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Comparison of the Effect of Commercial Fruit Juice on Enamel Erosion

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Abstract

This study was to identify the erosive potential of acidic fruit juice on the enamel, and to analyze how the risk on surface is increased by the duration of exposure. Healthy extracted human premolar enamel surfaces were divided into 8 groups by exposure time, including the control group that was exposed to phosphate buffered saline (PBS), and 7 experimental groups that were exposed to 10 ml Taylor Prune Juice for 1, 3, 5, 15, 30, 60, and 120 minutes, respectively. The pH and sugar content of the beverage were measured, and micromorphology were examined by a scanning electron microscope (SEM). The beverage used in present study had a pH as low as 3.74. The effect on the tooth surface was compared by using SEM. It has been shown to cause tooth erosion, he changes on the tooth being damaged, and the tooth particles being exfoliated or cracked irregularly. In addition, it was found that the impact of surface damage increased with the duration of exposure. Based on the study results, avoiding prolonged exposure by consuming the beverage within 10 minutes may reduce the risk of damaging the teeth and help maintain good oral health.

Keywords: Tooth surface; Enamel; Erosion; Fruit juice; Oral health

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Introduction

Oral health is known to be essential for maintaining systematic health throughout life, and maintaining healthy teeth is equally important to a pleasant life (Migliorati CA *et al*., 2007). Consumption culture is constantly changing due to the improvement of living standards. There are various significant changes in food consumption with the introduction of the term ‘well-being’.

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Among them, various refreshments are being developed in the beverage market, and beverage consumption is on the rise as it is easily accessible. Excessive intake of sugar due to increased beverage consumption is a known cause of systemic diseases, which include obesity, diabetes, cardiovascular disease, and other adult diseases (Vartanian LR *et al*., 2007). It is also a major risk factor for oral health (Tahmassebi JF *et al*., 2006). Among the factors that cause tooth erosion, concerns about acidic beverages and their well-known risks have been raised consistently (Järvien VK *et al*., 1991).

Tooth erosion can result from various factors, and it is known to be the destruction of dental soft tissue due to acid without the contribution of bacteria (Infeld T., 1996). Most research studies have demonstrated that dental erosion can be related to the type of acid (Muller RF *et al*., (1949), the pH level (Johansson AK *et al*., 2004), the intake type (Amaechi BT *et al*., 1999), and the titratable acidity (Ehlen LA *et al*., 2008) of drinks. Erosion and decalcification of teeth enamel occur at a pH of 5.0 or below (Meurman JH *et al*., 1996). Food with a pH below 4.0 is reported to increase the risk of tooth erosion (Rytomaa I *et al*., 1988). Most of the beverages have a pH below 4.0, and sour fruit that has a high acid value frequently causes tooth erosion (Willershausen B *et al*., 2008). Furthermore, Millward et al. (1994) reported that consuming fruit juice at night when saliva flows the least is highly associated with most severe cases of erosion, and fruit juice causes the most severe tooth erosion.

Previous studies have shown that dietary factors (e.g., acidic beverages) are significantly associated with tooth erosion (Zero DT., 1996; Gudmundsson K *et al*., 2004; Jensdottir T *et al*., 2005). Erosion increases the risk of dental caries (McDonald Jr JL *et al*., 1973) and produces an environment prone to plaque as the outermost enamel that is most resistant to caries is dissolved (White DJ., 1987). As frequent and excessive intake of these beverages is considered to be harmful to dental soft tissue, consistent research on the effect of fruit juice on tooth surface is deemed necessary.

Recommendations and policies are also being implemented worldwide in order to reduce sugar intake, with the World Health Organization recommending that sugar content to be less than 10% of the total calories (Nishida C *et al*., 2004). The Korean nutrition standard recommends a sugar intake of less than 10% to 20% of the total calories, and sugar intake from fruit, vegetables, and milk to be as much as 10% of the total calories (Jun MK *et al*., 2016). The currently available studies on the risk factors related to oral health are limited to the tooth erosion potential of a single factor, such as sugar content or acidity (Kit BK *et al*., 2013; Oh HN *et al*., 2015).

Therefore, the present study was conducted in order to identify not only the acidity, but also the

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sugar content, of the fruit juice marketed in Korea, and to examine the extent of erosion with regard to the exposure frequency of the enamel surface to beverages due to frequent consumption.

Materials and Methods

Tooth preparation

The extracted human premolar tooth without dental caries, pigmentation, and cracking were observed using a stereoscopic microscope (SZ-CTV, Olympus, Tokyo, Japan). The enamel surfaces of each tooth was obtained using a hard-tissue cutter equipped with a low-speed diamond saw (Struers Minitom, Struers, Denmark). The enamel parts were divided into a total of 8 groups. Thespecimensof control group were immersed in phosphate-buffered saline (PBS). The experimental groups were immersed in 10 ml test juice for 1, 3, 5, 15, 30, 60, and 120 minutes in order to observe the surface changes over time.

