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A Comparative Evaluation of Dental Erosion Caused by Tetra-packed and Aerated Beverages: An In-Vitro study

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Abstract

Introduction: Dental erosion is an evolving concern with the food market globalization. In a rapidly developing nation as India, beverage consuming behavior has significantly increased. There is free access to new foods and beverages even in the neighborhood grocery stores and they are perceived as modern and healthy. Extrinsic erosion appears to be a growing problem as a result of overconsumption of soft drinks or fruit juices or both**. Materials and Methods:** Freshly extracted premolars were treated with H_20_2 for 24 hours and weighed with 'Essae FB-200' with a readability of 0.001 gram. The beverages were grouped into 2 categories, 1- Natural or tetra-packed beverages, 2 - aerated beverages and a control. 20ml of each beverage was taken and the pH was measured. The tooth was immersed in each of the beverage and pH were noted 4th hourly for 48 hours accounting for sipping the beverage for 5 minutes every day for 1.5 years. The weight of the tooth was rechecked after 48 hours. **Results:** The mean pre-treatment pH of category 1 was 5±1.33 and that of category 2 was 4.66±1.32. There is no significant difference in the mean loss of weight between the two groups (p-value 0.94) there is no significant difference in the mean change of pH between the two groups (p-value 0.26) **Conclusion:** The objective erosive liability of tetra-packed and aerated beverages on the dental enamel was found to be similar. However, natural fruit juices showed nil to negligible objective signs of dental erosion.

Keywords: *Beverage, Dental erosion, Enamel*

Introduction

Enamel forms a protective layer over the entire surface of the crown. It consists of 96% inorganic material, 4% of organic substance & water. (1) It is constantly exposed to changing environments, and a significant portion of such changes is brought about by the type of diet consumed by the individual. (2) The dynamic nature of the oral environment is a major contributing factor for many of the prevalent dental conditions such as dental caries, periodontitis and of recent times, dental erosion. Erosion is a progressive dissolution of tooth substance by exposure to acids, without the involvement of bacteria which could be either intrinsic or extrinsic. Extrinsic dental erosion is an evolving concern with the food market globalization. In a rapidly developing nation as

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India, beverage consuming behavior has significantly increased. Juice & juice-based drinks are growing 2.5 times faster than aerated drinks. [3] Enamel present in the fully formed crown has no viable cells, hence enamel lost after a tooth has erupted cannot be formed again. [4] Accordingly dental erosion is irreversible which could further lead to hypersensitivity, the unaesthetic appearance of teeth, and can also lead to loss of vertical dimension. All of this could add up to the burden of oral diseases, decreasing the quality of life. [5] Hence an experimental study was conducted to compare the dissolution caused by tetra-packed beverages and aerated beverages on freshly extracted teeth.

Materials and Methods

Experimental design

An in-vitro study was designed to compare the erosive liability by measuring physiochemical properties like pH and calcium dissolution by measuring the weight of the tooth to assess the amount of dissolution of calcium into the beverage thereby leading to a loss in tooth structure.

Sample size

Sample size was calculated to be 20 (10 in each group) by setting a Power of 80%, level of significance at 5% and an effect size of 1.2 using G*Power software version 3.1.9.7. [6]

Beverage selection

The commonly consumed beverages in India were identified and categorized as

Category 1 - Natural or tetra-packed beverages

Category 2 - Aerated beverages and

The control was taken as distilled water.

The beverages under category 1 were fresh apple juice, fresh grape juice, tea, Amul Masti buttermilk, Amul lassi, B natural mixed, Tropicana mixed, Real orange, Nescafe and Frooti. The beverages under category 2 were Pepsi, Miranda, Slice, Bovonto, Eno, Limca, Pulpy orange, Coco-cola, and Maaza.

Physiochemical properties

20 ml of each beverage was poured in a labelled plastic transparent cup. The pre-treatment pH before the placement of tooth was noted for each of the beverage with PSI universal full range pH (1-14) strips (A-70, MIDC Industrial Area, Amravati, Maharashtra 444607)

Tooth Preparation

The selection criteria for the teeth are that they are freshly extracted permanent maxillary and mandibular premolars weighing between 4 to 4.85 grams. The teeth were treated with hydrogen peroxide for 24 hours. Each tooth is weighed before placement in the assigned beverage.

