International Scholars Journals

African Journal of Dentistry ISSN 3216-0216Vol. 7 (6), pp. 001-007, June, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

The acidity of some selected soft drinks on the Ghanaian market

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Accepted 26 April, 2019

Dental erosion is one of the various factors which affect oral health. Acids present in food and beverages are part of the major aetiological factors responsible for the erosive lesions of dental enamel. Frequent and excessive drinking of acidic soft drinks or beverages can subsequently be deleterious to teeth. The purpose of the study was to determine the acidity (pH) of some commercially available soft drinks on the Ghanaian market at room and refrigerated temperatures. The study was a cross sectional study. Thirty soft drinks were randomly selected after a market survey and categorized according to the type of drink (19 fizzy drinks, 7 fruit drinks, 2 energy drinks and 2 malts drinks). The pH values of samples of the soft drinks were measured (n=3) before refrigeration and after refrigeration at 25 °C and 4 °C respectively using a Horiba NAVI F52 pH meter at Noguchi Memorial Institute for Medical Research. The data was analyzed using one-way analysis of variance (ANOVA) from Statistical Package for the Social Sciences (SPSS). The pH values of the soft drinks obtained from the study were all lower than the critical pH value (5.5) for enamel demineralization. The pH values recorded at room temperature ranged from 2.488 to 4.674. At refrigerated temperature of 4°C, the pH values ranged from 2.604 to 4.941. There was no significant difference (P>0.05) in the pH values of the soft drinks when the values before refrigeration and after refrigeration were compared. The pH of the soft drinks studied all indicated erosive potential to dentition because of their acidic nature.

Keywords: pH, soft drinks, acidity, demineralization, dental erosion, erosive potential.

INTRODUCTION

Apart from water, soft drinks are probably the most widely consumed nonalcoholic beverages in the world (Ryan, 2014). Encyclopedia Britannica describes soft drinks as “non-alcoholic carbonated or non-carbonated beverages which usually contain a sweetening agent, edible acids, natural or artificial flavors”. The term ‘soft drink’ was coined to distinguish non-alcoholic beverages from hard liquor, or spirits. Soft drinks serve as a source of hydration. Compared to water, they are more readily absorbed, therefore, are rapid thirst quenchers (Ashurst, 2005). In addition to their thirst-quenching ability, soft drinks generally taste sweet and come in different desired flavors. The contents of a soft drink basically include carbonated water, sugar, acids, additives and preservatives.

In Western countries, the personal water requirements of most people come from soft drink consumption (Low et al., 2008). With the current influx of new brands of assorted soft drinks on the Ghanaian market, perhaps, the same may be said for Ghana. In 2013, about 196 billion litres of carbonated soft drinks were consumed, reflecting their importance in the global drinks market (Ashurst, 2016). Unlike the past years, children and adole-

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scents now have more diverse fluid consumption patterns.
Soft drinks or some non-alcoholic beverages contain acids and sugars which gives them both acidogenic and cariogenic potential (Cheng et al., 2009). Some soft drinks have a low pH and high titratable acidity, which may lead to dental erosion. Dental erosion is known as a painless irreversible loss of dental hard tissue normally from a chemical process either by chelation or dissolution without the involvement of microorganisms. Also, the sugars in these soft drinks are metabolized by bacteria in plaque to produce organic acids which demineralize dental hard tissues, leading to caries (Tahmassebi et al., 2004). Cheng also believed that, "Compared with caries, dental erosion seems to have much stronger relationship with soft drinks. The erosive potential of drinks is mainly represented by their pH and the buffering capacity.
In recent times, the Ghanaian market has seen an influx of assorted imported and locally produced non-alcoholic beverages. Commercially, different kinds of soft drinks are now widely and readily available and are well patronized. Several wholesale or retail drink depots have sprung up all over the country, indicating a booming market for both alcoholic and non-alcoholic beverages. Soft drink consumption is on the rise in Ghana probably due to availability and affordable prices. Many Ghanaians, especially children and adolescents, consume soft drinks daily without even knowing the deleterious effects of these soft drinks on their dental and general health. Excessive soft drink intake is an unhealthy lifestyle associated with diabetes, obesity and is also implicated in dental caries and dental erosion.
The negative effects of excessive soft drink intake on the Ghanaian population may not be felt or appreciated now. However, in a few years to come, the issue of dental erosion, tooth wear and sensitivity may be on the rise if people are not educated about the potential damage being caused. Although many studies have been carried out globally related to soft drink consumption, however, research on this in Ghana is seriously lacking. With the frequent and excessive consumption of acidic, sugar-rich soft drinks, Ghanaians have a high risk of acid demineralization and in the long run, leading to erosion, caries development and other possible complications.
The purpose of the study was to determine acidity (pH) of some selected commercially available soft drinks on the Ghanaian market at room and refrigerated temperatures.