Study materials

Taylors Farms Taylor Prune Juice was used in this study, and the pH provided by the manufacturer was 3.8 to 4.0 (margin of error±0.23).

Sugar content and pH measurement

The beverage was calibrated with a standard buffer solution and incubated at room temperature for 2 hours. It was poured in a 100 ml beaker and its pH was measured by a pH meter (water quality pH meter, LAQUA, HORIBA, Japan). The sugar content was measured by using a digital saccharimeter (PAL-α, Atago, Tokyo, Japan). The value was measured three times, respectively, and the mean value was used.

Scanning electron microscopy (SEM)

Each sample surface was examined by using a scanning electron microscope (SEM) to observe the changes of the crystal structure of the enamel surface and microscopic change of the surface in order to compare the erosive potential by exposure time. The enamel specimens were completely dried in room temperature, invested in platinum, and fixed on the specimen stand with adhesive tape. The enamel surface was magnified by 50,000 under 15 kV.

Results and Discussion

Beverage consumption is steadily increasing due to the growth of the beverage market and westernized diet (Dennis EJ *et al*., 2017). Nowadays, people are frequently consuming fruit juice for health purposes. Most of the juice products on the market are acidic and are known to cause various effects on teeth, such as tooth erosion (Allan DN., 1967). Erosion may be caused

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by frequent consumption of acidic beverages (Eygen VI *et al*., 2005). It is reported that the daily or weekly consumption of acidic beverages is strongly associated with tooth erosion (Järvien VK *et al*., 1991). This study examined the erosive potential of frequently consumed fruit juice and observed changes on the affected tooth surface.

The pH and sugar content of Taylor Prune Juice are presented in Table 1. The pH provided by the manufacturer was 3.8 to 4.0 (margin of error±0.23), and the measured value was 3.74±0.006, within the range specified by the manufacturer. The pH of the test juice was low and the acidity was high.

Based on previous research that observed enamel erosion after exposure to 7 beverages with pH of 3.01, the pH is significantly associated with the decrease in enamel surface hardness (Kim EJ *et al*., 2012). Lee et al. reported that exposure to orange juice with an average pH of 4.0 results in enamel erosion within 10 minutes (Lee CY *et al*., 2004). Similarly, this study showed that a pH as low as 3.74 has a significant effect on the tooth surface, which results in tooth erosion.

The sugar content of the juice measured by using a saccharimeter was 388.33±30.989. It is known that the occurrence of tooth caries increases with sugar content (van Loveren C., 2019). Since tooth decalcification is followed by dental caries, high sugar content is considered to be associated with tooth erosion. Therefore, high sugar content and low pH are likely to increase the risk of erosion on tooth surface.

SEM is a nondestructive method for measuring tooth erosion (Eisenburger M *et al*., 2001). This study investigated the risk of tooth surface damage with regard to extended exposure to the environment of interest due to frequent beverage consumption, and the exposure time studied ranged from 1 minute to 120 minutes. The effect on the tooth surface was compared by using SEM (Fig. 1). The surface was smooth after a 1-minute exposure, similar to the control group, but a 10-minute exposure showed that the surface was not smooth and cracks between particles were observed. A similar pattern was observed in longer durations with increased severity. For the control group, which was exposed to distilled water, there was no crevice or damage seen on the tooth surface. Meanwhile, surface damage, including grooves on the surface, exfoliation of tooth particles, or cracks, was observed as the duration of exposure was extended. The surface roughness was higher in the 10-minute exposure as opposed to the 1-minute exposure. Moreover, the surface roughness distinctively increased in 30 minutes compared to 10 minutes, and 60 minutes compared to 30 minutes, thus demonstrating surface loss.

Although a variety of juice was not observed in this study, the test juice was found to be acidic and associated with tooth erosion. The eroded teeth were compared, and the erosive potential

increased with the duration of exposure.

It is therefore recommended to consume the fruit juice within 10 minutes and avoid consuming the beverage for a longer duration in order to maintain good oral health and reduce the risk of damaging the teeth. Accurate information based on titrated acidity is deemed necessary when guidance for the prevention of tooth erosion is provided.

Conclusion

Sugar content and pH were assessed with regard to oral health risk, and the habit of frequently consuming the fruit juice used in this study should be avoided. In addition, acidic juice of low pH is not recommended as it may adversely affect the surface of the teeth.

