Evaluation of the Dental Erosive Potential of Popular Wines and Beers in Nigeria

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Abstract

Aims: To assess whether the pH and titratable acidity of popular commercial wines and beers in Nigeria are below or above the critical levels for enamel dissolution (pH 5.0–5.7) so as to predict their dental erosive potential. Methods: All 7 beers and top 3 wines commercially available in retail shops listed by 43 heavy drinkers (once/week) were evaluated in this study. The pH of each sample was determined using a digital pH meter. Moreover, the titratable acidity was assessed by titrating 0.1 N sodium hydroxide with 20 mL of each sample until a neutral pH of 7.0 was achieved. Results: The pH of the drinks on opening ranged from 3.46 to 4.4. After 120 min of opening, the pH ranged from 3.6 to 4.6. On opening, Guinness had the lowest pH (3.7) among the beers and Eva the lowest pH (3.4) among the wines. Guinness also showed a tendency to decrease in pH at the end of 120 min. Generally wines showed pH values relatively lower than beers. The volume of base needed to raise the pH of the samples to 7.0 ranged from 3.2 to 11.1 mL. The volume of base required for neutralization was highest for Guinness among the beers (7.1 mL) and Classic red wine among the wines (11.1 mL). Wines showed higher titratable values than beers. Conclusion: All the investigated alcoholic beverages are acidic and have pH values below the critical value for enamel dissolution and titratable acidity higher than a known erosive drink. Thus, they possess the potential to cause dental erosion.

Keywords
Dental erosion, pH, titratable acid, alcoholic beverage

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Introduction

Dental erosion is a non-caries, pathological loss of tooth surface, distinct from abrasion and attrition. It is defined as the irreversible loss of dental hard tissue by a chemical process not involving bacteria (1). Acid erosion, or corrosion, of the tooth surface is now recognized as a major cause of tooth wear (2). Unless halted, enamel erosion often leads to widespread exposure of dentin, resulting in an unsightly appearance of the teeth, tooth hypersensitivity, and consequently, reduced chewing function. Advanced cases may also involve the destruction of dentin and pulp. Hence, treatment may be complicated, difficult, and challenging. The costs of treatment and rehabilitation are also often very high.

Dental erosion has a multifactorial etiology, attributable to intrinsic and extrinsic causes. The extrinsic factors involved in erosion include environmental factors, dietary factors, medications, and lifestyle. Associations between diet and dental erosion have received considerable attention, especially in relation to acidic foods and drinks. With changes in lifestyles, the consumption of alcoholic beverages such as wine has increased even in countries outside the traditional wine-producing ones. The probable consequence is that wine has since been reported, though infrequently, as a cause of dental erosion (3). In 1996, Ferguson et al. (4) published a report on the association between winemaking and dental erosion, and in 1998, Gray et al. (5) reported a case associating wine tasting with dental erosion.

Alcohol is as old as human history, and its consumption in different socio-cultural environments extend beyond the last ten thousand years. Its consumption has been considered normal in Africa and other parts of the globe, especially when ingested without outright intoxication (6). Beer is the most popular alcoholic drink in Nigeria, which is partly a consequence of the tremendous growth of brewing industries in recent years. In 2005, Mitchel and Tomo (7) observed that, years ago, there were a handful of beer brands in Nigeria; however, today, there are several breweries brewing millions of liters of beer under different brand names.

As far back as 1977, Anumonye (8) stated that “so far alcohol has not received the attention it deserves in Nigeria. It is increasingly abused and this abuse will become a serious problem within the next few years.” Till date, except in some states in the northern part of Nigeria, there is no policy to regulate the production, marketing, advertising, and availability of alcohol. At present, bars, restaurants, hotels, etc. sell alcohol at any time of the day resulting in increased use of alcoholic beverages.

In alcoholics, dental erosion may be from intrinsic and extrinsic sources (9). The erosive potential of alcoholic beverages might be due to the acidic content of the drink or the frequent vomiting associated with excessive alcohol consumption. In support of this theory, Robb and Smith in 1990 (10) observed that significantly more tooth wear is found in alcoholic patients than in age- and sex-matched controls.

The critical point at which enamel dissolves is reported to lie between pH of 5.0 to 5.7 (11,12), and hence, alcohol can play a major role in tooth erosion owing to its acid content. The salivary concentration of calcium and phosphate normally is supersaturated in relation to enamel hydroxyapatite. An acid challenge results in under-saturation of these salivary salts, and tooth demineralization with softening of dental enamel takes place (13). The dissolution of enamel in acid occurs as a result of reaction between the hydrogen ion
and the inorganic material (hydroxyapatite) that forms the principal part of the enamel. The reaction results in dissolution of enamel leading to liberation of calcium and phosphate ions along with water molecules (14).

