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Evaluation of the Erosive Potential of Common Soft Drinks in Ethiopia

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Abstract:

The erosive potential of some soft drinks consumed in Ethiopia was assessed. A range of commonly consumed carbonated drinks, *viz.* cola and non-cola, and fruit juices were selected. Their initial pH was measured, upon opening their bottles. The volumes of 1.0M sodium hydroxide needed to raise the pH of 50 mL of the drinks to pH 5.5 and pH 7.0 were determined. The pH before titration ranged from 2.43 to 3.19 for the carbonated drinks and 3.12 to 3.75 for the fruit juices. The initial pH of all the tested soft drinks upon opening the bottle was found to be below the critical pH 5.5 for enamel dissolution. The volume of 1.0M sodium hydroxide required to bring the drinks to pH 7.0 ranged from 1.5 to 2.9mL. Most non-cola drinks required the highest volume of base to neutralize its acidity. Despite their lower initial pH, cola drinks consumed the lowest volume of base. To conclude, all the investigated soft drinks had significant erosive potential. The erosive potential of non-cola drinks was more than cola drinks and fruit juices. Clinicians can take advantage of this information when counseling patients with dental erosion.

Key words: Ethiopia, Dental erosion, Soft drinks, acidulant

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1. Introduction

There has been an increasing trend in the sales and consumption of soft drinks worldwide. Progressive globalization of the food supply and the increase in food intake, such as snacks, soft drinks and fast food, typically form a significant part of daily life. A healthy life style is also probably jeopardized through indiscriminate consumption of soft drinks[1]. Consumption of such soft drinks leads to erosion of teeth enamel.

Dental erosion is the chemical dissolution of the surface of dental hard tissue caused by extrinsic and/or intrinsic acids[2], as opposed to a caries lesion that is caused by acids formed by bacterial degradation of sugars[3].One important extrinsic factor in erosive tooth wear is the high consumption of soft drinks[4, 5]. Previous research works reported a link between excessive soft-drink consumption and high occurrence of dental erosion [6, 7]. The critical pH below which enamel begins to erode is 5.5; however, one study reported that titrable acidity (TA) was a more important indicator than pH value for determining the erosive potential of beverages [4, 8].

Dental erosion has been reported to be a rising health problem among children and adults globally [3, 6]. In contemporary societies, there is an increasing concern on the effect of consumption of acid drinks such as: soft drinks, sport drinks, fruit juices and fruit teas on dental erosion [9]. Intake of soft drink, even for short duration, can diminish enamel micro-hardness [10]. In this respect, some epidemiological and clinical studies have reported that carbonated drinks, particularly cola drinks, result in dental erosion ascribed to their low pH [11, 12]. Other studies have also revealed the potential erosive nature of fruit juices because of their high content of titrable acid [3, 13].

Different features of soft drinks are associated to dental erosion. Low pH and high content of titrable acid are known to cause the erosive capacity of the fruit juices and beverages [14-16]. Study conducted by Hughes *et al.* [17] associated increasing dental erosion with decreasing pH and increasing acid concentration. Among other factors that can modify development of dental erosion include: the total acid level, acid types, concentration of phosphate, calcium and fluoride in food drinks[14, 18, 19]. Temperature and exposure time has also been an important factor affecting the erosive potential of beverages [20, 21].

Some researchers suggested that the effect of total acid level (titrable acid) on dental erosion predominates over that of pH level [14, 20], for a simple reason that it will determine the actual H^+ available to interact with the tooth surface [20]. The degree of saturation with respect to the tooth mineral and thus the driving force for its dissolution is determined by pH and titrable acidity [16].

Acidulant is used in soft drink products to perform two main functions. Firstly, it is used so as to balance the sweetness because people generally prefer more acidic foods and drinks. Secondly, it hinders microbial growth because main food poisoning organisms grow and multiply preferably near neutral pH conditions, but not in acidic environment [4]. Phosphoric acid and citric acid are common acidulants that are used in most soft drinks. Sometimes, other acidulants such as malic acid or tartaric acid are also used.