MATERIALS AND METHODS

The materials used for the study as indicated in Tables 1-4 and Figure 1, were thirty soft drink brands selected after a market survey. The drinks were categorized into seventeen fizzy drinks, seven fruit drinks, two malt drinks and two energy drinks. The type of acid contained in the soft drinks and their manufacturers were also indicated in Tables 1-4.
The market survey was carried out in a number of shops selected randomly and located in different suburbs in the Greater Accra region. The results of the survey indicated that these thirty soft drink brands studied were the most popular brands patronized by consumers.

LABORATORY PROCEDURE

A Horiba NAVI F52 pH meter in Figure 2 with relative accuracy of ±0.001 pH unit was used to measure the pH of the soft drinks immediately after they were opened. The pH meter was first standardized using a standard buffer of pH 7. It was necessary to standardize the pH meter to get accurate pH measurements. To make a pH measurement, the electrode was rinsed with distilled water and blotted dry with a soft tissue paper. The electrode was dipped in a sample deep enough so the reference junction was immersed in the sample. The electrode was kept in the sample till the pH reading stabilized. Once a stable reading was obtained, the pH was recorded. The electrode was then removed from the sample, rinsed and pH measurement done for the subsequent samples. The pH value of each beverage was measured in triplicate immediately after opening at temperature of (25°C). The drinks were then refrigerated at a temperature of (4°C) for two weeks after which their pH was measured in triplicate. This was carried out at both room (25ºC) and fridge temperature (4ºC) because most soft drinks are consumed when cold.

STATISTICAL ANALYSIS

Data obtained were entered into excel sheet. The data was analyzed using one-way analysis of variance (ANOVA) from Statistical Package for the Social Sciences (SPSS) version. Significance was set at 0.05.

RESULTS

The means and the standard deviations of the pH of the thirty soft drinks of different categories before refrigeration at room temperature of 25^{o}C and refrigerated at a temperature of 4^{o}Care summarized in Tables 5-8. The variation of the pH with temperature and comparison of these values before and after refrigeration is indicated in Figure 3.
The pH values of the sampled soft drinks ranged from 2.488 to 4.674 at room temperature (25°C) and 2.607 to 4.941 after refrigeration (4°C). Beta malt had the highest pH value and Coca cola had the lowest pH value before and after refrigeration.
One way analysis of variance (ANOVA) indicated significant differences ($p<0.05$) in the pH values of the

Table 1. Fizzy drinks studied and their manufacturers.

