

Influence of soft drinks on dental enamel: An *in vitro* study

Yagmur Sener¹, Murat Selim Botsali², Ebru Kucukyilmaz³, Gul Tosun², Mustafa Altunsoy^{4*}

Department of Pediatric Dentistry, Faculty of Dentistry, ¹Necmettin Erbakan University, Konya, ²Selcuk University, Konya, ³Izmir Katip Celebi University, Izmir, ⁴Sifa University, Izmir, Turkey

ABSTRACT

This *in vitro* study was to evaluate the erosive potential of four soft drinks at different times on bovine teeth by profilometry. Bovine incisors buccal side was sectioned with a diamond saw and a total of 100 enamel blocks were prepared (8 × 4 × 0.5 mm). Five specimens each were exposed to 60 ml of soft drinks (Sprite, Coca Cola, Cappy-orange and Ayran) for 15, 30, 60, 120 and 180 minutes in a continuously vibrating soft drinks bath in a beaker at room temperature. Surface loss of the specimens was determined with a profilometry. The data were analyzed by two-way analysis of variance and Tukey HSD test. Loss of enamel was observed in Coca Cola, Cappy and Sprite groups. Coca Cola was significantly higher erosive potential in 180 minutes than other soft drinks ($p < 0.05$). Ayran was no sign of erosive potential in all time. It can be concluded that the composition of the beverages had a significant effect on dental erosion, so consumption of Ayran can be advised.

Key words: Chemical Properties, Enamel Erosion, Profilometry, Soft Drinks

Access this article online

Website:

www.jpediatrdent.org

DOI:

10.4103/WKMP-0028.117445

Quick Response Code:



INTRODUCTION

Dental erosion is defined as loss of tooth substance by chemical processes caused by a variety of extrinsic and intrinsic factors.^[1] Intrinsic factors are mainly caused by gastric acid reaching the oral cavity as a result of vomiting or gastro-esophageal reflux. Extrinsic factors are related to frequent consumption of acidic comestibles or drinks in daily life. In today's lifestyle the extrinsic factor is becoming more important in the etiology of dental erosion due to increased consumption of acid drinks as soft drinks, sport drinks, fruit juices and fruit teas.^[2] This is because these drinks are based on fruits with high citric acid content and were found to have a highly erosive effect on dental hard tissues.^[3-5] According to diet and food surveys, over half of people suffered from between the age of 4 and 18 years exhibited signs of dental erosion; moreover, 46% of children aged 4-6 years had signs of erosion of their primary teeth.^[6,7] Demineralization of tooth by erosion is caused by thick contact between the tooth surface and acidic foods or beverages. Strategies to prevent dental erosion include reducing consumption of acidic

foods and beverages and protect the teeth from erosive materials. Numerous reports on evaluation of enamel erosion have been published in the literature.^[2,7-12] Many of these studies have demonstrated enamel softening and/or loss of tissue after surface treatment with various acid solutions. Enamel erosion is measured by various methods including loss of enamel weight, SEM or light microscope, microradiograph or image analysis, electron probe analysis and profilometry.^[13-17] However each method has limitations. For instance, some methods provide only qualitative information, some are very costly. Profilometry is a simple, rapid and cheap to measure the depth of the erosion. Clinical studies suggest that the length of time which the teeth are exposed to acidic environment is more critical to erosion than the volume of drink consumed. Moreover, the total acid level, acid type, concentration of phosphate, calcium and fluoride in the beverages have a modifying effect on the development of erosion induced by dietary components.^[10,12] The purpose of this study was to evaluate the erosive potential of four soft drinks at different times on bovine teeth by profilometry.

