(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 6, Issue 5 , Page No: 556-564
September-October 2023

IJMSCR

Effect Of Different Soft Drinks On Enamel Surface Roughness Using Optical Profilometry

[1]Rajshekhar Chatterjee, [2]Soumyadeep Mondol, [3]Paromita Mazumdar, [4]Preeti Desai, [5]Gaurav Saha.
[1]MDS Reader, [2]MDS Senior Lecturer, [3] PhD MDS Professor and HOD, [4] MDS Professor, [5] BDS Practitioner,
Department Of Conservative Dentistry And Endodontics,
[1] Guru Nanak Institute Of Dental Science & Research, Panihati, Kolkata, West Bengal, India
[2] Kusumdevi Sunderlal Dugar Jain Dental College & Hospital, Cossipore, Kolkata, West Bengal, India
[3,4] Guru Nanak Institute Of Dental Science & Research, Panihati, Kolkata, West Bengal, India

***Corresponding Author:**
Rajshekhar Chatterjee
MDS Reader In Department Of Conservative Dentistry And Endodontics.
Gurunanak Institute Of Dental Science & Research. Kolkata. Westbengal. India

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Background: The aetiology of dental erosion is complex and multi-factorial, being attributed to a wide range of factors that may be either extrinsic or intrinsic. Amongst the various extrinsic factors, dental erosion can be induced by acidic beverages due to demineralization. Inorganic minerals and organic remnants can be dissolved by acidic solutions, which would result in roughened and weakened enamel surface.

Aims & Objective: To evaluate the change in enamel surface roughness at 7th day caused by 5 different brands of soft drinks. Evaluate the enamel surface roughness changes caused by 5 different brands of soft drinks after 7days of exposure and also Comparison of the enamel surface roughness changes caused by 5 different brands of soft drinks after 7 days of exposure.

Materials & Methodology: To facilitate measuring of the surface roughness parameters, circular molds of 6 mm in diameter and 3 mm deep were taken and filled with by self-cured resin. And sample was embedded in resin and rinsed with water. Finally the samples were exposed to 50 ml of soft drinks for 15 min, 3 times daily, for 7 days. Between immersions, the samples were kept in artificial saliva

Results: One way Analysis of variance (ANOVA) followed by post hoc Tukey's test yielded that there were no statistically significant differences between the five experimental groups and Statistically significant differences were seen between the control group and the experimental group ($p < 0.001$).

Conclusion: All of the tested soft drinks were found to be erosive.

Keywords: ENAMEL, SURFACE ROUGHNESS, OPTICAL PROFILOMETRY, SOFT DRINKS

Introduction

Tooth enamel is a rigid, inert and acellular. It is the most highly mineralized and hardest tissue in the human body, which is a rigid, inert and acellular in nature. It consists of 96 wt% inorganic minerals, which are mainly well-organized carbonated hydroxyapatite crystals, and 2 wt% organic substances such as proteins and 2 wt% water. Dental erosion can be defined as painless irreversible loss of dental hard tissue due to a chemical process (chelation or dissolution) without the involvement of microorganisms Eccles (1979).The aetiology of dental erosion is complex and multi-factorial, being attributed to a wide range of factors that may be either extrinsic or intrinsic.[2,3] Amongst the various extrinsic factors, dental erosion can be induced by acidic beverages due to demineralization. Inorganic

minerals and organic remnants can be dissolved by acidic solutions, which would result in roughened and weakened enamel surface.[6]

In modern day scenario diet is thought to be a major factor in the aetiology of dental erosion and has received the most attention in the dental literature. The main dietary components thought to be involved are citrus fruits and soft drinks.[4] "Soft drinks" is a term used for beverages that doesn't contain alcohol ("hard" liquor). Which has become so much a part of modern living, especially in major urban areas around the world. [1] Even though soft drinks are mainly composed of filtered water, artificial additives and refined sugar, thus offering limited nutritional benefit, they still boost energy.[3]Numerous studies have reported that the acids present in the soft drinks represent a major etiological factor responsible for the erosive lesions of dental enamel. [5,6]