The number of carbonated drinks and fruit juices has recently grown in the Ethiopian market following the expansion of production companies and the available free market for a large number of foreign products. This coupled with the change in life style and feeding habit of people, especially among children and adolescents, has led to ever increasing consumption of soft drinks. Consequently, an abrupt increase in soft drink-induced demineralization of dental enamel prevalent in the country over the last two decades stimulated this research. This study was, therefore, conducted with the aim of providing baseline information on the erosive potential of some soft drinks commonly available in the Ethiopian market.

2. Experimental Section

In this paper, eleven different brands of soft drinks were tested. Among these, 8 of them were carbonated drinks (2 cola and 6 non-cola) while three of them were fruit juices. The carbonated soft drinks were manufactured by the two famous bottling companies, Moha soft drink factory and East African bottling company, supplying the country with a range of soft drink products for several decades. On the other hand, the fruit juices were imported from the Middle East. All the selected drinks had been in the market for at least 5 years. Table 1 shows the investigated soft drinks with their manufacturers, packaging and acidulants.

Table 1: Tested soft drinks; their Manufacturers, Packaging and Acidulants

S.No.	*Soft drink*	*Manufacturer*	*Packaging*	*Acidulant*
Cola Drinks				
1	Coca-cola	East African Bottling Company	Glass bottle	Phosphoric Acid
2	Pepsi-cola	Moha soft drink factory	Glass bottle	Phosphoric Acid
Non-cola Drinks				
3	Seven-up	Moha soft drink factory	Glass bottle	Citric acid, Malic acid
4	Mirinda apple	Moha soft drink factory	Glass bottle	Citric acid
5	Mirinda orange	Moha soft drink factory	Glass bottle	Citric acid
6	Sprite	East African Bottling Company	Glass bottle	Citric acid
7	Fanta orange	East African Bottling Company	Glass bottle	Citric acid
8	Fanta ananas	East African Bottling Company	Glass bottle	Citric acid
Fruit Juices				
9	Mango Mizo	Arrow juice factory for bottling & production	Plastic bottle	Citric acid
10	Mango Fakher	AUJAN soft drink industry	Plastic bottle	Citric acid
11	Mango Rani	AUJAN soft drink industry	Glass bottle	Citric acid

The laboratory procedure was carried out at the Department of Chemistry Laboratory, University of Gondar. Before conducting the analysis, the type of acid used for each drink was recorded from the label of the packaging. Then, the pH was determined with a digital pH meter (Mettler-Toledo,MP220, Schwerzenbern, Switzerland) by pouring about 100mL of each drink into a conical flask and inserting the probe of the pH meter. Immediately after determining the initial pH of each soft drink upon opening the bottle, the volume of 1.0 M sodium hydroxide consumed to raise the pH of 50 mL of the drinks to pH 5.5 and pH 7.0 was also determined.

2.1. Quality Control/Quality Assurance

All the glassware used for the analysis were first immersed in aquaregia, washed with detergent, and then rinsed with deionized water. Deionized water was used in the entire procedure. The pH meter was calibrated regularly with buffer solutions (pH 4.01, 7.0 and 10.0). Moreover, all the analyses were performed in triplicate.

3. Results and Discussion

As can be seen from Table 1, phosphoric acid was used as an acidulant in the cola drinks, while citric acid was used in most non-cola drinks and all fruit juices. Seven-up, one of the most commonly consumed non-cola drinks, contained malic acid and citric acid as acidulants. Assessment of the pH upon opening the drinks revealed that Coca-Cola had the lowest pH (2.43), whereas one of the fruit juice under study, Mango Fakher, had the highest average pH (3.75). In general, the cola drinks had the lowest average pH while fruit juices had the highest average pH. The table given below (Table 2) also illustrates that the amount of sodium hydroxide consumed to raise the pH of soft drinks to 5.5 varied from 0.7 to 1.5 mL. Similarly, 1.5 to 2.9 mL of 1M sodium hydroxide was required to bring the pH of 50 mL soft drink samples to a value of 7.0. Mirinda orange consumed the highest volume of base to raise its pH to 5.5 and 7.0. In contrast, Coca-Cola required the lowest volume of base to increase its pH to 5.5 and 7.0. Most non-cola drinks generally needed the highest average volume of sodium hydroxide to raise their pH to 5.5 and 7.0. In contrast, cola drinks consumed the lowest base despite their lowest average pH upon opening.