DRINK TYPE	ACIDULANT	MANUFACTURER
Coca cola	Phosphoric acid	Coca cola Bottling Company
Fanta Orange	Citric acid	Coca cola Bottling Company
Fanta lemon	Ascorbic acid	Coca cola Bottling Company
Fanta fruit cocktail	Citric acid	Coca cola Bottling Company
Club orange	Citric acid	Accra Brewery Limited
Mirinda	Citric acid	SBC Ghana Beverages Limited, under PEPSICO INC NY
7-Up	Citric acid	SBC Ghana Beverages Limited, under PEPSICO INC NY
Pepsi	Phosphoric acid	SBC Ghana Beverages Limited, under PEPSICO INC NY
Club musketella	Citric acid	Accra Brewery Limited
Squeeze	Citric acid	Blow Chem Industries Limited
Sprite	Phosphoric acid	Coca cola bottling company
Alvaro	Acid type not specified	Guinness Ghana Breweries Limited
Special Red Grape drink	Citric acid	Special Ice Company Limited
Royal apple drink	Acid type not specified	Kasapreko Company Limited
Cocktail de fruits	Citric acid	Brassieries BB, UEMOA
Planet Citron	Citric and ascorbic acids	Twellium Industrial Company Limited
Appela	Malic acid and Citric acid	Blow Chem Industry Limited
10over10red grape and cherry drink	Acid type not specified	Kasapreko company Limited
Special apple drink	Citric acid	Special Ice Company Limited

Table 2. Fruit drinks studied and their manufacturers.

DRINK TYPE	ACIDULANT	MANUFACTURER
Kalypo pineapple	Citric acid	Aquafresh Ghana Limited
Kalypo fruit cocktail	Citric acid	Aquafresh Ghana Limited
Fandango Tropical drink	Acid type not specified	Fanmilk Limited
Don Simon multi fruitas	Citric acid	Ekulo International Limited
Royal exotic cocktail	Acid type not specified	Kasapreko Company Limited
Tampico citrus punch	Citric acid	Acadia Industries Limited
Juicee	Citric acid	Aquafresh Ghana Limited

Table 3. Energy drinks studied and their manufacturers.

DRINK TYPE	ACIDULANT	MANUFACTURER
Rush energy drink	Citric acid	Monarch Beverage Company and Twellium Industrial
5-Star energy drink	Not indicated	Multi Pac Limited

Table 4. Malt drinks studied and their manufacturers.

DRINK TYPE	ACIDULANT	MANUFACTURER
Malta Guinness	Not indicated	Guinness Ghana Breweries Limited
Beta malt	Not indicated	Accra Brewery Limited

different categories of soft drinks before and after refrigeration. However, ANOVA indicated no significant differences ($p>0.05$) in the pH when the values of the different categories of soft drinks before and after refrigeration were compared.

DISCUSSION

Important parameters for the erosive potential of soft drinks include pH, acid concentration (with respect to buffer capacity and concentration of undissociated acid),

Figure 1. Soft drinks obtained for the study.

Figure 2. Horiba NAVI F52 pH meter.

mineral concentration and degree of saturation. pH is the dominant factor in the erosive dissolution of enamel. Though the buffer capacity and mineral concentration can have significant effects on the erosive potential against the enamel, their effects are pH dependent (Barbour et al., 2011). According to studies, the initial or immediate erosive potential of soft drinks depends on the pH (Benjakul and Chuenarrom, 2011; Jensdottir et al., 2006; Barac et al., 2015). In a comprehensive analysis of the pH of beverages in the United States, Reddy et al, in

Table 5. ph measurements of fizzy drinks.

DRINK TYPE	pH (NON-REFRIGERATED) (25°C)	pH (REFRIGERATED) (4°C)
Coca cola	2.488(.014)	2.607(.075)
Fanta Orange	2.873(.017)	2.996(.017)
Fanta lemon	2.558(.008)	2.691(.118)
Fanta fruit cocktail	2.881(.005)	2.924(.006)
Mirinda	2.960(.006)	3.002(.006)
7-Up	3.289(.022)	3.416(.021)
Pepsi	2.574(.017)	2.631(.035)
Club musketella	3.280(.002)	3.332(.008)
Squeeze	3.062(.107)	2.943(.018)
Sprite	3.079(.001)	3.096(.009)
Alvaro	3.071(.011)	3.137(.130)
Special Red Grape drink	3.170(.024)	3.308(.008)
Royal apple drink	2.821(.019)	2.899(.023)
Cocktail de fruits	2.831(.006)	2.793(.003)
Planet Citron	2.575(.004)	2.625(.055)
Appela	2.811(.039)	2.837(.011)
10over10red grape and cherry drink	2.869(.107)	2.937(.015)
Special apple drink	2.891(.002)	2.993(.023)

Table 6. pH measurements on fruit drinks.