The acidic content of a drink can be quantified by assessing the pH value and the titratable acidity (TA). The pH is a measure of the hydrogen ion concentration present in a solution, while TA is the total number of acid molecules and determines the actual hydrogen ion availability for interaction with the tooth surface (15). TA represents the amount of alkali (base) needed to be added to an acid to bring it up to a neutral pH. It actually suggests the strength and the amount of available acid of the composition (16). The lower the pH, the more acidic the drink and the more difficult it is to bring the pH to neutrality (17). In practice, pH is measured by a pH paper or a digital pH meter. TA or the buffering capacity is assessed by measuring the weight (in grams) of standardized sodium hydroxide (NaOH) necessary for titration to a predetermined pH level (18). Although a pH of 5.5 is traditionally considered to be the “critical pH” for enamel dissolution, mineral loss may begin at a higher pH (19). In a study by Hughes et al. (20), increased erosion was found to correlate with decreasing pH and increasing acid concentration.

In recent years, the pattern, quantity, and reason for consumption of alcohol are changing rapidly in Nigeria, especially among the youth (21). Increased consumption may lead to an increase in the burden of alcohol-related oral health problems; therefore, there is a need to evaluate the erosive potentials (i.e., pH and TA) of popular alcoholic beverages in Nigeria.

Methods

The determination of pH and TA levels was carried out in the Central Science Laboratory of the Obafemi Awolowo University, Ile-Ife, Nigeria. Ten (10) popular commercial alcoholic beverages (7 beers, 3 wines) were selected for this study. This was done after a convenience sample of 43 adults, who drink alcoholic beverages at least once per week, were asked to list all the commercially available wines and beers they were acquainted with and which can be obtained in retail shops. Their responses were then imputed into an Excel sheet and the frequencies generated. All 7 beers (33 Export, Star, Harp, Heineken, Guinness, Gulder, and Trophy) and the top 3 wines (Classic white wine, Classic red wine, and Eva wine) listed were noted. These 10 items were then purchased from licensed wine and beer retailers and stored in a refrigerator before transporting them to the Central Science Laboratory of the university.

The laboratory scientist who carried out the experiment was blinded to the samples. Data were recorded in study-specific charts and authenticated by the laboratory staff before retrieval.

pH Measurement

The pH of the specimens was measured using a portable pH meter (Hanna Instruments, USA). The pH meter was calibrated according to the manufacturer's instructions; firstly, three buffer solutions were prepared (from the buffer powders) with the following pH values: 4.0, 7.0, and 9.0. The meter was thereafter adjusted with 4.0 and 9.0 buffers and made to accurately detect the buffer solution at pH 7.0 before it was used. Twenty (20) mL of freshly opened specimen at room temperature was poured into a beaker and stirred using a non-heating magnetic stirrer until a stable reading was obtained. Seven readings were taken for each drink over a period of 2 h, i.e., pH on
opening and after 15, 30, 45, 60, 90, and 120 min.

**Titratable acidity**
Twenty (20) mL of each drink was titrated with 0.1 N NaOH added in 0.2 mL increments until a pH of 7.0 was reached. This was done by using a non-heating magnetic stirrer until a stable pH reading was obtained. Titrations were repeated in triplicate for all the drinks to assess the reproducibility and to obtain a mean value.

**Results**
The pH of the drinks on opening ranged from 3.46 to 4.4. After 120 min of opening, the pH ranged from 3.6 to 4.6 (Table 1). This shows that all the beers and wines evaluated were acidic and remained so for the 120-min evaluation period. On opening, Guinness had the lowest pH of 3.7 among the beers, and Eva was the most acidic wine with a pH of 3.4. The following beers: 33 Export, Harp, Heineken and all the wines showed a tendency to increase in pH after 120 min. Guinness beer contrarily showed a tendency to decrease in pH just 30 min after opening, which was maintained throughout the remaining 90 min of the evaluation period. The pH of beers like Star, Gulder, and Trophy remained unchanged throughout the 120 min. White wines showed a slightly lower pH (3.4) than red wines (3.7). Generally wines showed relatively lower pH values (ranging from 3.4 to 3.8) than beers (pH 3.7 to 4.4).

