World Journal of Medical Sciences 2 (2): 115-119, 2007
ISSN 1817-3055

Erosive Potential of Soft Drinks in Nigeria

[1]Cornelius T. Bamise, [2]Eyitope O. Ogunbodede, [1]Adeyemi O. Olusile and [1]Temitope A. Esan

[1]Department of Restorative Dentistry,
[2]Department of Community and Preventive Dentistry,
Faculty of Dentistry, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: The aim of this study was to assess the erosive potential of some soft drinks commonly consumed in Nigeria. A range of popular carbonated drinks (cola and non-cola) and fruit juices were selected. On two occasions, the followings were determined; (1) the pH, measured by a digital pH meter on opening of the packaging can or bottle. (2) The volume of 1.0M sodium hydroxide required to raise the pH of 50 ml of the drinks to pH 5.5 and pH 7.0. The pH before titration ranges from 2.70 to 4.48 for the carbonated drinks and 3.54-3.91 for the fruit juices. The soft drinks and the fruit juices investigated had pH before titration lower than the critical pH 5.5 for enamel dissolution. The volume of 1.0M sodium hydroxide required to bring the drinks to pH 5.5 ranged from 0.5 to 6.1mls and 1.8 to 8.2 mls of the base needed to neutralize the drinks to pH 7.0. The fruit juices needed the most base to neutralize its acidity. Despite having a lower pH than the fruit drinks, the carbonated drinks required a relatively lower base to neutralize. This study concludes that all the popular soft drinks in Nigeria selected for this study had significant erosive potential. They had pH below the critical pH of enamel dissolution. The erosive potential of the fruit juices was more than the carbonated cola and non-cola drinks. This information will be of use to clinicians when counseling patients with tooth surface loss.

Key words: Nigeria · Dental erosion · Soft drinks · acidity

INTRODUCTION

Soft drinks are non-alcoholic, flavoured, carbonated beverage, usually commercially prepared and sold in bottles or cans.

In modern societies, the increased consumption of acid drinks as soft drinks, sport drinks, fruit juices and fruit teas is increasingly becoming more important because of the concern for dental erosion [1]. Soft drink intake, even of relatively short duration, has been found to reduce enamel microhardness [2].

Epidemiological and clinical studies have found carbonated drinks especially cola drinks associated with erosion, most likely due to their low pH [3,4].

Also, studies have shown that fruit juices may also be potentially erosive, due to their high content of titratable acid [5,6].

Various features of soft drinks relevant to dental health had been identified. The erosive capacity of the fruit juices and beverages were found to be related to their pH and titratable acid [7-9]. In a study by Hughes *et al*., decreasing pH and increasing acid concentration was found to correlate with increased erosion [10].

Furthermore, the total acid level, acid type, concentration of phosphate, calcium and fluoride in food drinks have a modifying effect on the development of dental erosion. [8,11,12] Temperature and exposure time had also been discussed as important to the erosivity of beverages [13,14].

Some workers suggested that the total acid level (titratable acid) be considered as more important than pH level in evaluating the erosive potential of acidic drinks, [8,13] because it will determine the actual H+ available to interact with the tooth surface [13]. pH and titratable acidity of the erosive challenge were said to determine the degree of saturation with respect to the tooth mineral and thus the driving force for its dissolution [9].

Most soft drinks contain one or two common food acidulants - phosphoric acid and citric acid. Occasionally, other acidulants such as malic acid or tartaric acid are also used. Acid is used in soft drink products to accomplish two main functions. Firstly, acidity is a key factor in the taste profile of a drink as it balances the sweetness.

Corresponding Author: Dr. Cornelius T. Bamise, Department of Restorative Dentistry, Faculty of Dentistry, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria

People generally prefer more acidic foods and drinks. Secondly, it inhibits the growth of micro-organisms such as yeasts, moulds and bacteria. Most bacteria grow in moist, warm environments that avoid extremes of acidity or alkalinity. The main food poisoning organisms also require near neutral conditions to grow and multiply. Therefore an acidic environment ensures the safety of a product by providing conditions which do not allow pathogenic organisms survive. High acid foods with a pH less than 4.5 are generally regarded as safe from pathogens [15].

Animal studies have shown that phosphoric acid is very erosive at pH 2.5 but much less so at pH 3.3. Citric, malic and tartaric acids are considered to be especially erosive because of their acidic nature and the ability to chelate calcium at higher pH [16].

Citric acid was more erosive than malic acid when formulated to experimental drinks at high pH [10,17].

There has been a recent growth in the number of carbonated drinks and fruit juices in the Nigerian market possibly due to new production companies and the expansion of established ones. This, coupled with the rise in consumption of soft drink especially among adolescents was our chief concern. The aim of this study therefore was to provide information on the erosive potential of some common soft drinks in Nigeria.