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References(Harvard Style)

1. Migliorati C.A. and Madrid C., 2007. The interface between oral and systemic health: the nee d for more collaboration. *Clin Microbiol Infect*, 13(4 Suppl), 11-16.
2. Vartanian L.R., Schwartz M.B. and Brownell K. D., 2007. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health*, 97(4), 66 7-75.
3. Tahmassebi J.F., Duggal M.S., Malik-Kotru G. and Curzon M.E.J., 2006. Soft drinks and den tal health: a review of the current literature. *J Dent*, 34(1), 2-11.
4. Järvien V.K., Rytömaa I.I. and Heinonen O.P., 1991. Risk factors in dental erosion. *J Dent R es*, 70(6), 942-947.
5. Infeld T., 1996. Dental erosion. Definition, classification and links. *Eur J Oral Sci*, 104, 151-155.
6. Muller R.F. and Gortner Jr.R.A., 1949. The influence of sugar content on pH in vivo decalcifi cation of rat molar teeth by acid beverages. *Arch Biochem Biophys*, 20(1), 153-8.
7. Johansson A.K., Lingström P., Imfeld T. and Birkhed D., 2004. Influence of drinking method on tooth-surface pH in relation to dental erosion. *Eur J Oral Sci*, 112(6), 484-489.

8. Amaechi B.T., Higham S.M. and Edgar W.M., 1999. Factors influencing the development of dental erosion in vitro: enamel type, temperature and exposure time. *J Oral Rehabil*, 26(8), 624-630.
9. Ehlen L.A., Marshall T.A., Qian F., Wefel J.S. and Warren J.J., 2008. Acidic beverages increase the risk of in vitro tooth erosion. *Nutr Res*, 28(5), 299-303.
10. Meurman J.H. and Ten Cate J.M., 1996. Pathogenesis and modifying factors of dental erosion. *Eur J Oral Sci*, 104(2), 199-206.
11. Rytomaa I., Meurman J.H., Koskinen J., Laakso T., Gharazi L. and Turunen R., 1988. In vitro erosion of bovine enamel caused by acidic drinks and other foodstuffs. *Eur J Oral Sci*, 96(4), 324-33.
12. Willershausen B., Callaway A., Azrak B. and Duschner H., 2008. Influence of apple juice on human enamel surfaces of the first and second dentition - an in vitro study. *Eur J Med Res*, 13(7), 349-354.
13. Millward A., Shaw L., Smith A.J., Rippin J.W. and Harrington E., 1994. The distribution and severity of tooth wear and the relationship between erosion and dietary constituents in a group of children. *Int J Paediatric Dent*, 4(3), 15115-15117.
14. Zero D.T., 1996. Etiology of dental erosion-extrinsic factors. *Euro J Oral Sci*, 104(2 (Pt 2)), 162-177.
15. Gudmundsson K., Theodors A., Holbrook W. P., Bardow A., Thorsdottir I., Jensdottir T. et al., 2004. Relationship between dental erosion, soft drink consumption, and gastroesophageal reflux among Icelanders. *Clin Oral Investig*, 8(2), 91-96.
16. Jensdottir T., Bardow A. and Holbrook P., 2005. Properties and modification of soft drinks in relation to their erosive potential in vitro. *J Dent*, 33(7), 569-75.
17. McDonald Jr. J.L. and Stookey G.K., 1973. Laboratory studies concerning the effect of acid containing beverages on enamel dissolution and experimental dental caries. *J Dent Res*, 52(2), 211-216.
18. White D.J., 1987. Reactivity of fluoride dentifrices with artificial caries. I. Effects on early lesions: F uptake, surface hardening and remineralization. *Caries Res*, 21(2), 126-140.
19. Nishida C., Uauy R., Kumanyika S. and Shetty P., 2004. The joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. *Public Health Nutr*, 7(1A), 245-250.
20. Jun M.K., Lee D.H. and Lee S.M., 2016. Assessment of nutrient and sugar content and pH of

some commercial beverages. *J Dent Hyg Sci*, 16(6), 464-471.

21. Kit B.K., Fakhouri T.H., Park S., Nielsen S.J. and Ogden C.L., 2013. Trends in sugar-sweete ned beverage consumption among youth and adults in the United States: 1999-2010. *Am J Cli n Nutr*, 98(1), 180-188.
22. Oh H.N. and Lee H.J., 2015. The effect of energy drink on enamel erosion. *J Dent Hyg Sci*, 1 5(4), 419-423.
23. Dennis E.J., Kang M.J. and Han S.N., 2017. Relation between beverage consumption pattern and metabolic syndrome among healthy Korean adults. *Korean J Community Nutr*, 22(5), 44 1-55.
24. Allan D.N., 1967. Enamel erosion with lemon juice. *Br Dent J*, 122(7), 300-302.
25. Eygen V.I., Vannet B.V. and Wehrbein H., 2005. Influence of a soft drink with low pH on en amel surfaces: an in vitro study. *Am J Orthod Dentofacial Orthop*, 128(3), 372-377.
26. Kim E.J., Lee H.J., Lee E.J., Bae K.H., Jin B.H. and Paik D.I., 2012. Effects of pH and titrata ble acidity on the erosive potential of acidic drinks. *J Korean Acad Oral Health*, 36(1), 13-19 .
27. Lee C.Y., Jung T.S. and Kim S., 2004. A study on the enamel erosion caused by orange juice s. *J Korean Acad Pediatr Dent*, 31(4), 617-624.
28. van Loveren C., 2019. Sugar restriction for caries prevention: amount and frequency. which i s more important?. *Caries Res*, 53(2), 168-175.
29. Eisenburger M., Addy M., Hughes J.A. and Shellis R.P., 2001. Effect of time on the reminera lization of enamel by synthetic saliva after citric acid erosion. *Caries Res*, 35(3), 211-215