Table 2: pH on opening the bottle; volume of 1M NaOH required to raise the pH to 5.5 and 7.0

S.No	*Soft drinks*	*pH on Opening the bottle*	*Volume (ml) of base required to increase pH to*	
			5.5	*7.0*
Cola Drinks				
1	Coca-Cola	2.43	0.7	1.5
2	Pepsi-Cola	2.48	0.7	1.6
Non-cola Drinks				
3	Seven-up	3.19	1.4	2.6
4	Mirinda apple	3.09	0.9	2.2
5	Mirinda orange	2.74	1.5	2.9
6	Sprite	3.02	1.0	2.3
7	Fanta orange	2.81	1.5	2.5
8	Fanta ananas	3.01	1.3	2.5
Fruit Juices				
9	Mango Mizo	3.12	1.5	2.0
10	Mango Fakher	3.75	1.4	1.8
11	Mango Rani	3.70	1.4	1.9

There are several factors affecting the erosive potential of a soft drink. These include the immediate effect of the drink on the tooth surface, the time taken to clear the drink from the mouth, the drinking method, the protective effect of saliva, the amount of residual drink after swallowing, the actual amount of beverage consumed and the frequency of consumption [13, 22, 23].

The pH value of soft drinks and foodstuff is more crucial than other factors in determining their erosive potential as reported by Lussi and Jaeggi[24]. In this respect, other researchers also indicated that the pH of drinks determines their erosive potential within the first minutes of exposure [25]. The pH of all the drinks tested, upon opening, was found to vary from 2.43 to 3.75. This range was below the critical pH at which enamel dissolution occurs. It was quite in agreement with other research works conducted in Canada and Nigeria [4, 26].

A number of studies have explained the fact that soft drinks with low pH can cause dental erosion in permanent and deciduous teeth [3, 14, 17, 27-29]. In this case, increase in dental erosion is something related to decrease in pH [17]. Other clinical studies showed that decrease in salivary pH, and induction of a prolonged drop in oral pH observed after consumption of the drinks could exacerbate dental erosion caused by acidic drinks [30, 31]. Titrable acid also affects the erosive potential of soft drinks as explained in several studies [13, 30], and its effect is more important than pH as suggested by Zero [20].

The present work revealed that non-cola drinks consumed relatively high volumes of the base to neutralize 50 mL of soft drink samples. Hence, they are believed to cause greater erosive potential than both cola drinks and fruit juices. In spite of the lowest pH of cola drinks upon opening the bottles, they are easily neutralized with small amount of base. This was in agreement with other findings. [4, 13, 32]

The type of acidulant used in the formulation of soft drinks could possibly be linked to the ability of non-cola drinks to resist change in pH as observed in this study, where citric acid predominated in non-cola drinks and fruit juices; however, phosphoric acid was the only acidulant in cola drinks. Findings in a related and other *in-vitro* study have shown that citric acid caused far more erosion than phosphoric acid [5, 33] attributed to its acidic nature and ability to chelate calcium at higher pH [34].

4. Conclusion

In light of the data obtained in this study, we can conclude that all the tested soft drinks had pH below the critical pH of enamel dissolution which could lead to significant dental erosion problems in younger age groups. The erosive potential of non-cola drinks was the highest in contrast to carbonated cola drinks which showed the least erosive potential. Despite the growing consumption of soft drinks in Ethiopia, nothing has been studied on the erosive potential of soft drinks available in the market. Thus, the information provided by this research work can be used as a baseline study. Moreover, this information can be used by clinicians when counseling patients with tooth surface loss. Manufacturers should also opt for appropriate modification of soft drink ingredients without reducing their acidulation role.