MATERIALS AND METHODS

Ten soft drinks were tested; 8 carbonated drinks (2 cola and 6 non-cola) and two fruit juices were tested. The carbonated soft drinks were a range of products from three first generation soft drinks bottling company while the fruit juices were from the two first generation manufacturers in Nigeria. All the selected drink had been in the market for at least 4 years.

Table 1 showed the investigated soft drinks with their manufacturers, packaging and acidulants.

Firstly, the type of acid used for each drink was recorded from the label of the packaging. The laboratory procedure was carried out in the Central Science Laboratory of the Obafemi Awolowo University Ile-Ife. On two occasions, the followings were determined; (1) the pH; a digital pH meter (WPA, CD70, Cambridge, UK) was used in the assessment. This was determined by pouring about 100mls of each drink in a conical flask and inserting the probe of the pH meter.

(2) The volume of 1.0M sodium hydroxide required to raise the pH of 50 ml of the drinks to pH 5.5 and pH 7.0. 1.0M of Sodium hydroxide base was prepared by dissolving 1g of sodium hydroxide pellets in 250mls of distilled water. The sodium hydroxide was then titrated against 50mls of each drink.

RESULTS

Table II showed that the cola drinks had phosphoric acid as acidulant; the fruit juices, Schweppes®, Mirinda® and Fanta® oranges had only citric acid while Seven-up® and LaCasera® had citric acid plus malic acid. Krest club soda® contains only carbonated water plus other additives without indication of addition of any of the common acidulants as ingredients.

Assessment of the pH on opening the drinks showed that LaCasera® apple drink had the lowest pH 2.70 and Krest club soda® had the highest of 4.48. The cola drinks had the lowest average pH while the fruit juices had the highest average pH.

Results showed that the volume of sodium hydroxide base needed to raise the pH of the drinks to 5.5 ranged from 0.5 to 6.1mls. 1.8 to 8.2 mls of the base was needed to raise the pH of the drinks to 7.0. 5 Alive needed the most

Table 1: Tested Soft drinks; The Manufacturers, Packaging and Acidulants

S/N	Soft drink	Manufacturer	Packaging	Acidulant
1	Coke ®	Nigerian Bottling Company Plc	Glass bottle	Phosphoric Acid
2	Pepsicola®	Seven-up Bottling Company Plc	Glass bottle	Phosphoric Acid
Non-cola drinks				
3	Seven-up®	Seven-up Bottling Company Plc	Glass bottle	Citric acid, Malic acid
4	Mirinda orange®	Seven-up Bottling Company Plc	Glass bottle	Citric acid
5	Fanta orange®	Nigerian Bottling Company Plc	Glass bottle	Citric Acid
6	Schweppes®	Nigerian Bottling Company Plc	Glass bottle	Citric Acid
7	Krest club soda®	Nigerian Bottling Company Plc	Glass bottle	Nil
8	LaCasera®	Classic Beverages Nig Ltd	Plastic bottle	Ctric acid Malic acid
Fruit Juices				
9	5 Alive® citrus burst	Nigerian Bottling Company Plc	Paper casing	Citric acid
10	Fumman (vouge 2)® apple drink	Fumman Agricultural Products Industrials Limited	Paper casing	Citric acid

Table 2: Type of acid used for each soft drink

S/N	Soft drinks	pH on opening the can	Volume (mls) of base needed to increase pH to: 5.5	7.0
Cola drinks				
1	Coke ®	2.76	1.0	2.0
2	Pepsicola®	2.75	1.5	3.8
Non-cola drinks				
3	Schweppes® bitter lemon	2.92	3.7	5.7
4	Krest club soda®	4.48	0.5	1.8
5	Seven up®	3.15	2.6	5.7
6	LaCasera®	2.70	4.2	6.6
Cabonated orange drink				
7	Mirinda® orange	3.04	1.8	3.5
8	Fanta® orange	3.12	1.8	3.0
Fruit juices				
9	5 Alive® citrus drink	3.91	6.1	8.2
10	Fummana (vouge 2)® apple drink	3.54	4.9	6.2

base to raise its pH to 5.5 and 7.0 while Krest club soda needed the lowest volume of base to raise its pH to 5.5 and 7.0. The fruit juice despite having the highest average pH on opening needed the highest volume of sodium hydroxide to raise its pH to 5.5 and 7.0. Conversely, despite having the lowest average pH on opening, the cola drinks needed the lowest base to raise the pH to both 5.5 and 7.0.