The volume of 0.1 N NaOH base needed to raise the pH of the drinks to 7.0 ranged from 3.2 to 11.1 mL (Figure 1). Among the brands of the beers in the study, Guinness required the largest volume of base to be neutralized while Harp required the lowest. Classic red wine required the most base of 11.1 mL while Eva wine required the least (8.7 mL). Wines showed relatively higher titratable values (8.7 to 11.1) than beers (3.2 to 7.1), i.e., they required more base to raise the pH to 7.

**Discussion**
All the test samples were acidic and generally possessed pH levels lower than the critical pH (5.0–5.7) at which enamel dissolves (11,12). Since at this critical pH, dissolution of enamel and release of calcium and phosphate ions take place (14), we theorized from our findings that all the alcoholic beverages evaluated in this study possess the potential to dissolve enamel hydroxyapatite, which is clinically observed as erosive tooth wear. This finding supports the study of Robb and Smith (10), which showed that significantly more tooth wear is found in alcoholic patients than in age- and sex-matched controls.

<table>
<thead>
<tr>
<th>Syrup</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tr>
<td>Heineken</td>
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<td>4.3</td>
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<td>3.7</td>
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<td>3.8</td>
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A-pH on opening; B-15 min; C-30 min; D-45 min; E-60 min; F-90 min; G-120 min; H-Change in pH
Erosive Potential of Alcoholic Beverages in Nigeria

The pH of wines obtained in the present study was comparable to that reported in South Africa by Chkte et al. (22). In that study, the pH of white wine was around 3.2 to 3.5 and that of red wines ranged from 3.5 to 4.0. In reference to the relatively low pH values of wine, Mandel (23) suggested that wine can be an important causative agent in the etiology of dental erosion. He reported a case associating wine consumption with dental erosion. Similar findings were observed in a study conducted by Gray et al. (24) in wine tasters.

Wines are usually produced from grapes. Therefore, they are composed of principal acids found in grapes; namely, tartaric acid, potassium hydrogen tartrate (cream of tartar), malic acid, and potassium hydrogen malate. Malic and tartaric acids are considered to be particularly erosive for dental tissues because of their acidic nature and the ability to chelate calcium at higher pH (25). The ratio of each depends on the degree of malolactic fermentation. Small quantities of succinic and citric acid are also present in wines. In a study done by Rytömaa et al. (26), it was found that lactic acid does not cause significant erosion when compared to citric acid; moreover, drinks containing phosphoric and citric acid are very erosive. Holloway (27) found that the addition of sucrose, fructose, or invert sugar to a 0.5% citric acid solution led to greater dental erosion. This fact is very relevant in the present situation because wine has gradually become a part of our society’s diet and more and more clients and supermarkets demand higher sugar levels in wines.

In an experimental study by Seow and Thong (28), beverages with the greatest erosive effects on enamel were found to be the most acidic. The total acid content of a drink is evaluated by measuring the TA or buffering capacity of the beverage and is a more important indicator than actual pH value in determining the erosive potential of beverages (29). Lussi and Jaeggi (30) reported that the greater the buffering capacity of a drink or food, the longer it will take for saliva to neutralize the acid. Higher buffer capacity of a drink or foodstuff will enhance the processes of dissolution because more ions from the tooth mineral are needed to render the acid inactive for further demineralization. In this study, the TA of wines was slightly higher than that of beers, which suggests that they belong to a more erosive group.

Winemakers generally believe that red wines cause considerable dental problems especially severe staining of teeth but are the least damaging in terms of dental erosion. The longer maturation periods required for red wines may result in the greater production of potential inhibitors of erosion. In a study done by Mok (31), continuous exposure of enamel and root surface cementum to samples of rieslings and champagne-style wines and claret showed that red wine was the least erosive.
The white wines resulted in the deepest erosion. This result was indicated in our study as white wine was found to have lower pH values than red wine.

The acidity of wine is one of its most appealing characteristics (32). In case of wine-induced dental erosion, several factors that enhance its formation and severity have been described in literature. Naturally, the more wine that is consumed, the more acid will be exposed to one’s teeth. The method by which wine tasting is executed is one of the factors that enhances erosion due to the prolonged time of contact with the teeth. Approximately 15 to 60 seconds of holding wine in the mouth, for example, as done by wine tasters, has been described as sufficient time for widespread erosion of teeth (11,31). Professional wine tasters sample 5 to 50 wines each day and hold the wine in their mouth from 15 to 60 seconds (31). Wine is swirled around the mouth to stimulate the taste buds and to reach the sides and base of the tongue, while inhaling mouthfuls of air to aerate the wine, before the wine is expectorated. This ritual might take about 15 seconds at a time. Thus the wine covers all areas of the mouth for an extended period. This frequent and long exposure to an acidic pH makes the teeth more likely to be eroded than if the person rapidly swallows the wine (33). The time of the day that wine tasting is executed is also important. For example, if wine is consumed just before sleep (that means no further beverages will follow the wine), the acid environment in one’s mouth will also extend for a longer period of time, and thus, dental erosion will be more severe. Food, with its resulting salivary stimulation and detergent effect, usually function to lessen wines’ dental contact time. Food served immediately after wine consumption is said to flush and physically clear the wine from the teeth (23).