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6. References

1. R Xavier; S Sreeramanan; A Diwakar; G Sivagnanam; KR Sethuraman; ASEAN Food Journal., (**2007**), 14(2), 69-81.
2. Yan-Fang Ren; The Academy of Dental Therapeutics and Stomatology., A Division of PennWell Corp., (**2011**).
3. MJ Larsen; B Nyvad; Caries Research. (**1999**), 33, 81-87.
4. CT Bamise; EO Ogunbodede; AO Olusile; TA Esan; World Journal of Medical Sciences., (**2007**), 2(2), 115-119.
5. SCS Pinto; MC Bandeca; CN Silva; R Cavassim; AH Borges; JEC Sampaio; BMC Research., (**2013**), 6, 67.
6. CT Bamise; KA Kolawol; EO Oloyede; Rev ClinPesqOdontol., (**2009**), 5(2), 141-154.
7. MA El-Zainy; AM Halawa; AA Rabea; Journal of American Science., (**2012**), 8(3), 632-643.
8. P Benjakul; C Chuenarrom;Journal of Dental Sciences., (**2011**), 6, 129-133.
9. A Lussi; T Jaeggi; D Zero; Caries Research., (**2004**), 38, 34-44.
10. I Van Eygen; BV Vannet; H. Wehrbein; American Journal of Orthodontics and Dentofacial Orthopedics.,(**2005**),128,372-7.
11. CR Dugmore; WP Rock; British Dental Journal., (**2004**), 196, 283-6.
12. T Jensdóttir; IB Arnadottir; I Thorsdottir; A Bardow; K Gudmundsson; A Theodros; Clinical Oral Investigations.,(**2004**),8,91-96.
13. T Jensdóttir; A Bardow; WP Holbrook; Journal of Dentistry., (**2005**), 33, 569-575.
14. TH Grenby; M Mistry; T Desai; British Journal of Nutrition., (**1990**), 64, 273-83.
15. RG Lissera; ER Luna Maldonado; LJ Battellino; Act odontologicalatinoameri-cana., (**1998**), 11, 55-71.
16. DT Zero; A Lussi; International Dental Journal., (**2005**), 55(Suppl 1), 285-90.
17. JA Hughes; NX West; DM Parker; MH van den Braak; M Addy; Journal of Dentistry., (**2000**), 28, 147-52.
18. A Lussi; T Jaeggi; S Schärer; Caries Research., (**1993**), 27, 387-393.
19. A Behrendt; V Oerste; WE Wetzel; Caries Research., (**2002**), 36, 405-410.
20. DT Zero;European Journal of Oral Science., (**1996**), 104, 162-77.
21. NX West; JA Hughes; M Addy; Journal of Oral Rehabilitation., (**2000**), 27, 875-80.
22. AK Johansson; P Lingström; T Imfeld; D Birkhed; European Journal of Oral Science., (**2004**), 112, 484-489.
23. P Jain; P Nihill; J Sobkowski; MZ Agustin; General Dentistry., (**2007**), 55, 151-154.
24. A Lussi; T Jaeggi; Monographs in Oral Science., (**2006**), 20, 77-87.
25. T Jensdóttir; P Holbrook; B Nauntofte; C Buchwald; A Bardow; Journal Dental Research., (**2006**), 85, 226-30.
26. LZ Touyz; Journal of Canadian Dental Association. (**1994**), 60, 454-8.
27. LJ Grando; DR Tames; AC Cardoso; NH Gabilan; Caries Research.,(**1996**), 30, 73-8.
28. WK Seow; KM Thong; Australian Dental Journal., (**2005**), 50, 173-8.

29. CJ Brown; G Smith; L Shaw; J Parry; AJ Smith; International Journal of Pediatrics Dentistry., (**2007**), 17, 86-91.
30. M Edward; SL Creanor; RH Foye; WH Gilmour; Journal of Oral Rehabilitation., (**1999**), 26, 923-927.
31. LK Banan; AM Hedge; Journal of Clinical Pediatrics Dentistry., (**2005**), 30, 9-13.
32. T Jensdóttir; I Thornórsdóttir; IB Arnad -óttir ; WP Holbrook; Laeknabladid., (**2002**), 88, 569-572.
33. NX West; JA Hughes; M Addy; Journal of Oral Rehabilitation. (**2001**), 28, 860-4.
34. AJ Rugg-Gunn; JH Nunn; Nutrition, Diet and Oral Health. Hong Kong: Oxford University Press., (**1999**).