Measurement

The freshly extracted teeth were immersed in the beverage for 48 hours. Immersing in the beverage for 48 hours would account for sipping the beverage every day for 5 minutes for 1 and a half years. The pH of the beverage was then measured at a 4-hour interval for 48 hours.

After 48 hours the tooth was removed from the beverage and rinsed with distilled water. The weight of the tooth was then measured on a calibrated weighing scale 'Essae FB-200' with a readability of 0.001 gram (# 410, 100ft Road 4th Block, Koramangala, Bengaluru, Karnataka – 560034)

Statistical Analysis

Descriptive and inferential statistics were analyzed by IBM SPSS version 20.0. Throughout the study, a 'P' value of <0.05 was considered as a statistically significant difference. [7]

Results

Table 1 shows that beverages B natural, Frooti, Pepsi, Miranda and Pulpy orange showed a low pre-treatment pH of 3 before placement of the tooth. The mean pre-treatment pH of category 1 was 5±1.33 and that of category 2 was 4.66±1.32. Immersing the freshly extracted teeth in the beverages for 48 hours showed an increase in mean pH from day 1 to day 2 as 3±0 to 4.1±0.4 in B natural, 6.5±0.54 to 7±0 in Amul Masti buttermilk and Amul lassi, 4±1.5 to 5.5±0.54 in Pepsi, 6.33±0.51 to 8.66±0.51 in Eno, 3.7±0.75 to 6±0 in Pulpy orange and 5±0 to 6±0 in Coco-Cola. The other beverages showed the following changes in pH between day 1 and day 2 – Tea 7±0 to 7.66±0.51, Tropicana mixed 3.66±0.51 to 3.33±0.51, Real orange 4.66±0.51 to 3.83±0.4, Nescafe 6.5±0.54 to 7±0, Frooti 3.5±0.54 to 4±0, Miranda 2.66±0. 51 to 3±0, Slice 5±0 to 5.33±0.51, Bovanto 4.66±0.51 to 3±0 and Limca 6.14±0.4 to 7.66±0.51. However, there was an almost negligible increase in pH in fresh apple juice (5±0 to 5±0), fresh grape juice (5±0 to 5.66±0.51) and Maaza (6±0 to 6±0). The control showed a constant pH of 7 throughout the 48 hours. Table 2 shows weight of the tooth before and after placement in each beverage for 48 hours. The mean weight of teeth considered for placing in the tetra-packed beverages and aerated beverages was 4.425±0.35 and 4.442±0.22 respectively. After 48 hours the mean weight of tooth in tetra-packed and aerated beverages was 4.311±0.33 and 4.326±0.23. Comparison of mean difference in weight before and after placement in the beverage for 48 hours revealed no significant difference between the two beverages (p-value = 0.9)

TABLE 1: pH of Tetra-packed and Aerated beverages

Beverage	Pre pH	Post pH at 24 hrs	Post pH at 48 hrs
Fresh apple juice	5	5±0	5±0
Fresh grape juice	5	5±0	5.66±0.51
Tea	7	7±0	7.66±0.51
Amul masti	6	6.5±0.54	7±0
Amul lassi	6	6.5±0.54	7±0
B natural mixed	3	3±0	4.16±0.4
Tropicana mixed	4	3.66±0.51	3.33±0.51
Real orange	5	4.66±0.51	3.83±0.4
Nescafe	6	6.5±0.54	7±0
Frooti	3	3.5±0.54	4±0
Water	7	7±0	7±0
Pepsi	3	4±1.54	5.5±0.54
Miranda	3	2.66±0.51	3±0
Slice	5	5±0	5.33±0.51
Bovonto	5	4.66±0.51	3±0
Eno	6	6.33±0.51	8.66±0.51
Limca	6	6.14±0.4	7.66± 0.51
Pulpy orange	3	3.71±0.75	6±0
Coco-Cola	5	5±0	6±0
Maaza	6	6±0	6±0

TABLE 2: Weight of tooth before and after 48 hours

Beverage	Pre-weight	Post-weight
Fresh apple juice	4.85	4.77
Fresh grape juice	4.33	4.26
Tea	4.9	4.71
Amul masti	4.53	4.43
Amul lassi	4.05	4
B natural mixed	4.02	3.84
Tropicana mixed	4	3.99
Real orange	4.79	4.65
Nescafe	4.57	4.45
Frooti	4.21	4.01
Water	4	3.89
Pepsi	4.63	4.49
Miranda	4.7	4.64
Slice	4.13	4.03
Bovonto	4.12	4
Eno	4.34	4.22
Limca	4.53	4.43
Pulpy orange	4.41	4.27
Coco-Cola	4.71	4.63
Maaza	4.41	4.23

