EFFECTS ON THE ENAMEL DUE TO THE CARBONATED DRINKS — A SEM STUDY

S KAZMI, A MUGHAL, M HABIB, M AYAZ, H TARIQ, ARSHMAN KHAN

ABSTRACT

Carbonated beverages are becoming immensely popular among individuals. These drinks are one of the major contributing factors which lead to the dissolution of apatite crystals of enamel. Study the effects of different carbonated drinks on the labial surface of enamel and its esthetic outcomes. The objective differences of various drinks are examined and evaluated under SEM.

Twelve extracted anterior teeth were selected and thoroughly cleansed for debris and disinfected by sodium hypochlorite for 24 hours. Distributed into four groups, these samples were submerged into different carbonated drinks (Pepsi, carbonated juice-Big Apple, Sports drink-Sting, control group-natural saliva) each for 5min, in 4 cycles per day (6hours apart) for 15 days. The samples from the control group were exposed to natural saliva during experimentation. Throughout the experiment the samples were stored in Saline (0.9% W/V NaCl). This storage medium was changed on daily basis and in each cycle a new chilled (at 3-4°C) bottled drink was used. Samples were dried under a lamp keeping a safe distance of 15cm, coated with Aurum (gold) foil to be examined under the JSM-5200 Scanning Electron Microscope (JEOL, Tokyo, Japan) at 20kV and were then photographed at different magnitudes. The SEM images show rough enamel surface which is due to the acidic content (phosphoric acid and citric acid) of Pepsi, carbonated drink and sports drink. As the samples were immersed in (NaOCl) for 24 hours, it is expected that micro pores noticed in the images from control group were developed due to this initial immersion. It is reported that NaOCl create 3-8 micron pores on the surface of tooth after immersion.

It was concluded acidic soft drinks induce roughness on the enamel, which eventually reduces the mechanical and physical properties of the structure. These changes in physical properties render the enamel more vulnerable to staining, fracturing and developing of caries.

Key Words: Carbonated drinks. Anterior teeth. Surface roughness. SEM.

INTRODUCTION

Nutritional intake and dietary habits affect the structural characteristics of both deciduous and permanent dentition. This happens not only through the indirect effect of nutrition on tooth development but also through the direct effect associated with the erosive characteristics of the drinks. Carbonated beverages used for quenching thirst are much popular among all age groups nowadays and the commercial sale has been increased as well. These beverages are acidic in formulation, having cariogenic potential as well and their excessive consumption is associated with damage to the tooth structure like erosion. Tooth erosion is caused by multifactorial but divided into two categories such as intrinsic and extrinsic. Intrinsic factors are related to gastric acid produced by gastrointestinal disturbances. Nourishment, life style and environmental factors are the extrinsic factors.
Enamel is the hardest biological tissue and its stability depends on pH dependent and salivary minerals.\textsuperscript{9,10} Dissolution of the enamel starts at the critical pH of around 5.5.\textsuperscript{2} Carbonated drinks are identified acidic in nature and are a major contributing factor in the enamel dissolution.\textsuperscript{11} Also, these acids are one of the etiological causes of the dental erosion.\textsuperscript{12} This dental erosion is defined as nonbacterial chemical reaction which releases the Ca, OH and PO\textsubscript{4} mineral ions from the enamel hydroxyapatite.\textsuperscript{13}

Surface roughness is a measure of the texture of a surface which is quantified by the vertical deviations of a real surface from its ideal form. Larger the deviations, the surface is rough and smaller the deviations, the surface is smooth.\textsuperscript{14} The aim of this study is to investigate the effects produced by different acids found in carbonated drinks on the enamel morphology at micron level with the use of Scanning Electron Microscopy.

**METHODOLOGY**

This research proposal was approved by Riphah Academy of Research and Education (RARE). Twelve samples were selected from the 40 extracted human anterior teeth. After extraction, the sample teeth were cleared from soft tissue detritus under running tap water and then carefully inspected for caries and other defects under dental chair light. Restored, caries and fractured tooth were excluded. The sample teeth were decontaminated in Sodium Hypochlorite (NaOCl) for 24 hours. The samples were stocked in normal saline (0.9 % W/V NaCl) during the whole experimentation.