*Address for correspondence

Dr. Mustafa Altunsoy, Sifa University, Faculty of Dentistry, Department of Pediatric Dentistry, 35100, Izmir, Turkey.
E-mail: dtaltunsoy@gmail.com

MATERIALS AND METHODS

A total of 100 freshly extracted bovine incisors were used. The teeth were disinfected by storage in a 5% sodium hypochlorite solution for 24 h after their roots and pulps had been removed. The teeth buccal side was sectioned with a diamond saw (İsomet, Buehler, Germany) and a total of 100 enamel blocks were prepared (8 × 4 × 0.5 mm). The enamel surfaces of the specimens were ground flat and polished with silicon carbide papers (grades 320, 600, 1500) (Wirtz, Buehler, Germany) under water irrigation. The centers of the polished surfaces were isolated with water-resistant band. The residue polished surfaces were covered with nail varnish. After nail varnish dried, the band was removed from the polished enamel surfaces. Five specimens each were exposed to 60 ml of Sprite (Coca-Cola Co., Istanbul, Turkey), Coca Cola (Coca-Cola Co., Istanbul, Turkey), Cappy-orange (Coca-Cola Co., Istanbul, Turkey) and Ayran (Yoruklar Inc., Balıkesir, Turkey) for 15, 30, 60, 120 and 180 minutes in a continuously vibrating soft drinks bath in a beaker (Are, Velp, USA) at room temperature [Figure 1]. Specimens were then washed in running water and dried. Nail varnish was completely removed from the specimens surface with acetone. Surface enamel loss was determined with a profilometer (Crysta-Apeks, Mitutoyo, Japan). For profilometric measurements the stylus moved across the eroded and uneroded enamel surfaces. The erosion depth is defined as the distance between the uneroded and the eroded surface. Each specimen was measured three times different part of the enamel surface and the average value of three measurements was calculated for each specimen.

The data were analyzed by two-way analysis of variance and Tukey HSD test.

RESULTS

Table 1 shows the mean pH values and chemical concentrations of the soft drinks. The mean enamel loss of the specimens are presented on Table 2. There were no difference among Sprite, Coca Cola and Cappy in 15, 30, 60 and 120 minutes according to the erosive effects ($p > 0.05$). The Coca Cola had a higher erosive effect than other soft drinks in 180 minutes ($P < 0.05$). Ayran was no sign of erosive effect in all times.

DISCUSSION

Soft drinks caused considerable enamel demineralization below the critical pH (5.5). Viscosity, buffering capacity and pH remain the most important chemical parameters in determining the erosive potential of soft drinks.^[18-20]

The profilometric measurement for determining erosively induced dental hard tissue loss is a well-founded and an

Table 1: Chemical concentrations (ppm) and pH values of soft drinks

	Sprite	Coca Cola	Cappy	Ayran
Ca	—	—	121	950
P	423	592	509	1148
Na	267	280	319	3077
pH	2.6	2.4	3.2	4.1

Table 2: Erosion depth of soft drinks (µm)

Time (minutes)	Sprite (Mean±SD)	Coca Cola (Mean±SD)	Cappy (Mean±SD)	Ayran (Mean±SD)
180	16.4±2.2 ^b	24.6±2.4 ^a	17.6±2.3 ^b	0 ^e
120	13.8±.9 ^b	16.8±2.2 ^b	14.6±1.8 ^b	0 ^e
60	6.8±1.9 ^c	9.8±1.6 ^c	5.8±1.5 ^c	0 ^e
30	5.2±1.5 ^{cd}	5.6±1.5 ^d	5.0±1.2 ^{cd}	0 ^e
15	2.4±1.1 ^d	2.8±1.3 ^d	2.2±1.1 ^d	0 ^e

*Groups with different letters are statistically significantly different. SD: Standart deviation

