be mentioned. Also, required time for plaque pH return to resting state depends on the flow rate of saliva (15). Gum chewing can stimulate saliva, which is influenced by different characteristics such as size, consistency, taste, viscosity and time of chewing (17). Park, *et al.* reported that the sucrose-containing gums do not neutralize the acid as much as sugar-free gums (23). Xylitol commercial products can be used to help controlling rampant caries in primary dentition period.

Washington University studies and information revealed that Xylitol- containing gum, chocolate, candy and cakes are associated with other dental treatments and stopping the caries. Xylitol yield is not dependent to reduction of a variety of sugars and dietary effect; meaning, the dentist may recommend the use of Xylitol without asking the patient to add another alternative to its diet pattern (24). It has been shown in numerous studies that the Xylitol present in gums reduces SM levels in saliva and plaque, but do not produce a measurable reduction in plaque pH. Since Xylitol is an expensive sweetener, instead of using it alone, it is used as

a mixture of Xylitol and Sorbitol. Various studies have shown that Xylitol presence in chewing gum has beneficial effects on plaque formation, plaque pH and oral microbial flora compared to Sorbitol (18). Park, *et al.* studies on effects of Sorbitol gums on the plaque acidogenicity showed that such a repeating chewing can cause remineralized caries-like lesions. In this context, Sorbitol has the same effect as Sorbitol and Xylitol mixture (17). In our study, the use of chewing gum containing artificial sweeteners and the control sample (turpentine) also increased plaque pH, which may be partly due to this factor. The gums cause less reduction in plaque pH compared to paraffin (17).

### **Conclusion:**

According to the current study results, three types of Xylitol, Xylitol + Calcium and Sorbitol gums (Orbit Factory products) cause increased plaque pH after consumption of sugar syrup. The increase rate varies according to the type of gum. Examining five substances and having positive and negative controls (turpentine and sucrose) are as unique features of this study.

### **Conflict of Interest: “None Declared”**

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