DISCUSSION

Theoretically, the erosive potential of a soft drink must be dependent upon the immediate effect of the drink on the tooth surface, the time it takes to clear the drink from the mouth), the drinking method, [18] the protective effect of saliva, [19] the amount of residual drink after swallowing, the actual amount of beverage consumed and the frequency of consumption (that is, if small sips are taken at frequent intervals or the entire can/bottle is consumed quickly) [20].

More importantly, the nature of the drinks has been suggested to determine their erosive potential. In a review by Lussi and Jaeggi, pH value of a drink or foodstuff among other factors was said to be important in explaining erosive attack. [21] Jensdottir et al. also pointed out that the pH of drinks determines their erosive potential within the first minutes of exposure [22]. The pH of all the drinks investigated ranged from 2.70 to 4.48 on opening which was well below the critical pH at which enamel dissolution occurs. This was quite similar to the finding of Touyz who concluded that Canadian fruit juices had pH below the critical dissolving pH of enamel [23].

In vitro studies have shown that soft drinks with low pH can cause dental erosion [7,24,25] in permanent [6,10] and deciduous teeth. [26] Decrease in pH has also been associated with increase in dental erosion [10].

Findings in some clinical studies showed that the erosive potential of acidic drinks could be further enhanced by the lowering of salivary pH [27] and induction of a prolonged drop in oral pH [28] observed after consumption.

Titratable acid had been found by several studies to affect the erosive potential of soft drinks [5,28] and Zero has suggested that it should be considered more important than pH in determining the erosive potential of drinks [13].

The present study showed that fruit juices needed the most base to neutralize thereby having greater erosive potential than the cola and the non-cola drinks. The cola drinks despite having the lowest pH on opening were easy to neutralize than the fruit juices and non cola drinks. This was quite similar to the findings of two studies by Jensdottir and coworkers [5,29].

The type of acid used may possibly explain the ability of the fruit juices to resist pH change as observed in the present study where phosphoric acid was the only acid in the cola drinks while citric acid predominated in the fruit juices and the non-cola drinks. Surprisingly a study has shown that citric acid caused far more erosion than phosphoric acid [30]. Other important contributors were possibly the concentration of the acids and additive ingredients.

Of note is the absence of acid modifier in the ingredient of the Krest club soda which may have been responsible for the highest pH (4.48) observed on opening it and the minute amount of sodium hydroxide needed to raise the pH to pH 5.5 and 7.0. A previous study had shown that there was no erosion with water (pH 7.0) and erosion decreases with increasing pH [10].

We therefore surmise that appropriate modification of soft drink's ingredients without necessarily compromising the vital role of acidulation is critical to the erosivity of soft drinks.

Although several factors had been discussed in literature to be important in the erosivity of food drinks, we were able to provide information on three of them which seems an apparent limitation of this study. With the dearth of literature on these variables as regards the

Nigerian market, the information provided by this work will assume a vital role as a baseline study.

Finally the data obtained from this study have shown that all the commonly consumed carbonated drinks selected for this study had significant erosive potential. All the drinks had pH below the critical pH of enamel dissolution. The erosive potential of the fruit juices was more than the carbonated cola and non-cola drinks. This information will be of use to clinicians when counseling patients with tooth surface loss. Content modification is also critical to the erosive potential of soft drinks.

ACKNOWLEDGEMENT

The authors wish to acknowledge Mr SA Adisa of the Central Science laboratory, Obafemi Awolowo University Ile-Ife for his technical assistance.