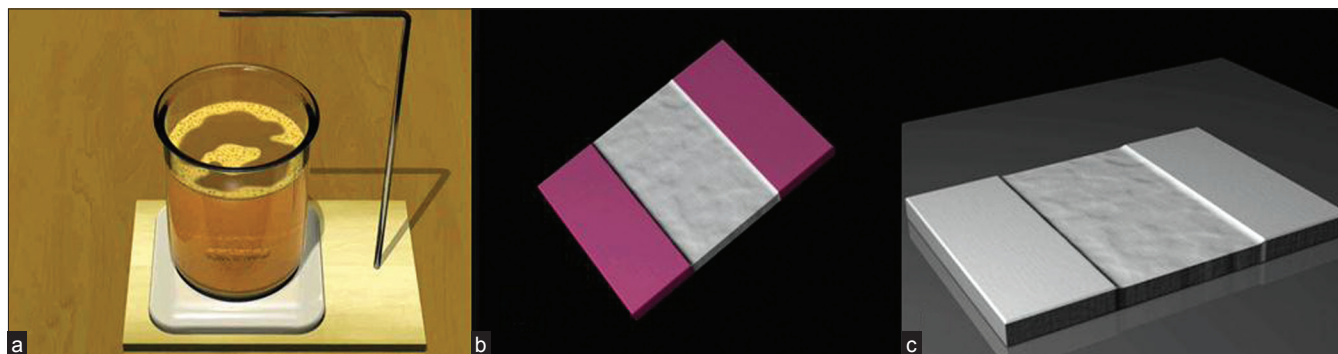


Figure 1: (a) Vibrating soft drink bath, (b) Surface of isolated with water-resistant band and surfaces with nail varnish, (c) Surface enamel loss (simulation)

appropriate method for evaluation of the erosive potential of various acidic drinks.^[21-23]

Most *in vitro* studies used bovine enamel since it is considered a suitable substitute for human enamel,^[8,24] but there are structural differences between bovine and human enamel. Bovine enamel is more porous than human enamel. Therefore it is less resistant to acid diffusion.^[25] In this study we used bovine enamel because it is suitable to desired size of enamel blocks.

In the present study we evaluated the effect of beverages on bovine enamel surfaces. The erosive potential of soft drinks were different because of their composition; such as type of acid, pH and chemical composition. This may explain the different erosive effect of the solutions. The erosive potential was corresponded well to the pH of the beverage, thus Coca Cola had a clearly higher erosive potential than the other beverages.

In our study the most erosive potential was observed for Coca Cola and the least was Ayran. Ayran has higher concentrations of calcium and phosphate than the others and it showed no sign of erosion. These variables may be influenced by the concentrations of different ions, such as phosphate and calcium. However some studies have shown that beverage modification by addition of calcium is efficient in preventing erosion.^[26,27] The results of our study revealed that amount of calcium or phosphate was effective in reducing the loss of enamel.

The effect of the type of acid and the amount of ionized acids on mineral dissolution had been demonstrated earlier.^[28] The literature is contradictory regarding the erosive potential of beverages containing citric acid or phosphoric acid. Some studies have shown that beverages containing citric acid are more erosive than those containing phosphoric acid,^[29,30] while others have shown the opposite.^[31,32] All acids had different erosive effects on dental enamel. Several parameters have been previously identified as influencing the erosion process of acids against human dental enamel.^[33] From the literature it is known that mono-, di- and tricarboxylic acids interact with hydroxy apatite (HA) and chemically adsorb onto the enamel surface.^[34] This adsorption leads to a dissolution of Ca⁺² ions out of the HA surface. Coca Cola contains phosphoric acid. Cappy and Sprite contain citric acid. Citric acid demonstrated severe demineralizing potential in several studies.^[35,36] The erosive potential of citric acid is pronounced because of the fact that it acts as a chelator able to bind minerals of the apatite, such as calcium. In our study Coca Cola showed higher erosive potential in 180 minutes than Cappy and Sprite and this may be explained by its low pH and lack of calcium in its content.

The present *in vitro* study, however, cannot fully reproduce the clinical conditions, and should only be interpreted as a prediction of the relative erosive potential of a dietary substance. In the mouth, tooth surfaces are covered with the acquired pellicle, comprising many of the proteins present in saliva,^[37] and this pellicle has been shown to protect tooth surfaces against erosion.^[38-40]

In conclusion, the present study confirmed the erosive potential of soft drinks (Coca Cola, Sprite and Cappy) and tooth erosion had a significant relationship with pH, phosphate and calcium concentrations of drinks; so we can suggest consumption of Ayran.

