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Original Article

Anticariogenic potential of white cheese, xylitol chewing gum, and black tea

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ABSTRACT

Objective: This study aimed to examine the effects of these foods on plaque pH and the potential development of tooth decay. **Materials and Methods:** Plaque pH was measured using the sampling method before and after 1, 5, 10, 20, 30, 45, and 60 min following consumption of these foods individually and after rinsing with a 10% sucrose solution. Statistical analysis was performed using one-way ANOVA and Tukey honestly significant difference *post hoc* tests ($\alpha = 0.05$). **Results:** Although there were statistically significant differences in all test groups except the BT ($P = 0.620$) and sucrose + XCG ($P = 0.550$) groups in time, none of the participants chosen for this study were having a plaque pH value anywhere close to the critical value (pH = 5.5). **Conclusion:** WC, BT, and XCG are advisable as anticariogenic foods because pH values are not below critical value.

Keywords: Black tea, dental health, plaque pH, white cheese, xylitol chewing gum

INTRODUCTION

Dental caries are one of the diseases exposed by individuals. One contributing factor is carbohydrates in the diet. Sucrose and glucose in the mouth are fermented by microorganisms, mainly *Streptococcus mutans*, yielding lactic and other organic acids that cause erosion and decalcification, thus leading to the creation of cavities, decay, and the development of caries.[1,2]

Among the types of food mentioned in the literature as having anticariogenic components are black tea (BT), xylitol chewing gum (XCG), and white cheese (WC), all of which are commonly consumed during or after meals by members of the Turkish community.[3-9] The fact that cheese has a ancariogenic effect may stem from several mechanisms.

Previously, cheese is one of the foods which stimulates the salivary flow. The second mechanism is that there is a strong relationship between the calcium and phosphate ions included in dental plaque. As a result of consumption of cheese, it enhances the concentration of calcium in plaque, which raises plaque pH above the critical level before demineralization occurs. Third, cheese contains casein, an anticariogenic phosphoprotein. Caries development decreases due to the casein in cheese. Casein from milk and cheese in saliva binds with hydroxyapatite to prevent the adhesion of *S. mutans*.[10-12] It has been reported that casein phosphopeptides stabilize calcium phosphate by the formation of casein phosphopeptide-calcium phosphate complexes, thereby facilitating plaque calcium and phosphate uptake. Many studies have shown casein phosphopeptides to be anticariogenic.[10,11,13,14]

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Xylitol has been reported to directly decrease the growth of *S. mutans* and may prevent caries by limiting plaque formation and bacterial adherence.[15,16] Xylitol's ability to inhibit the accumulation of plaque and *S. mutans* appears to be affected by xylitol content and frequency of usage. Xylitol cannot be fermented by most oral microorganisms.[2,3]

Tea contains fluoride, polyphenols, catechins (epicatechin, epicatechin gallate [ECG], and epigallocatechin gallate [EGCG]), and flavonoids.[11] Tea, or some of its various components, has a direct bactericidal effect on *S. mutans* and prevents bacterial adherence to teeth.[17,18] Polyphenols, which are abundant in BT, were determined to suppress the growth of *S. mutans*, reducing its ability to synthesize glucan and suppressing amylase activity.[11,17,19] It was also reported that polyphenol compounds in BT caused to enhance the fluoride amount in plaque.[11] Other studies have shown that catechins remain in saliva until 60 min following rinse of the mouth with tea.[17,20]

The purpose of this study was to examine the effects of WC, tea, and xylitol on plaque pH and potential for tooth decay.

SUBJECTS AND METHODS

The study participants comprised of student volunteers from the Faculty of Dentistry selected in line with the recommendations of Wang *et al*.[2] and Sönmez and Aras.[21] The study was approved by the Ethical Committee of University, and all participants gave their informed consent.