Research has demonstrated that there is a strong correlation between soft beverages and enamel loss. Also the exposure time of erosive challenge in soft drinks does affect the mechanical properties especially the surface integrity of dental enamel. [7] Different brands of soft drinks have different tastes due to their differences in their ingredients, thus will have a difference in their individual pH values.It has been traditionally understood that acidity, the measured pH, is an accurate indicator of the erosive potential of a drink. Baseline pH values gives a measure of the initial hydrogen ion concentration and thus will provide, information of the erosive potential of the drink on enamel.[2,8]

Thus due to these chemical aspects of erosion, the physical characteristics of enamel surface are needed to be evaluated to indicate the loss of tissue due to exposure to various soft drinks.[9]These characteristics can be evaluated by measurement of roughness parameters. [8,9]

Aims & Objectives:

A. To evaluate the change in enamel surface roughness at 7th day caused by 5 different brands of soft drinks.[1,2]

B. To evaluate the enamel surface roughness changes caused by 5 different brands of soft drinks after 7days of exposure.[2]

C. Comparison of the enamel surface roughness changes caused by 5 different brands of soft drinks after 7 days of exposure.[4]

Materials

PRODUCT	MANUFACTURER	INGREDIENTS
Coca Cola (pH= 2.67)	**The Coca-Cola Company, Atlanta, Georgia, United States**	**Carbonated water, Sucrose/high-fructose corn syrup, Caffeine, Phosphoric acid, Caramel, Natural flavorings (which include coca leaf extract)**
Thumbs Up (pH= 2.56)		**Carbonated water, Sugar, Acidity regulator, Caffeine, Natural colour and Added flavours ("Natural, nature identical and artificial flavouring substances").**

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Limca (pH= 3.03)		**Carbonated Water, Sugar, Acidity Regulators, Preservatives, Added flavours [Natural & Nature- Identical Flavouring Substances (Lemon Flavour)]**
Sprite (pH= 3.04)		**Carbonated Water, High Fructose Corn Syrup, Citric Acid, Natural Flavours, Sodium Citrate, Sodium Benzoate**
Pepsi (pH= 2.5)	**PepsiCo, United States**	**Carbonated Water, Sugar, Caramel, Phosphoric Acid, Flavourings (including Caffeine).**

METHODOLOGY

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Maxillary Central

Incisors (n=60) Decoronation at the level of CEJ

Flat enamel sample measuring

5 mm X 5 mm

Measurement and cutting of the crown portion

To facilitate measuring of the surface roughness parameters, circular molds of 6 mm in diameter and 3 mm deep were taken and filled with by self-cured resin.

Surface Roughness Measurement

A profilometric read out was taken for each group samples before subjecting them for the soft drink challenges.[2]The Ra value reading was recorded using a profilometer with 0.8 mm cutoff and 0.25 mm/s speed. three measurements were made and an average was calculated.[4,6]The Profilometric measurement was carried out again for each group samples after 7 days after the completion of the procedure. [7,8]

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Each enamel sample was embedded in resin and rinsed with water and dried with compressed air.

- Group 1:- Coca Cola
- Group 2:- Thumbs Up
- Group 3:- Pepsi
- Group 4:- Limca
- Group 5:- Sprite
- Group 6:- Artificial Saliva (Control)

The samples were exposed to 50 ml of soft drinks for 15 min, 3 times daily, for 7 days.

Between immersions, the samples were kept in artificial saliva[9]

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Statistical Analysis:

Statistical Analysis was performed with the help of Epi Info (TM) 3.5.3. EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC). [8]Descriptive statistical analyses were performed to calculate the means with corresponding standard deviations (s.d.). [8,9]One way Analysis of variance (ANOVA) followed by post hoc Tukey's test was performed with the help of Critical Difference (CD) or Least Significant Difference (LSD) at 5% and 1% level of significance to compare the mean values.[7,9]

Results:

Groups	N	Mean Change in Surface Roughness (in µm)	Standard Deviation	Minimum Change in Surface Roughness (in µm)	Maximum Change in Surface Roughness (in µm)
Coca Cola	10	1.4528	0.0129	1.439	1.475
Thumbs Up	10	1.3061	0.0162	1.288	1.332
Pepsi	10	1.5498	0.0123	1.535	1.570

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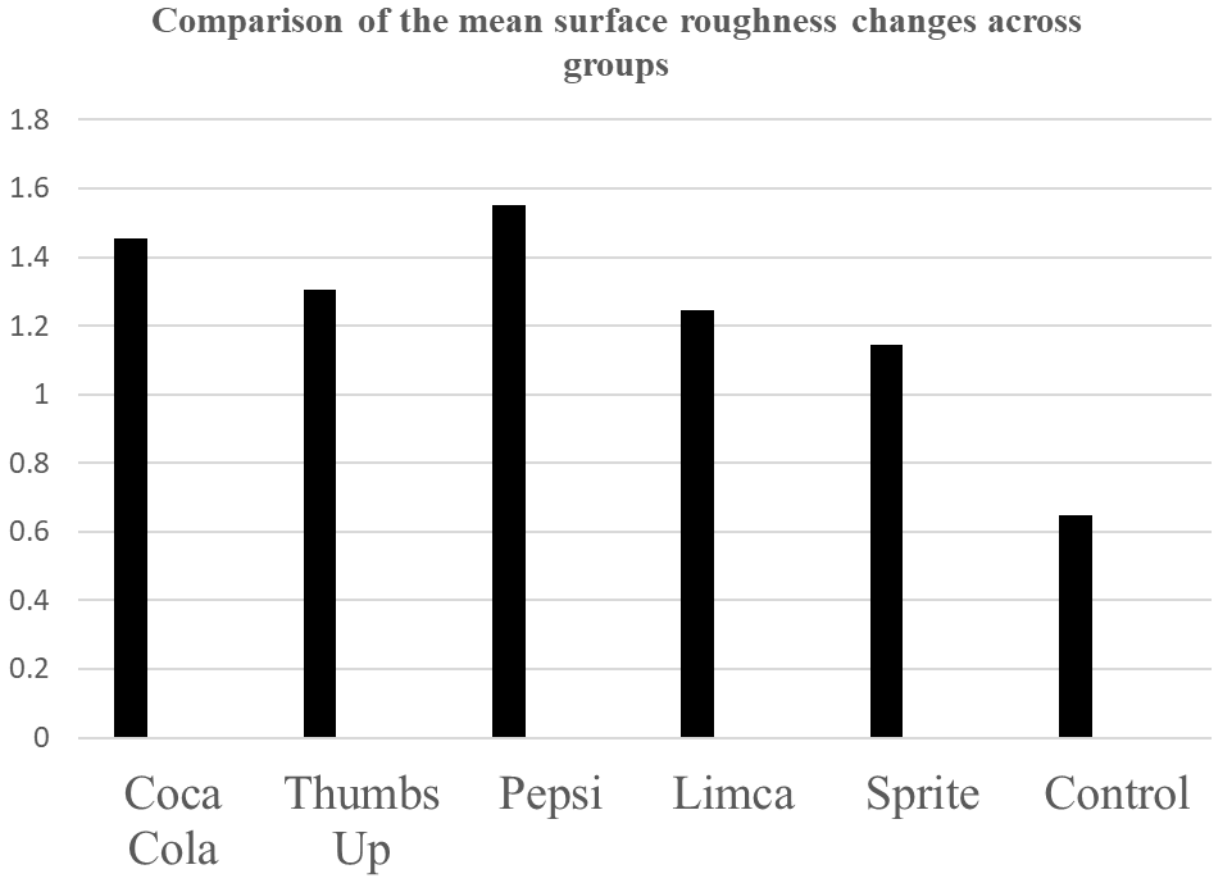
Limca	**10**	**1.2458**	**0.0147**	**1.233**	**1.270**
Sprite	**10**	**1.1464**	**0.0149**	**1.134**	**1.172**
Artificial Saliva (Control)	**10**	**0.6492**	**0.0457**	**0.609**	**0.738**