REFERENCES

1. Eccles JD. Dental erosion of nonindustrial origin. A clinical survey and classification. *J Prosthet Dent* 1979;42:649-53.
2. Lussi A, Jaeggi T, Zero D. The role of diet in the aetiology of dental erosion. *Caries Res* 2004;38 Suppl 1:34-44.
3. O'Sullivan EA, Curzon ME. Dental erosion associated with the use of 'alcopop' – a case report. *Br Dent J* 1998;184:594-6.
4. Rees JS, Burford K, Loyn T. The erosive potential of the alcoholic lemonade Hooch. *Eur J Prosthodont Restor Dent* 1998;6:161-4.
5. Rees JS, Davis FJ. An *in vitro* assessment of the erosive potential of some designer drinks. *Eur J Prosthodont Restor Dent* 2000;8:149-52.
6. Deery C, Wagner ML, Longbottom C, Simon R, Nugent ZJ. The prevalence of dental erosion in a United States and a United Kingdom sample of adolescents. *Pediatr Dent* 2000;22:505-10.
7. Nunn JH, Gordon PH, Morris AJ, Pine CM, Walker A. Dental erosion – changing prevalence? A review of British National childrens' surveys. *Int J Paediatr Dent* 2003;13:98-105.
8. Zero DT. Etiology of dental erosion – extrinsic factors. *Eur J Oral Sci* 1996;104:162-77.
9. Hunter ML, West NX, Hughes JA, Newcombe RG, Addy M. Erosion of deciduous and permanent dental hard tissue in the oral environment. *J Dent* 2000;28:257-63.
10. Behrendt A, Oberste V, Wetzel WE. Fluoride concentration and pH of iced tea products. *Caries Res* 2002;36:405-10.
11. Grenby TH, Phillips A, Desai T, Mistry M. Laboratory studies of the dental properties of soft drinks. *Br J Nutr* 1989;62:451-64.
12. Lussi A, Jaggi T, Scharer S. The influence of different factors on *in vitro* enamel erosion. *Caries Res* 1993;27:387-93.
13. Jain P, Nihill P, Sobkowski J, Agustin MZ. Commercial soft drinks: pH and *in vitro* dissolution of enamel. *Gen Dent* 2007;55:150-4; quiz 155, 167-158.
14. Owens BM, Kitchens M. The erosive potential of soft drinks on enamel surface substrate: An *in vitro* scanning electron microscopy investigation. *J Contemp Dent Pract* 2007;8:11-20.
15. Hall AF, Buchanan CA, Millett DT, Creanor SL, Strang R, Foye RH. The effect of saliva on enamel and dentine erosion. *J Dent* 1999;27:333-9.
16. Willershausen B, Schulz-Dobrick B. *In vitro* study on dental erosion provoked by various beverages using electron probe microanalysis. *Eur J Med Res* 2004;9:432-8.
17. Phelan J, Rees J. The erosive potential of some herbal teas. *J Dent* 2003;31:241-6.
18. Meurman JH, ten Cate JM. Pathogenesis and modifying factors of dental erosion. *Eur J Oral Sci* 1996;104:199-206.
19. West NX, Hughes JA, Addy M. The effect of pH on the erosion of dentine and enamel by dietary acids *in vitro*. *J Oral Rehabil* 2001;28:860-4.
20. Hughes ML, Rees JS. Alcopop induced erosion: management in general dental practice. *Dent Update* 2008;35:326-8.
21. Bartlett DW, Blunt L, Smith BG. Measurement of tooth wear in patients with palatal erosion. *Br Dent J* 1997;182:179-84.