All 10 participants (20–25 years old) were healthy, nonsmoking, and adults free of any periodontal disease. Salivary *S. mutans* and *Lactobacillus* levels of the participants were measured using Caries Risk Test Bacteria (Ivoclar Vivadent AG), and the buffering capacity of the participants was determined using Caries Risk Test Buffer (Ivoclar Vivadent AG). All the participants had salivary *S. mutans* and *Lactobacillus* levels below 10^5 colony-forming unit/ml and normal buffering capacity and unstimulated salivary flow rates (0.3–0.4 ml/min), suggesting them to be at low risk for caries development.

To facilitate adequate plaque accumulation, the participants were demanded to not brush their teeth 48 h prior to their test sessions. Participants were also demanded to stop eating or drinking anything for at least 2 h before testing. Applications of the all the test groups were started at 9:30 a.m.

Plaque pH was determined by the sampling method.[22] On each test session, a sample of approximately 1 mg of plaque was obtained from the buccal surfaces of the participant's first permanent molars using a sterile excavator, mixed with 50 μL of distilled water, and the resting pH was measured *ex vivo* using a microelectrode (Perphect™ Ross™ 8220BN, Thermo Scientific, USA) which had been previously calibrated with pH 7 and pH 4 buffer solutions.

Plaque pH was determined at baseline and after 1, 5, 10, 20, 30, 45, and 60 min the following treatments:

1. 10% sucrose solution (10 ml) (control) (rinsed for 1 min)
2. WC (10 g) (chewed for 1 min)
3. XCG (Vivident Xylit; Gum weight: 1.15 g; Xylitol content: 15.36%, 0.17 g) (chewed for 1 min)
4. Tea solution (10 ml) (Doğuş Çay) (solutions were prepared using 10 g [5 bags] of BT and 1 L double-distilled deionized water.)[23,24] (rinsed for 1 min)
5. Sucrose + WC (WC chewed for 1 min 5 min after rinse with sucrose solution for 1 min)
6. Sucrose + chewing gum (chewing gum chewed for 1 min 5 min after rinse with sucrose solution for 1 min)
7. Sucrose + tea (tea rinsed for 1 min 5 min after rinse with sucrose solution for 1 min).

Salivary contamination of plaque sample was avoided by asking participants to swallow just before plaque collection as well as blood contamination was also avoided during sample collection. Plaque was collected from the gingival margin of each of the four teeth sampled at each time interval, and the plaque samples were collected in 30 s for standardization.

Statistical analysis

The data were analyzed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA) software. pH values measured in time for each test group were analyzed using one-way ANOVA and Tukey honestly significant difference (HSD) *post hoc* tests ($\alpha = 0.05$).

RESULTS

Table 1 presents comparison of mean ± standard deviation of pH values at different time intervals for test groups. One-way ANOVA and Tukey HSD tests indicated that there were statistically significant differences in all test groups except the BT ($P = 0.620$) and sucrose + XCG ($P = 0.550$) groups in time.

Table 1: Comparison of mean pH values at different time measurements by test groups