DRINK TYPE	pH (NON-REFRIGERATED) (25°C)	pH (REFRIGERATED) (4°C)
Kalypo pineapple	3.069(.010)	3.150(.034)
Kalypo fruit cocktail	3.254(.031)	3.332(.055)
Fandango Tropical drink	2.939(.021)	3.090(.008)
Don Simon multi fruitas	3.246(.011)	3.326(.007)
Royal exotic cocktail	2.624(.016)	2.785(.016)
Tampico citrus punch	3.035(.017)	3.183(.006)
Juicee	3.035(.026)	3.163(.025)

Table 7. pH measurements on energy drinks.

Drink type	pH (Non-Refrigerated)(25°C)	pH (Refrigerated) (4°C)
Rush energy drink	3.416(.010)	3.431(.002)
5-Star energy drink	3.844(.023)	3.927(.067)

2016 strongly believed that the pH of dietary beverages coming into contact with the dentition appears to be the main determinant of dental erosion and was primarily responsible for the immediate dissolution and softening of surface tooth structure (erosive potential) by acidic beverages (Reddy et al., 2016). Larson and Nyvad concluded from their study in 1999 that "apart from orange juice, the erosive capability increased logarithmically inversely with the pH of the drink and parallel with the solubility of apatite" (Larsen and Nyvad, 1999).

This study was undertaken to analyze the pH values of thirty soft drinks found on the Ghanaian market. The thirty soft drinks analyzed in the study consisted of nineteen fizzy drinks, seven fruit drinks, two energy drinks and two malt drinks as shown in Tables 1-4.

The results as indicated in Tables 5-8 shows that the pH values of all the thirty soft drinks recorded were in the acidic range. Coca cola had the lowest pH values of 2.488 and 2.602 before and after refrigeration respectively. Beta malt had the highest pH values 4.674 before refrigeration and 4.941 when refrigerated respectively. The rest of the drinks recorded pH values between 2.5 and 4.9. The pH values recorded in this study fell below the critical pH for enamel demineralization (5.5). This was consistent with the finding of Bamise et al, who concluded from their study in 2007, that Nigerian soft drinks had pH below the critical

Table 8. pH measurements on malt drinks.

Drink type	pH (NON-Refrigerated) (25°C)	pH (Refrigerated) (4°C)
Malta Guinness	4.320(.015)	4.555(.025)
Beta malt	4.674(.023)	4.941(.141)