22. Ganss C, Klimek J, Schwarz N. A comparative profilometric *in vitro* study of the susceptibility of polished and natural human enamel and dentine surfaces to erosive demineralization. *Arch Oral Biol* 2000;45:897-902.
23. Hughes JA, Jandt KD, Baker N, Parker D, Newcombe RG, Eisenburger M, *et al.* Further modification to soft drinks to minimise erosion. A study in situ. *Caries Res* 2002;36:70-4.
24. Meurman JH, Frank RM. Progression and surface ultrastructure of *in vitro* caused erosive lesions in human and bovine enamel. *Caries Res* 1991;25:81-7.
25. Arends J, Christoffersen J, Ruben J, Jongebloed WL. Remineralization of bovine dentine *in vitro*. The influence of the F content in solution on mineral distribution. *Caries Res* 1989;23:309-14.
26. Hughes JA, West NX, Parker DM, Newcombe RG, Addy M. Development and evaluation of a low erosive blackcurrant juice drink. 3. Final drink and concentrate, formulae comparisons in situ and overview of the concept. *J Dent* 1999;27:345-50.
27. West NX, Hughes JA, Parker DM, Newcombe RG, Addy M. Development and evaluation of a low erosive blackcurrant juice drink. 2. Comparison with a conventional blackcurrant juice drink and orange juice. *J Dent* 1999;27:341-4.
28. Featherstone JD, Rodgers BE. Effect of acetic, lactic and other organic acids on the formation of artificial carious lesions. *Caries Res* 1981;15:377-85.
29. Bibby BG, Mundorff SA. Enamel demineralization by snack foods. *J Dent Res* 1975;54:461-70.
30. Miller CD. Enamel erosive properties of fruits and various beverages. *J Am Diet Assoc* 1952;28:319-24.
31. Imfeld TN. Identification of low caries risk dietary components. *Monogr Oral Sci* 1983;11:1-198.
32. Stephan RM. Effects of different types of human foods on dental health in experimental animals. *J Dent Res* 1966;45:1551-61.
33. Lussi A, Jaeggi T. Erosion — diagnosis and risk factors. *Clin Oral Investig* 2008;12 Suppl 1:55-13.
34. Yoshida Y, Van Meerbeek B, Nakayama Y, Yoshioka M, Snauwaert J, Abe Y, *et al.* Adhesion to and decalcification of hydroxyapatite by carboxylic acids. *J Dent Res* 2001;80:1565-9.
35. Attin T, Koidl U, Buchalla W, Schaller HG, Kielbassa AM, Hellwig E. Correlation of microhardness and wear in differently eroded bovine dental enamel. *Arch Oral Biol* 1997;42:243-50.
36. Lussi A, Jaeggi T, Jaeggi-Scharer S. Prediction of the erosive potential of some beverages. *Caries Res* 1995;29:349-54.
37. Lendenmann U, Grogan J, Oppenheim FG. Saliva and dental pellicle—a review. *Adv Dent Res* 2000;14:22-8.
38. Meurman JH, Frank RM. Scanning electron microscopic study of the effect of salivary pellicle on enamel erosion. *Caries Res* 1991;25:1-6.
39. Amaechi BT, Higham SM, Edgar WM, Milosevic A. Thickness of acquired salivary pellicle as a determinant of the sites of dental erosion. *J Dent Res* 1999;78:1821-8.
40. Nekrashevych Y, Stosser L. Protective influence of experimentally formed salivary pellicle on enamel erosion. An *in vitro* study. *Caries Res* 2003;37:225-31.

How to cite this article: Sener Y, Botsali MS, Kucukyilmaz E, Tosun G, Altunsoy M. Influence of soft drinks on dental enamel: An *in vitro* study. *J Pediatr Dent* 2013;1:42-5.
Source of Support: Nil. **Conflict of Interest:** None declared.



New features on the journal's website

Optimized content for mobile and hand-held devices

HTML pages have been optimized of mobile and other hand-held devices (such as iPad, Kindle, iPod) for faster browsing speed.

Click on **[Mobile Full text]** from Table of Contents page.

This is simple HTML version for faster download on mobiles (if viewed on desktop, it will be automatically redirected to full HTML version)

E-Pub for hand-held devices

EPUB is an open e-book standard recommended by The International Digital Publishing Forum which is designed for reflowable content i.e. the text display can be optimized for a particular display device.


Click on **[EPub]** from Table of Contents page.

There are various e-Pub readers such as for Windows: Digital Editions, OS X: Calibre/Bookworm, iPhone/iPod Touch/iPad: Stanza, and Linux: Calibre/Bookworm.

E-Book for desktop

One can also see the entire issue as printed here in a 'flip book' version on desktops.

Links are available from Current Issue as well as Archives pages.

Click on  View as eBook