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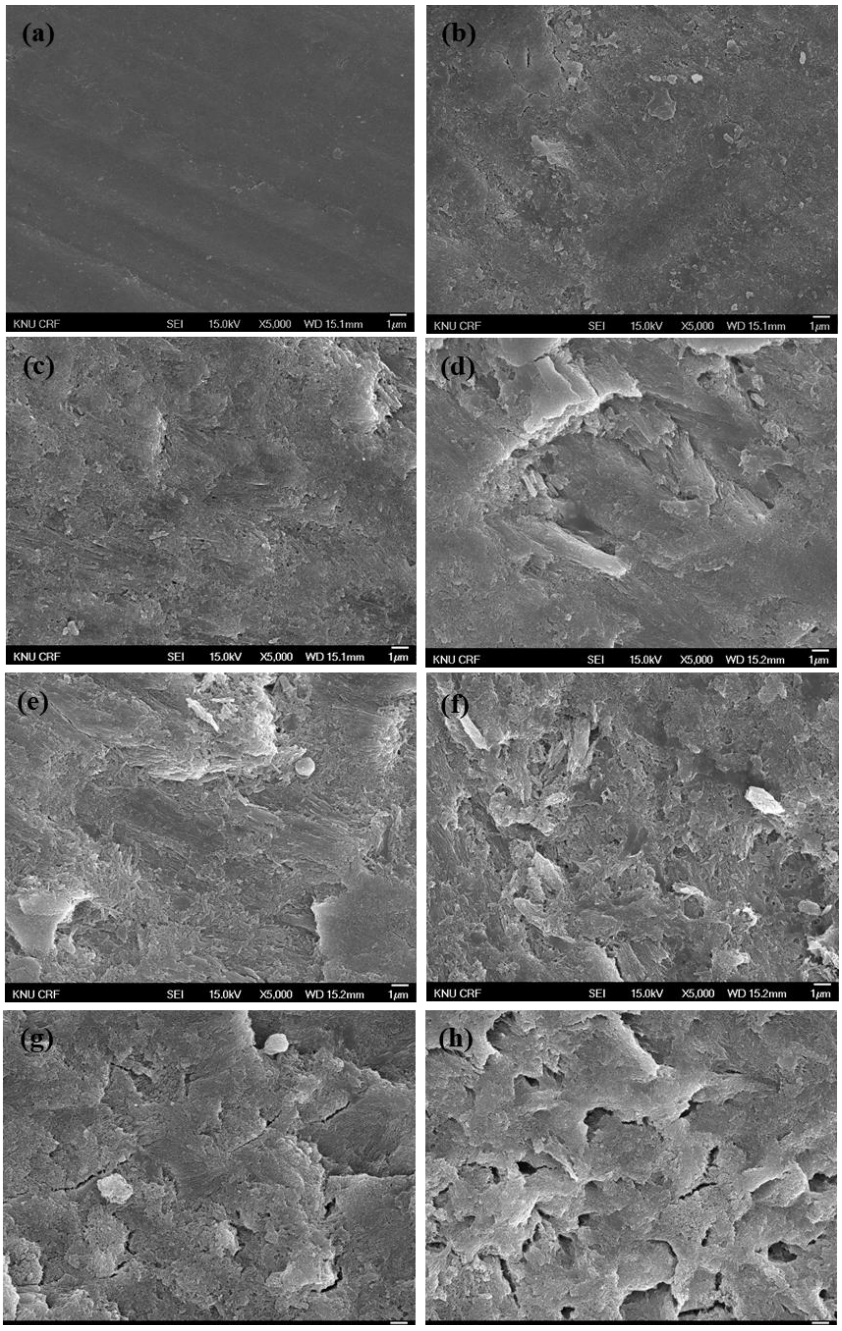

Figure 1. SEM images of tooth morphology according to treatment time (×50,000). (a) control, (b) 1 minute, (c) 3 minutes, (d) 5 minutes, (e) 15 minutes, (f) 30 minutes, (g) 60 minutes, and (h) 120 minutes.

Table 1: Characteristics of the Test Juice

Characteristics	Mean±SD
pH	3.74±0.006
Sugar content	388.33±30.989