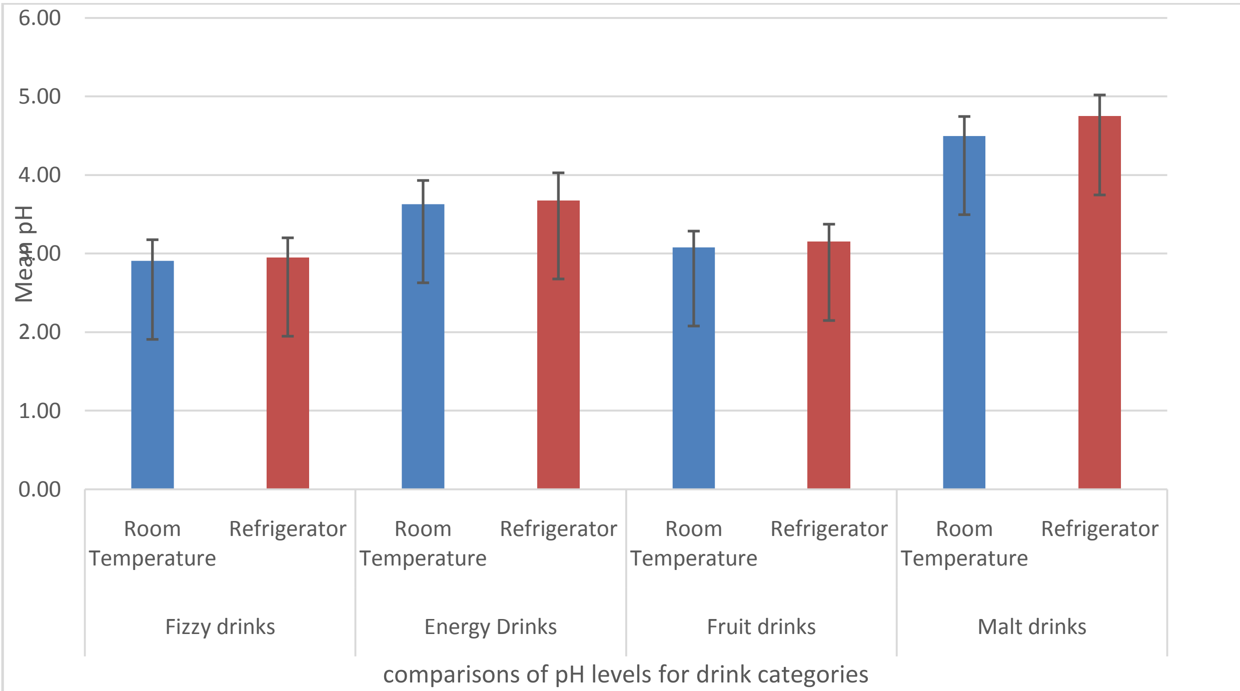

Figure 3. pH values of the various categories of drinks at the different temperature.

dissolving pH of enamel. Other studies have also had similar findings (Barac et al., 2015; Tadakamadla et al., 2015; Wang et al., 2014).

The pH values of all the drinks increased after refrigeration. However, the temperature changes did not significantly affect the pH (P>0.05, P=0.493). Although this study did not record a significant difference in the mean pH values of the drinks at the two different temperatures, literature shows that temperature has an influence on erosive effects of beverages.

In this study, different types of acids contained in the soft drink samples were noted. Phosphoric acid, citric acid, malic acid and ascorbic acids were the food acidulants present (Tables 1-4). Most of the soft drinks had citric acid as their acidulant. Beta malt and Malta Guinness were the only category of soft drinks without indication of acidulant. According to literature, the acids are added to give the soft drinks acidity and sharpness (Kirk and Ryan, 2003; Qing-Chuan and Wang, 2001). The acid contents of the soft drinks were responsible for the acidic nature of the soft drinks. The different acids have different erosive capacities. This was confirmed in a study by Beyer et al where slices of human enamel were used to investigate the erosive effect of tartaric acid, malic acid, lactic acid, ascorbic acid, citric acid and phosphoric acid, concluded that ''the acids had different erosive effects on in vitro enamel surfaces" (Beyer et al., 2011).

In 2006, the results of an in vitro study by Babour et al indicated a clear correlation between erosion, enamel softening, and temperature. In a study by Babour et al in 2003, the pH values of the soft drinks decreased with temperature and the rate of enamel erosion and extent of softening increased with decreasing pH. Generally, the rate of most chemical reactions varies with temperature. It is likely that, that the tendency of soft drinks to bring about dental erosion is lessened at lower temperatures and increased at higher temperatures and drinking it cold or chilled decreases its erosive effect (Amaechi and Higham, 2005).

CONCLUSION

The following conclusions were drawn from the study:

- All the soft drinks analyzed in the study had pH values within the acidic range and the values were below the critical pH value (5.5) for enamel demineralization.
- All the soft drinks, due to their low pH values, have the potential to contribute to dental erosion.

RECOMMENDATIONS

- Doctors and dental health practitioners should educate the general public about the effects of excessive soft drink consumption on oral (dental erosion) and general health.

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