Test groups	Time periods								*P*
	Baseline	1 min	5 min	10 min	20 min	30 min	45 min	60 min	
Sucrose	7.57±0.19^{c}	7.29±0.04^{a,b}	7.23±0.23^{a}	7.39±0.01^{a,b,c}	7.44±0.09^{b,c}	7.51±0.17^{c}	7.49±0.22^{c}	7.47±0.19^{b,c}	0.001*
WC	7.08±0.02^{a}	7.19±0.26^{a,b}	7.29±0.22^{b}	7.29±0.17^{b}	7.26±0.11^{a,b}	7.26±0.10^{a,b}	7.26±0.05^{b}	7.25±0.16^{a,b}	0.009*
XCG	6.89±0.11^{a}	7.36±0.05^{d}	7.24±0.09^{c}	7.18±0.05^{b,c}	7.10±0.08^{b}	7.12±0.08^{b}	7.17±0.06^{b,c}	7.17±0.07^{b,c}	0.001*
BT	6.67±0.40^{a}	6.63±0.23^{a}	6.71±0.29^{a}	6.78±0.27^{a}	6.75±0.15^{a}	6.76±0.12^{a}	6.80±0.17^{a}	6.72±0.19^{a}	0.620
Sucrose + WC	6.83±0.37^{b}	6.75±0.04^{a,b}	6.79±0.16^{b}	6.57±0.16^{a}	6.88±0.01^{b}	6.88±0.01^{b}	6.92±0.05^{b}	6.82±0.01^{b}	0.001*
Sucrose + XCG	7.04±0.02^{a}	7.08±0.07^{a}	6.98±0.23^{a}	6.97±0.26^{a}	6.93±0.26^{a}	6.97±0.25^{a}	6.95±0.24^{a}	7.01±0.06^{a}	0.550
Sucrose + BT	7.32±0.02^{d}	6.97±0.09^{a}	7.12±0.02^{b}	7.19±0.02^{c}	7.22±0.07^{c}	7.39±0.02^{e}	7.29±0.06^{d}	7.20±0.09^{c}	0.001*

**P<0.05 differences in letters in the same row represent statistically significant differences. WC: White cheese, XCG: Xylitol chewing gum, BT: Black tea, S + WC: Sucrose + white cheese, S + XCG: Sucrose + xylitol chewing gum, S + BT: Sucrose + black tea

Plaque pH values were partially decreased after sucrose was consumed alone and with test groups. However, after ingestion of test groups other than sucrose, plaque pH values were higher than initial pH even after 60 min. Although the pH values decreased following sucrose uptake, they generally increased above the baseline pH within 20 min after the test groups were taken. Although there were statistically significant differences, none of the participants chosen for this study were having a plaque pH value anywhere close to the critical value (pH = 5.5).

DISCUSSION

Dental caries occurs as a result of three different stage: (1) bacterial adherence to the tooth; (2) glucan synthesis as a result of bacterial enzymes acting on sucrose; and (3) accumulation of biofilm (plaque) and ongoing acid production by bacteria.[17]

Evaluating the magnitude of the pH response after ingestion is one of the methods used to determine cariogenic potential of foods. Plaque pH measurements can be carried out using various methodologies, such as plaque sampling, touching plaque with electrodes, and implanting electrodes in the dentition for telemetric monitoring.[21,23,24] However, the sampling method was chosen in the present study because this method is cheap and easy to apply.

In this study, it was found that there were statistically significant differences among plaque pH values for all the test groups except the BT (P = 0.620) and sucrose + XCG (P = 0.550) groups. Although there were statistically significant differences in all test groups, pH values were not below critical value (pH = 5.5) in all the test groups. The results of this study are in accordance with other studies.[21,24] Abelson and Mandel[25] found differences in plaque pH responses to a sucrose mouthrinse between groups of caries-resistant and caries-susceptible individuals when salivary access was permitted; however, when saliva was excluded from plaque, no differences were found.

Previous studies have demonstrated the anticariogenic properties of WC, BT, and XCG;[2,7,21] however, a literature search found no single study that addressed all the three items. Our study also suggests that WC, BT, and XCG may prevent the development of dental caries by maintaining plaque pH levels above 5.5.

Moynihan *et al*.[26] found significantly higher plaque Ca concentrations in individuals who ate meals containing cheese in comparison to controls who ate meals without cheese. Another study by Sönmez and Aras[21] that examined the anticariogenic effects of WC and sugarless yogurt found that after these foods were consumed, plaque pH levels dropped below the critical pH 5.5 at which demineralization occurs. A study by Silva *et al*.[27] examined the effects of the water-soluble components of cheddar cheese on plaque pH by placing to five participants two bovine enamel, with one side of each appliance (experimental) dipped in a 25% water extract of the cheese and the other side (control) dipped in deionized water. The authors reported that the calcium and phosphorous concentrations in plaque did not show statistically significant difference between experimental and control groups. Another study on rats with surgically removed submandibular/sublingual glands and parotid ducts found that rats consumed a highly cariogenic diet and cheese significantly had fewer and less severe caries lesions on coronal and root surfaces than rats fed a noncariogenic diet only.[13]

