Dental Erosion: Immediate pH Changes of Commercial Soft Drinks in Nigeria

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Abstract:
Aim: To observe the pH changes of commercial soft drinks in the Nigerian market, at different time intervals after opening the can. **Material and Methods**: Two cola soft drinks, six non-cola soft drinks and two canned or bottled fruit juices were selected based on their popularity. About 250 milliliters of each of the drinks were poured inside a beaker containing the probe of a digital pH meter and the initial pH recorded. The pH readings were then taken at 30 seconds interval for 3 minutes. **Results**: The pH ranged from 2.74 - 2.76 for cola drinks, 2.68- 4.48 for non-cola drinks and 3.55 - 3.91 for fruit juices. LaCasera®; t^0 (on opening) was 2.68, t^3 (3 minutes) was 2.72. Seven up®; t^0=3.15, t^3=3.15. Cocacola®; t^0=2.76, t^3=2.74. Schweppes®; t^0=2.94, t^3=2.83. Krest®; t^0=4.48, t^3=4.54. Pepsicola®; t^0=2.74, t^3=2.70. Mirinda®; t^0=3.04, t^3=2.95. Fanta®; t^0=3.12, t^3=3.01. Fuman®; t^0=3.55, t^3=3.51. 5-Alive®; t^0=3.91, t^3=3.91. A tendency to pH increase was observed in LaCasera® and Krest®; no changes observed in Seven up® and 5Alive®; a tendency to decrease in pH was observed in Cocacola®, Schweppes®, Pepsicola®, Mirinda®, Fanta® and Fuman®. This study showed that all the soft drinks assessed had pH on opening lower than critical pH for enamel to dissolve and therefore erosive in nature. A significant number of them showed a tendency to decrease in pH after opening. **Conclusion**: This study revealed that popular soft drinks in Nigeria had pH below the critical dissolving pH of enamel and a tendency to decrease in pH after opening.

Key words: Dental Erosion, Soft drinks, pH changes, Nigeria.

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Introduction

Dental erosion is the chemical wear of the dental hard tissue without the involvement of bacteria (1). Dental erosion is commonly caused by dietary factors, especially food or drinks that contain citric acid which may chelate as well as dissolve calcium ions (2-3).

Dental erosion has been reported to be a growing health problem (4) which may have arisen due to the monumental increase in the consumption of soft drinks, fruit juices and sport drinks in the UK, the US, and many other countries as reported by Hooper et al. (5).

Soft drinks are nonalcoholic, flavored, carbonated beverages, usually commercially prepared and sold in bottles or cans. Most soft drinks contain one or two common food acidulant- phosphoric and citric acid. Occasionally, other acidulant such as malic acid and tartaric acid are also used. Acidity forms one of the basic properties of a soft drink and serves two main functions. First, it is a key factor in the taste profile of a drink as it balances the sweetness (people generally prefer more acidic foods and drinks). Secondly, it inhibits the growth of micro-organisms such as yeasts, moulds and bacteria (6-7).

Due to the presence of the acid, the pH of soft drinks was known to be low and have, therefore, been implicated to be one of the important variables in the erosive potential of soft drinks and in the increasing incidence of dental erosion (8-9). Strength of the acid present in a solution is measured by pH, that is, the concentration of hydrogen ions. Larsen and Nyvad (10) in an *in vitro* study compared the pH and the buffering effect of various soft drinks with their erosive effects; they concluded that the lower the pH the more NaOH was necessary to bring the pH to neutrality and the higher the erosive capacity.

Clinical studies have found soft drinks, especially carbonated cola drinks, to be associated with erosion (11-12). Also, in vitro studies presented in Table I showed that soft drinks with low pH can cause erosion. The damaging effects of acidic soft drinks on the teeth have therefore prompted many researches. In a study by Johansson et al. (16), different methods of drinking were tested; they found that holding the drink in the mouth before swallowing led to the mostpronounced pH drop and they concluded that the drinking method strongly affects tooth-surface pH and thereby the risk for dental erosion.

There were very few studies in the literature investigating the prevention of dental erosion, while no information was accessed regarding immediate

ph changes of soft drinks and beverages also no previous work sighted on pH changes of soft drinks and beverages. This study was borne out of the consideration that the pH changes of soft drinks within the first few seconds and minutes after opening may be important in influencing the damaging effects on the dentition. In Nigeria, however, little is known about the immediate pH changes of commercially available soft drinks after opening.

Methods: Ten commercial soft drinks were selected based on their popularity. Each drink must have also been in the market for at least 4 years. Two cola drinks: Pepsicola® and Cocacola®; Six non-cola drinks: LaCasera®, Schweppes®, Seven up®, Mirinda®, Fanta orange®, Krest club soda®; Two fruit juices: 5Alive® and Fuman (vogue 2) ®. The procedure was carried out in the Chemistry (Lab I) unit of the Central Science Laboratory of the Obafemi Awolowo University Ile-Ife. The laboratory procedure was performed by one of the authors (CTB) assisted by one of the laboratory's Chief Technologists (acknowledged).

The former also recorded all the readings of the pH meter.

Calibration of the digital pH meter (WPA, CD70, Cambridge, UK): Firstly, three buffer solutions were prepared (from the buffer powders) with the following pHs; 4.0, 7.0 and 9.0. The meter was afterward adjusted with 4.0 and 9.0 buffers and made to accurately detect the buffer at pH 7.0 before it was used. The drinks were consecutively opened and about 250 milliliters of each drink poured inside a beaker containing the probe of the digital pH meter. Initial pH on opening was recorded as baseline and further readings taken at 30 seconds interval for 3minutes.