One way Analysis of variance (ANOVA) followed by post hoc Tukey's test yielded that there were no statistically significant differences between the five experimental groups.[4]Statistically significant differences were seen between the control group and the experimental group ($p < 0.001$). [9]Amongst the experimental groups, minimum enamel surface roughness change was seen in the Sprite group. The samples of Pepsi group had the maximum enamel surface roughness change ($p < 0.001$). [3]



Bar graph showing (mean) surface roughness changes values obtained after subtracting the Ra values of the samples prior to the experiment from the Ra values of the samples on the 7th day of the experiment, obtained through 3 D Optical profilometry.

Discussion:

The 5 tested soft drinks which was used in this study had a pH value below critical (pH 5.5), it was possible to expect the initial demineralization of

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enamel. The pH values of the soft drinks were taken from previous studies by Parkar et al (2018) and Li et al (2019).5,6Pepsi (pH = 2.5), Thumbs Up (pH = 2.56), and Coca Cola (pH= 2.67) had the lowest pH values. While Sprite and Limca had higher pH values (3.04, 3.03 respectively). 4Chemical composition of an acidic drink is clearly an important factor in the mechanical properties especially the surface characteristics of enamel. Drinks that contain citric acid have been shown to be more erosive than those containing phosphoric acid.- Meurman et al (1991). 4,5

According to information from the manufacturers, Coca-Cola and Pepsi contains phosphoric acid, whereas Sprite and Limca contains citric acid. Compared to citric acid, phosphoric acid is stronger. 4The effect of phosphoric acid results in a superficial etched zone which might be permanently lost from the tooth surface. on the other hand, citric acid may act as a chelator capable of binding the calcium from enamel or dentine, thus increasing the degree of undersaturation and favoring demineralization.- Barac et al (2015).2,3This explains the lower enamel surface roughness changes seen in the Sprite and Limca groups while compared to Pepsi and Coca Cola groups.2

The mean enamel surface roughness change seen in the Thumbs Up group is lesser in comparison to Pepsi and Coca Cola groups, inspite of having similar pH values and ingredients. This can be explained by the presence of "Acidity regulator" component which is sodium citrate which eventually acts as an buffer component, thus producing lesser changes in enamel surface roughness.2,3A positive relationship between the erosive potential and exposure time does exist. But according to a study by Barac et al (2015) it was not always observed. the Ra values showed a significant decrease for 30 and 60 min of exposure compared to a 15-min exposure to Coca-Cola. 6This can be explained by the assumption that Coca-Cola at short exposure times erodes enamel 'more evenly' compared to long exposures. Thus to counter any discrepancies the exposure time is kept constant for 15 min cycles, 3 times a day for 7 days.8,9

Many authors have suggested the complexity of the erosive process and the fact that in vitro studies cannot totally reproduce the clinical conditions as possible reasons. In vitro studies should only be interpreted as a prediction of the relative erosive potential of a soft drink. 7The flat cut-surface of the enamel sample was only rinsed with water with no mechanical damage before placement into erosive solutions. There was refrainment from grinding or flattening procedures which removes a certain amount of enamel which can become more sensitive to acidic solutions, and irregularities which develop on the sample surface do not have to be a consequence only of erosion but also of grinding. 6,9

The Non-Contact 3D Optical Profilometry method is tried and tested, and is accepted by most authors, for measuring surface characterestics. This method may represent a limitation because it only registers surface irregularities on the enamel but not the quantity of lost enamel.3Overall, the results of this study did not much differ from the results obtained from other studies [Machado et al (2008), Machado et al (2015), Li et al (2019)]with similar goals, regardless of the method of sample preparation. 4

Conclusion:

Within the limitations of In Vitro studies, it was observed that,-

All of the tested soft drinks were found to be erosive. Maximum surface roughness changes were seen in Pepsi and Coca Cola groups, while the least was seen in Sprite group.Thumbs Up and Limca showed surface roughness changes lesser than Pepsi and Coca Cola, but more than Sprite.

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