These 12 specimens were distributed into four classes, three teeth in each class. Carbonated apple juice (Big Apple), Carbonated Soft drink (Pepsi), carbonated sports drink (Sting) were chosen for the experimentation procedure and were divided as such:

- **Class 1:** Carbonated Apple Juice
- **Class 2:** Carbonated Soft Drink
- **Class 3:** Carbonated Sports Drink
- **Class 4:** Control group (Saline).

In carbonated apple juice the constituents are sugar, citric acid, carbonated water and apple flavor. The constituents of carbonated soft drink are; sugar, high fructose corn syrup, caramel color, Phosphoric acid, caffeine, citric acid and natural flavors.\textsuperscript{15} Carbonated sports drink contains carbonated water, sugar, citric acid and artificial flavors as its constituents. The drinks were stored at 4°C temperature. The pH of the drinks was measured with the help of pH strips manufactured by the Orion Industries China. The pH values of these beverages and storage medium (saline) are shown in Table 1.

### TABLE 1: pH MEASUREMENTS OF LIQUIDS UTILIZED IN THIS STUDY

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Samples Contents</th>
<th>Measured pH using pH paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apple Juice (Big Apple) Citric acid</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>2</td>
<td>Soft Drink (Pepsi) Citric acid</td>
<td>2.0-3.5</td>
</tr>
<tr>
<td>3</td>
<td>Sports Drink (Sting) Citric acid</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>4</td>
<td>Control group (Saline) Sodium chloride &amp; water</td>
<td>7.0</td>
</tr>
</tbody>
</table>

The experiment was carried out for fifteen days. Each day experiment was performed four times (cycles) with six hours interval between each cycle. The specimens were submerged into their assigned 50 ml of chilled drinks for five minutes each and shaken continuously manually. Soon after each cycle, the teeth were shifted to storage medium i.e. normal saline. Every time new drinks were used and the experiment was carried out between 25 to 30°C temperatures. The storage medium was also changed on the daily basis.

The teeth were exposed to different but specific liquids and after the exposures the teeth were placed under the lamp with distance of 15 centimeter for drying. After drying the teeth were layered with gold and inspected under the JSM-5200 SEM (JEOL, Tokyo, Japan) at 20 kV in different magnifications and photographs were taken.

**RESULTS**

Images of gold coated surfaces of enamel, after 15 days of exposure to carbonated apple juice, carbonated soft drink and carbonated sports drink along with the control group, taken under SEM are shown in Figu 1, 2, 3 and 4 respectively.

**Class 1**

Fig 1 (a, b) showed the honey-comb pattern of rod and inter-rod structure. The SEM observation of the enamel surface thus indicates disturbances in the crystal orientation resulting in surface roughness.

**Class 2**

Fig 2 (a, b) showed fish scale appearance. The SEM investigation indicates that due to high acid content, porosities and structural alternations are created at the
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The core of the prisms. These disturbances are markedly high in this class of carbonated drink.

**Class 3**

Fig 3 (a, b) showed no specific pattern. The results of this group revealed some amount of surface irregularities and pitting as observed in case of carbonated sports drink.

**Class 4**

Fig 4 (a, b) showed no specific pattern as well. SEM observation of this group showed comparatively smooth surface with pitting and micro holes, expected to be formed as a result of initial immersion in the disinfect medium (NaOCl).

DISCUSSION

For our study we used sound human anterior teeth, extracted because of different dental procedures which showed no signs of caries and fillings. Anterior teeth were chosen for esthetic concerns. When we planned our study, we assumed consumption of about 200ml of carbonated drinks belonging to soft drink, juice and sports drink family over a period of 20 minutes a day which are very popular among the users these days. The total exposure time for 15 days, thus, was 100 minutes (1hr 40mins) fulfilling the purpose of excessive intake.

Our investigation was carried out to analyze the surface roughness caused by exposure of carbonated drinks on tooth enamel resulting in esthetic changes. This experimental plan and artificial pattern of continuous exposure of tooth enamel surface to carbonated drinks were applied following the Ehlen et al\(^{14}\) protocol. All the drinks which we utilized in our study had acidic pH, which on pH measurement revealed that pepsi is most acidic, followed in descending order by carbonated sports drink and then carbonated apple juice. Each of these drinks caused great changes in characteristic appearance of enamel when viewed under Scanning Electron Microscope (SEM). In this regard upon SEM examination we noticed less structural loss in case of sports drink group, followed in ascending order by carbonated apple juice and then pepsi which exhibited clear, much deepened, pitted roughness. This observation suggests that pH plays the key role in enhancing roughness. These findings correlate with the study of Hughes et al\(^{16}\) who found an association between pH and erosion and stated that dental erosion increases upon decrease in pH value. Dugmore et al\(^{17}\) also reported similar findings proving association of carbonated drinks with erosion.