Tooth brushing and the use of mouthwash have been suggested to decrease the dental contact time of any residual wine. To some extent, failure to brush immediately after wine consumption is viewed as being beneficial because an intensified period of tooth demineralization and softening rapidly occurs after acid exposure. Enamel loss from tooth brushing abrasion is likely to be increased because sufficient time for re-mineralization will not have passed (34,35).

When acidic beverages are consumed, the pH environment in the mouth is at the critical stage at which erosion commences. There is increasing awareness of the important role of saliva, as it can increase the pH of the dental environment. Sorvari and Rytomaa (36) showed that a low flow rate of unstimulated saliva increased the risk of tooth erosion fivefold. In studies by Wiktorsson et al. (37), all subjects with severe erosion had abnormally low unstimulated salivary flow rates. Saliva, with its buffering capacity and its ability to form a protective enamel pellicle, can control dental decalcification. But this physiological protection fails when saliva is overwhelmed by large quantities of drinks with a low pH or when decreased salivary production occurs (23).

In wine tasters, attempts have been made to increase salivary pH by rinsing the mouth with water in-between tasting the samples of wine. The use of an alkaline mouth rinse after each tasting may alter the taste; so, this approach is not practical, but rinsing the mouth at the end of a tasting session with an alkaline mouth rinse may be beneficial. Also chewing gum that contains carbamide (urea) may be useful as it has been shown to rapidly increase salivary pH (38), which may contribute to reducing the erosive effect of acid in the mouth. Much research evidence has shown the protective action of milk products on enamel (39). This includes protection of enamel by casein phosphor-peptides, stimulation of salivation.
by flavoured cheeses, reduction of plaque formation by milk lipids, and enhancement of plaque calcium levels. By opposing enamel dissolution, reduced demineralization and enhanced re-mineralization can be achieved. After the consumption of wine, it is possible to re-mineralize damaged enamel by drinking milk or eating hard cheese.

It can be surmised that all the evaluated drinks in this study possessed sufficient erosive potential capable of dissolving enamel. It suffices to state that their erosive effect in clinical situations may not be as strong as what was discovered in the laboratory because of the interplay of other intrinsic and extrinsic factors. The capability of any drink (e.g., wine or beer) to erode dental enamel depend on factors such as the pH, total acid concentration, acid strength, buffering capacity, dissolution rate of acids, and specifically the calcium, phosphorous, and fluoride concentrations of teeth (because these elements form the building blocks of hydroxy- and fluoroapatite). Furthermore, the calcium, phosphate, and fluoride content counteract the effect of low pH and make the drink less harmful.

Despite their acknowledged health hazards, wine consumption has become a lifestyle trend and the number of consumers is also constantly growing. Experts and employees are needed to produce such high volumes of wines and assess their quality and taste them. Genuine interest in the effects of wine on dental health should lead to a stronger focus on the occupational health hazards of wine, increased erosive tooth wear in consumers, and the accompanying high dental care expenses.

Conclusion

Due to high TA, particularly in wines, and pH values that are generally below the critical pH for enamel demineralization, all popular wines and beers in Nigeria possess the potential to dissolve enamel and therefore cause dental erosion.

Nigerian dentists should be on the alert for possible alcohol incited tooth sensitivity, tooth wear lesions, poor esthetics, loss of vertical dimensions, and functional problems because of the increasing consumption of alcohol among the public. In the meantime, it is recommended that the Nigerian Dental Association takes a lead role in raising awareness among the population and sensitize dental professionals to watch out for the dental effects of alcohol. Dentists, like physicians, should be encouraged to utilize every opportunity to educate patients about the risks of alcohol use and abuse (50). The government’s will to strengthen and implement existing laws for the control of sales and consumption of alcoholic beverages will go a long way in reducing the burden of dental erosive tooth wear in consumers.

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