REFERENCES

1. Lussi, A., T. Jaeggi and D. Zero, 2004. The role of diet in the aetiology of dental erosion, Caries Research, 38: 34-44.
2. Van Eygen, I., B.V. Vannet and H. Wehrbein, 2005. Influence of a soft drink with low pH on enamel surfaces: an in vitro study. American Journal of Orthodontics and Dentofacial Orthopedics, 128:372-7.
3. Jensdottir, T., I.B. Arnadottir, I. Thorsdottir, A. Bardow, K. Gudmundsson and A. Theodors *et al.,* 2004. Relationship between dental erosion, soft drink consumption and gastroesophageal reflux among Icelanders. Clinical Oral Investigations, 8: 91-96.
4. Dugmore, C.R. and W.P. Rock, 2004. A multifactorial analysis of factors associated with dental erosion. British Dental Journal, 196: 283-6.
5. Jensdottir, T., A. Bardow and W.P. Holbrook, 2005. Properties and modification of soft drinks in relation to their erosive potential in vitro. Journal of Dentistry, 33: 569-575.
6. Larsen, M.J. and B. Nyvad, 1999. Enamel erosion by some soft drinks and orange juices relative to their pH, buffering effect and contents of calcium phosphate. Caries Research, 33: 81-87.
7. Lissera, R.G., E.R. Luna Maldonado and L.J. Battellino, 1998. *In vitro* erosive capacity of some fruit juices and soft or low alcoholic strength beverages on human teeth, Acta odontológica latinoamericana, 11: 55-71.
8. Grenby, T.H., M. Mistry and T. Desai, 1990. Potential dental effects of infants' fruit drinks studied *in vitro*, British Journal of Nutrition, 64: 273-83.
9. Zero, D.T. and A. Lussi, 2005. A Erosion--chemical and biological factors of importance to the dental practitioner, International Dental Journal, 55 (Suppl 1): 285-90.
10. Hughes, J.A., N.X. West, D.M. Parker, M.H. van den Braak and M. Addy, 2000. Effects of pH and concentration of citric, malic and lactic acids on enamel, in vitro. Journal of Dentistry, 28: 147-52.
11. Behrendt, A., V. Oerste and W.E. Wetzel, 2002. Fluoride concentration and pH of iced teas products, Caries Research, 36: 405-410.
12. Lussi, A., T. Jaeggi and S. Schärer, 1993. The influence of different factors on in vitro enamel erosion, Caries Research, 27: 387-393.
13. Zero, D.T., 1996. Etiology of dental erosion-extrinsic factors. European Journal of Oral Science, 104: 162-77.
14. West, N.X., J.A. Hughes and M. Addy, 2000. Erosion of dentine and enamel in vitro by dietary acids: the effect of temperature, acid character, concentration and exposure time. Journal of Oral Rehabilitation, 27: 875-80.
15. http://www.britishsoftdrinks.com/htm/qa/AdditivesIngredients/acids/acids.htm accessed on 10/13/07.
16. Rugg-Gunn, A.J. and J.H, Nunn, 1999. Diet and Dental Erosion. Nutrition, Diet and Oral Health. Hong Kong: Oxford University Press.
17. Meurman, J.H., M. Harkonen and H. Naveri *et al*., 1990. Experimental sports drinks with minimal dental erosion effect. Scandinavian Journal of Dental Research, 98: 120-8.
18. Johansson, A.K., P. Lingström, T. Imfeld and D. Birkhed, 2004. Influence of drinking method on tooth-surface pH in relation to dental erosion. European Journal Oral Science, 112: 484-489.
19. Jensdottir, T., B. Nauntofte, C. Buchwald and A. Bardow, 2005. Effects of sucking acidic candy on whole mouth saliva composition. Caries Research, 39: 468-474.
20. Jain, P., P. Nihill, J. Sobkowski and M.Z. Agustin, 2007. Commercial soft drinks: pH and *in vitro* dissolution of enamel. General Dentistry, 55: 151-154.
21. Lussi, A. and T. Jaeggi, 2006. Chemical factors. Monographs in Oral Science, 20: 77-87.

22. Jensdottir, T., P. Holbrook, B. Nauntofte, C. Buchwald and A. Bardow, 2006. Immediate erosive potential of cola drinks and orange juices. Journal Dental Research, 85: 226-30.
23. Touyz, L.Z., 1994. The acidity (pH) and buffering capacity of Canadian fruit juice and dental implications. Journal of Canadian Dental Association, 60: 454-8.
24. Brown, C.J., G. Smith, L. Shaw, J. Parry and A.J. Smith, 2007. The erosive potential of flavoured sparkling water drinks. International Journal of Paediatrics Dentistry, 17: 86-91.
25. Seow, W.K. and K.M. Thong, 2005. Erosive effects of common beverages on extracted premolar teeth. Australian Dental Journal, 50: 173-8.
26. Grando, L.J., D.R. Tames, A.C. Cardoso and N.H. Gabilan, 1996. *In-vitro* study of enamel erosion caused by soft drinks and lemon juice in deciduous teeth analysed by stereomicroscopy and scanning electron microscopy. Caries Research, 30: 373-8.
27. Banan, L.K. and A.M. Hegde, 2005. Plaque and salivary pH changes after consumption of fresh fruit juices. Journal Clinical Pediatrics Dentistry, 30: 9-13.
28. Edwards, M., S.L. Creanor, R.H. Foye and W.H. Gilmour, 1999. Buffering capacities of soft drinks: the potential influence on dental erosion. Journal of Oral Rehabilitation, 26: 923-927.
29. Jensdóttir, T., I. Thornórsdóttir, I.B. Arnadóttir and W.P. Holbrook, 2002. Erosive Drinks on the Icelandic Market. Laeknabladid, 88: 569-572. Abstract.
30. West, N.X., J.A. Hughes and M. Addy, 2001. The effect of pH on the erosion of dentine and enamel by dietary acids in vitro. Journal of Oral Rehabilitation, 28: 860-4.