Results

pH on opening

From table II, it was observed that all the soft drinks under investigation had a generally low pH on opening that ranged from 2.68-4.48.
LaCasera® had the lowest pH of 2.68 followed by Pepsicola® and Cocacola® with pH 2.74 and 2.76 respectively. Krest club soda® had the highest pH of 4.48.

Table I: In Vitro Studies of Soft Drink Consumption and Dental Erosion

Study	Results	Study type
Seow and Thong (13)	Inverse association between pH and enamel etching	In vitro; Extracted human teeth
Hemingway and coworkers (14)	Significant enamel loss was seen for all selected drinks. Erosion was correlated with pH and calcium concentration but not phosphate concentration or titratable acidity.	In vitro; Enamel
Larsen and Nyvad (10)	Inverse association between pH of drink and solubility of enamel apatite	In vitro; human teeth
Hughes and coworkers	No enamel erosion with water, increased erosion with drinks of decreasing pH	In vitro; Human teeth

pH changes

It was observed that within 3 minutes after opening, tendencies to increase or decrease in pH were observed among the drinks: decrease in pH was observed in Pepsicola®, Cocacola®, Mirinda®, Fanta orange®, Fuman® and Schweppes® while an increase in pH was noticed in Krest club soda and La casera. No pH change was observed in 5Alive® and Seven up®.

The highest percentage decrease in pH was noticed in Schweppes bitter lemon (3.74%), followed by Fanta orange (3.53%). The highest increase in pH was noticed in Krest club soda.

Discussion

Acidification of soft drinks is necessary for preservation and taste resulting in deleterious effects on the dental health that have severally been reported in literature (8-9). Consequently, a number of suggestions have also been made on reducing these effects by modifying the contents (17-18) and/or counseling in the methods of their consumption (19). This study was set out to provide information on the changes in pH (after opening the can) of some popular soft drinks in Nigeria. There are several soft drinks in Nigerian market, the authors agreed to select the popular ones that have been in the market for at least 4 years.

A calibrated digital pH meter (WPA, CD70) was used to measure the pH changes. This meter measures the voltage between two electrodes placed in the solution. Although, several factors can cause the observed value to differ from the actual pH, ie, contamination of the electrodes when testing more than one solution, the digital meter is still preferred because of a number of disadvantages of pH paper (litmus paper) which is mainly used for rough testing. This particular source of error was noted and thoroughly taken care of by adequate rinsing, and proper checking and calibration before working on any of the drinks

Table II: pH on opening and change in pH at 30 seconds interval for 3 minutes.

S/N	Soft drinks	pH measurements at 30s interval within 3 minutes (180s)							Change in pH between 0-180s	% change
		On opening	30s	60s	90s	120s	150s	180s		
Cola drink s										
1	Pepsicola®	2.74	2.74	2.73	2.72	2.71	2.71	2.70	0.04	1.46
2	Cocacola®	2.76	2.76	2.76	2.76	2.75	2.75	2.74	0.02	0.72
Non-cola drinks										
3	Seven Up®	3.15	3.15	3.15	3.15	3.15	3.15	3.15	0.00	0
4	Mirinda®	3.04	2.98	2.97	2.95	2.95	2.95	2.95	0.09	2.96
5	Schweppes®	2.94	2.89	2.88	2.86	2.85	2.83	2.83	0.11	3.74
6	Krest club soda®	4.48	4.53	4.55	4.57	4.60	4.54	4.54	-0.06	1.34
7	Fanta Orange®	3.12	3.09	3.06	3.05	3.04	3.02	3.01	0.11	3.53
8	**LaCasera®**	2.68	2.68	2.69	2.70	270	2.71	2.72	-0.04	1.49
Fruit juices										
9	5 Alive®	3.91	3.90	3.91	3.91	3.91	3.91	3.91	0.00	0
10	Fuman®	3.55	3.50	3.50	3.51	3.51	3.51	3.51	0.04	1.13

All the soft drinks under investigation were acidic with pH that ranged from 2.70-4.48 on opening which was similar to the finding of Jain et al. (20). This was well below the critical pH of 5.5 at which enamel dissolution occurs. In a review by Lussi and Jaeggi (21), pH value of a drink or foodstuff among other factors has been said to be important in explaining erosive attack. The pH of soft drinks and carbonated drinks are known to be low and have, therefore, been implicated in the increasing incidence of erosion (8). Clinical and laboratory evidences have shown inverse association between pH of soft drinks and dental erosion (10-14). A significant finding is the tendency to a decrease in pH value of some drinks within three minutes period of investigation. This was observed in about 60% of the drinks. Although the differences in pH change were not quite significant, they were not on the path of lessening the burden of harmful effects of these acidic drinks. This variation could well explain findings where high level of soft drink consumption and long retention time of the drink in the mouth before swallowing were found to have significant correlation with the presence of dental erosion (22-23).

The seemingly limitations of this laboratory study, such as not looking at types of acid used, calcium, phosphate and fluoride content and buffering capacities in the oral cavity, were not designed to be achieved at the outset.

It could be surmised that pattern of drinking that promotes prolonged contact with the teeth would be critical in delivering a more 'harmful' soft drinks, i.e. drinks that had pH values well below the pH at which enamel dissolves (10). It is therefore appropriate to include advice on the method of drinking in dietary counseling related to dental erosion. This information would be of immense use to dental practitioners and oral hygienists.

It is our recommendation that by exploding future studies on this subject, more information would be provided on the nature and erosivity of soft drinks.

Conclusions

pH value of all the soft drinks under investigation were well below the critical pH expected for enamel demineralization and subsequent dental erosion. A tendency to decrease in pH of majority of the drinks that are commercially available in Nigeria was observed, which might have detrimental effects on dentition.

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