In these results, there is no significant difference between carbonated apple juice and pepsi; however, considering typical images of tooth structure, the images of control group and energy drink are quite different. Carbonated apple juice showed honey-comb like pattern of enamel surface with feather-like surface roughness. Exposure of pepsi resulted in pitted, fish-scale appearance of enamel while carbonated sports drink showed structure less feather-like surface alterations on SEM examination. These results are in agreement with the study of Al-Zainy et al\(^{18}\) who worked on human pre-molars exhibiting similar patterns upon exposure to acidic beverages.

The SEM results revealed that due to high acidic content of the drinks, enamel surface experienced great roughness which is clearly visible in case of pepsi and carbonated apple juice, however, images of teeth submerged in carbonated sports drink were not very clear but they did show structural loss of enamel. These rough surfaces can lead to cracks, disintegration of the tooth structure and ultimately reduce the physical and mechanical characteristics of enamel structure. On the contrary, the control group showed porous structure along with few scratches. It is reported that NaOCl creates 3-8 micron pores on the surface of tooth after...
immersion. As the samples in our study were immersed in sodium hypochlorite for 24 hours before treating them with carbonated acidic drinks, it is expected that micro pores were developed due to NaOCl upon initial immersion.

In this study, it is to be noted that specimens from different groups treated with beverages revealed some sort of different roughness patterns upon examination under SEM. This could be attributed to the difference in compositions of these drinks, as reported by Lussi et al who studied the effect of citric and hydrochloric acids on enamel surface and found that all kinds of acids have specific erosive patterns. They further stated that citric acid is likely to give honey-comb like erosive pattern while hydrochloric acid produces characteristic loosened enamel structure. The study conducted by Von Fraunhofer et al also found that beverages containing higher concentrations of citric acid have an aggressive effect on the enamel surface leading to its dissolution. The acid content determines the erosive potential of a beverage as according to our study Apple Juice (Big Apple) drink had the lowest pH when compared to other drinks suggesting lower pH value has greater erosive effects on the structure of enamel and this was evident in SEM image which showed feather like roughness of enamel surface caused by carbonated apple drink. Apart from pH, buffering capacity plays a vital role in determining the erosive potential of a beverage and is a more accurate method of detecting the erosive potential. The greater the buffering capacity of a beverage, the longer it will take for the saliva to restore the pH value. Sports and carbonated drinks have been reported to have a high buffering capacity and a low pH. Beverages are mostly sweetened with refined carbohydrates and contain additives which in combination with sugar substitutes lead to dissolution of enamel surface. These beverages known for their erosive potential damage the enamel and bring about undesirable esthetic changes in permanent teeth as shown in our study but another area of concern is the effect of these beverages on deciduous teeth in which the dental erosion is aggravated as the deciduous teeth are more porous and having a varying prismatic structure when compared to permanent teeth. The porous nature of deciduous teeth allows them to be easily dissolved by acids until conditioned from exposure to salivary ions.

Results of our study are confined to the labial enamel surface of anterior teeth affecting esthetics upon continuous exposure to carbonated drinks over a time period of 5 days. Other studies concerning the effect over a longer period of time utilizing the protective effect of saliva by creating in vitro oral environment on not only enamel but other tooth forming structures as well (dentine and cementum) can help in a better understanding of the natural phenomenon. Furthermore, our study lacked a surface roughness value and buffering capacity which are highly recommended in this type of study and help to obtain accurate results. More studies are required to be carried out in order to provide some information about the safe amount of carbonated drink which can be utilized by the consumer to expand the scope and knowledge in this field of research.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Arif Habib, School of Materials, National University of Science and Technology, (NUST) Islamabad for his laboratory assistance. Moreover authors would like to thank Mr Shamas, School of Materials, National university of Science and technology (NUST), Islamabad for his cooperation and support with SEM.

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CONTRIBUTIONS BY AUTHORS

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3 M Habib: Experiment carried out, compilation of the results.
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