Studies had indicated that cheese consumption in humans did not bring about decrease in plaque pH.[23,28] Similarly, Rugg-Gunn *et al*.[29] stated that consuming cheddar cheese after digestion of a sugary food quickly returned the plaque pH toward neutrality. They also stated that the stimulation of saliva flow was caused by the pH-raising effect of cheese. As a result, authors

stated that cheese may benefit in the reduction of caries due to its effect on plaque pH. In accordance with this study, our study found that plaque pH was significantly increased by the consumption of cheese alone or following sucrose uptake.

Various studies have mentioned the anticariogenic properties of BT. In one study, both black and green teas were found to contain anticariogenic catechins, and in spite of their oxidation and condensation to larger, dark-colored molecules that included theaflavins and thearubigins during fermentation, some simple catechins continued to be present in BT.[17] Tsuchiya *et al*.[20] showed that catechins remained in saliva until 60 min after rinsing the mouth with tea. Zhang and Kashket[19] found that both black and green teas inhibited amylase activity from *S. mutans* through the action of polyphenols, which are more abundant in BT than in green tea.

Studies have been conducted on polyphenol fractions of tea due to their antimicrobial properties. Previous studies have found that catechins from BT, especially ECG and EGCG, inhibited the growth of many bacterial species.[5,30,31] Lee *et al*.[7] found that catechins and theaflavins could be determined in saliva in the 1st h following the consumption of green tea and BT. They suggested tea leaves to be able to be used as the prevention of dental caries. In addition, Linke and LeGeros[32] found that frequent consumption of BT can significantly decrease caries development. In another study[33] in which hamsters were fed a cariogenic diet containing sucrose with either water or tea, the group given tea developed fewer dental caries than those given water. The authors of this study suggested that the anticariogenic effects shown by tea were due to the action of both polyphenols and fluoride. Similarly, our study found that the BT increased the plaque pH above neutral pH in 5 min following sucrose consumption.

Studies in the literature also mention the anticariogenic effects of xylitol. Studies had shown that cariogenic microorganisms do not metabolize xylitol, and consuming xylitol does not decrease plaque pH. Consequently, convenient use of xylitol-sweetened gum decreases salivary *S. mutans* counts.[34] Wang *et al*.[2] found that individuals given xylitol had lower levels of plaque accumulation and *S. mutans* than a control group. Ertuğrul *et al*.[1] found that rats fed with a diet included in sucrose had significantly higher levels of *S. mutans* than those fed with xylitol. The authors attributed these results to the inability of *S. mutans* to ferment xylitol. A study by Haresaku *et al*.[35] found that *S. mutans'* level in saliva and plaque declined significantly in individuals who chewed xylitol gum for 6 months, whereas plaque increased significantly in a control group given maltitol as a substitute for xylitol. There are parallel studies[36-38] which examine the reduction of *S. mutans* as a result of use of xylitol. It has been universally agreed that xylitol helps to prevent the dental caries not only by increasing the pH of saliva and dental plaque, but also by decreasing the number of salivary microorganisms in the oral cavity.[39] Similar to these findings, our study was found to increase the plaque pH.

In the literature, although there are differences among studies with regard to time, the effects on plaque pH are similar. The differences observed may be due to the selection of participants with good oral hygiene and high saliva-buffering capacities.

CONCLUSION

WC, BT, and XCG are advisable as anticariogenic foods because none of the participants chosen for this study were having a plaque pH value anywhere close to the critical value (pH = 5.5). However, caries is a multifactorial disease and the only measurement of pH value is not indicative of whether the caries will be generated. Therefore, it is suggested to do further comprehensive studies.

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Conflicts of interest
There are no conflicts of interest.

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