TABLE 3: Comparison of change in pH after the procedure, between the two groups

Group	Mean change of pH	SD	SEM	Mean difference	95% Confidence Interval		t	P-value
Tetra-packed beverages	.333	0.571	.180	-0.500	-1.42	0.42	1.14	0.26
Aerated beverages	.833	1.244	.414					

Test: Mann-Whitney U test (Non-parametric equivalent of Student's t-test: Since SD is not less than half the mean value)

Inference: The test shows that there is no significant difference in the mean change of pH between the two groups

TABLE 4: Comparison of loss of weight after the procedure, between the two groups

Group	Mean change	SD	SEM	Mean difference	95% Confidence Interval		t	P-value
Tetra-packed beverages	0.114	0.064	0.020	-.00156	-.052	.049	0.065	0.94
Aerated beverages	0.116	0.036	0.012					

Test: Mann-Whitney U test (Non-parametric equivalent of Student's t-test: Since SD is not less than half the mean value)

Inference: The test shows that there is no significant difference in the mean loss of weight between the two groups

Discussion

Earlier studies reveal the effects of carbonated beverages and acidic dietary choices leading to an increased prevalence of dental erosion. A study by Al-Malik MI on the relationship between erosion, caries and rampant caries and dietary habits in preschool children in Saudi Arabia showed a direct relationship between carbonated beverage consumption and dental erosion. [8] However tetra-packed juices are consumed as a replacement to fresh fruit juices increasingly especially with the ease of availability. In the present study B natural, Frooti, Pepsi, Miranda and Pulpy orange showed a pre-treatment pH of 3 before placement in the beverage. Of which Pepsi showed a pH change from 4±1.5 to 5.5±0.54. A study by Avanija Reddy et al 2016 on the pH of beverages in the United States showed that pH <3 were considered extremely erosive. [9] A study by Rafey Ahmad Jameel et al 2016 showed that all beverages exhibited a positive erosive effect on the tooth enamel

surface on quantitative analysis of tooth erosion, micro hardness, surface hardness and surface height ($p<0.005$). [10] A study by Leonardo S Antunes et al 2017 on Sports drink consumption and dental erosion among amateur runners that there was no significance between the association of isotonic drinks & dental erosion. [11] In the present study beverages containing isotonic pH showed nil to negligible change in pH after 48h hours. A study by Yousef H Al-Dlaigan 2017 showed that Sixty per cent of the children regularly consumed juice drinks. Among daily consumers, 84% of children showed erosion prevalence with a strongly significant association ($p < 0.005$). Holding the drink in the mouth also showed a significant association with erosion ($p < 0.02$). [12] These results agree with the present study, as greater the exposure time, the greater is the erosion that is objectively identified by an increase in pH. A study by Palak Shroff, Shailesh M Gondivkar et al 2018 showed that that the mean titratable acidity values of the packaged fruit juices were higher than carbonated drink [13] which agrees with the present study as both tetra-packed and aerated beverages showed a mean pre-treatment pH of 5±1.33 and 4.66±1.32 respectively. Limitations to the present study are that rather than measuring the subjective signs of erosion, objective signs of erosion were measured. They are the change in weight and pH. A study by Brent L Gravelle et al 2015 on Soft drinks and invitro erosion showed there was a significant positive correlation between the amount of titratable acid and percentage of tooth erosion, while a significant negative correlation was revealed between the beverage pH and percentage of tooth erosion. [5] This study serves as a pilot showing that the difference in erosion caused by tetra-packed beverages and aerated beverages are not significant.

Conclusion

The objective erosive liability of tetra-packed and aerated beverages on the dental enamel was found to be similar. The greater the exposure time of the beverage to the tooth surface, the greater is the erosion. However, natural fruit juices showed nil to negligible objective signs of dental erosion. Hence, although the tetra-packed beverages are consumed with the intent of an alternative substitute for natural fruit juices, they are as erosive as the aerated beverages.

Ethical Clearance: Taken from CARE IHEC committee, Tamilnadu.

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Conflicts of Interest: There is no conflicts of interest

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