Research Article

Evaluation of PH and buffering capacity of sports drinks and carbonated drinks

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ABSTRACT

Introduction: Dietary intake of young adults has been modified in the recent years. This decade has shown the increase in consumption of carbonated and energy drinks. People are unaware about the acidogenic ad cariogenic properties of the carbonated drinks which cause dental erosion, dental caries, etc. This study is done to evaluate the pH and buffering capacity of sports and energy drinks. **Aim:** The aim of this study is to determine the pH and buffering capacity of sports drink and energy drink. **Materials and Methods:** Three groups were selected of which Group 1 is mineral water, Group 2 is carbonated drinks, and Group 3 is energy drink. Before the study, the drinks were kept unopened and in normal room temperature. PH meter was used to measure the PH of each beverage. Buffering capacity was measured using the same pH meter at pH 5 and pH 7. The data are recorded in mean and standard deviation. **Statistical Analysis:** Kruskal- Wallis Test was used to compare the mean differences of pH between the groups. **Results:** Results show that carbonated drinks are more acidic compared to energy drinks. **Conclusion:** Consumption of carbonated and energy drinks should be reduced amount youths since it causes dental erosion and other medical problems.

KEY WORDS: Buffering capacity, Dental erosion, pH

INTRODUCTION

High consumption of sugar-sweetened and acidulated beverages including energy drinks and soft drinks is associated with numerous adverse health outcomes, including obesity, type 2 diabetes, increased risk for cardiovascular diseases, dental erosion, and dental caries.[1] Soft drinks have become increasingly available in the market, with a surge in their usage, especially among young people and children.[2] These carbonated and energy drinks contain caffeine, artificial sweetener, coloring agents, and acids such as phosphoric or citric acid. Based on the known effects of caffeine, consumption of energy drinks may lead to caffeine intoxication, sleep disruption and insomnia, and hyperactive and risky behaviors.[3]

Energy drinks are typically made to: (1) prevent dehydration, (2) supply carbohydrates to augment available energy, (3) provide electrolytes to replace losses due to perspiration, (4) conform to requirements imposed by regulatory authorities and probably the most important, and (5) be highly palatable. The greatest benefit of energy drinks for an exercising individual is said that they generally increase voluntary fluid consumption.

Dental erosion is commonly seen nowadays. It is one among the four non-carious tooth defects. It is defined as wear of tooth structure due to chemical substances without the presence of bacteria.[4] The etiology can be extrinsic or intrinsic. Intrinsic causes are exposure to gastric contents, such as in gastric reflux or spontaneous or induced vomiting. Such exposure causes a number of medical problems and results in extensive dental erosion when it persists in a susceptible individual.[5] Extrinsic causes include factors such as an individual's environment, medications, diet, and lifestyle.[6] Environmental extrinsic exposures are seen in dynamite factory workers, battery industry workers, workers in galvanizing plants, and workers in factories involved in cleaning processes and acid.[6] Some of the medications may cause dental erosion such as Vitamin C tablets and iron formulations that are too acidic, especially when in chewable form.[5] Continuous use of isotonic drinks could lead to dental erosion.[5] The greatest loss of inorganic tooth structures typically occurs at a pH of 5.5.[7] Extrinsic

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sources with a low pH include fresh citrus fruit and citrus fruit juices, acidulated carbonated drinks, and supplementary sports drinks, many of which contain citric acid.[8]

One of the principle extrinsic etiological factors which cause dental erosion is carbonated soft drinks and sports drinks.[9] The erosive potential of soft drinks depends on total titratable acid along with their pH.[10] The sugars present in soft drinks are one of the contributing factors to dental caries.[11]

Studies state that the amount of time the teeth are soaked in the acidic environment is more crucial to erosion than the volume of beverage consumed. It is known widely that carbonated drinks are frequently held in the mouth until all the bubbles have dissipated. Hence, the contact time of carbonated drinks can be much longer than for non-carbonated beverages due to its acid content and taste.[12-14] The total acid level, acid type, and concentration of phosphate, calcium, and fluoride in the drinks have a modifying effect on the erosion induced by dietary components.[15]

Current recommendations are to limit total soft drink and energy drink consumption and replace them with healthy alternatives such as water.[1] The erosive potential of the enamel is associated with low pH and titratable acidity of the carbonated drinks.[15] Titratable acidity is considered to be an important indicator than the pH to determine the erosive potential for the drinks.[4] Although the causes of dental erosion are well known, their relative degrees of importance are not clear. This study is done to evaluate the pH and buffering capacity of sports and energy drinks.

MATERIALS AND METHODS

Study Design

This is an *in vitro* study which includes one control group and two test groups. They are:

- Group 1: Mineral water (control group)
- Group 2: Carbonated drinks (test group)
- Group 3: Energy drinks (test group).

Each group contains 2 drinks. These drinks were obtained randomly from the local market/supermarket in Chennai, India. All the samples had a 10-month usage period from their production date. These bottles were stored in their original closed containers at room temperature until analysis.

- Group 1 – Mineral water: This group consists of 2 commercially available mineral water [Table 1]
- Group 2 – Carbonated drinks: This group consists of 2 commercially available carbonated drinks [Table 2]
- Group 3 – Energy drinks: This group consists of 2 commercially available energy drinks [Table 3].

pH Measurement

The pH was measured immediately after removing the bottle cap using a pH meter. 100 ml of freshly opened drink at room temperature was placed in a beaker and stirred using a pH pen until a stable reading was obtained. Three readings were taken of each drink from each group to give a mean measurement for that drink.

Buffering Capacity

100 ml of each drink was titrated with 1 M sodium hydroxide (NaOH) added in 0.2 ml increments until the pH of 5.5 and 7 obtained. This was done using the pH meter until a stable pH reading was obtained after each increment (0.2 ml) of NaOH. This was done to measure the total titratable acidity.[16] Titrations were repeated for all drinks to check for reproducibility and to give a mean value for that drink.

Titratable acidity of a solution is measured by reacting the acids present with a base such as NaOH to a chosen end point, close to neutrality. The titratable acidity was kept at pH 5.5 and pH 7. The amount of NaOH required to raise the pH to 5.5 and 7 was noted, and the data were subjected to statistical analysis using the Kruskal–Wallis test.

Statistical Analysis

Data were entered in Microsoft Excel spreadsheet and analyzed using SPSS software

- (version 17)
- Numerical data were presented as mean and standard deviation values
- For test, $P < 0.05$ is to be considered statistically significant
- Kruskal–Wallis test was used to compare the mean differences of pH between the groups.

Table 1: Group 1 mineral water

Name of the drink	Trade name	Manufacturer
Water	Bisleri	Bisleri International Pvt. Ltd.
Water	Aquafina	PepsiCo

Table 2: Group 2 carbonated drinks

Name of the drink	Trade name	Manufacturer
Cola	Pepsi	PepsiCo
Cola	Coca-Cola	The Coca-Cola company

Table 3: Group 3 energy drinks

Name of the drink	Trade name	Manufacturer
Lemon	Monster	Monster Beverage Corporation
Strawberry	Sting	PepsiCo

RESULTS

Table 3 depicts the mean pH and the titratable acidity of the three groups. Table 4 shows the pH and titratable acidity of various beverages at pH 5.5 and pH 7. pH was 7.2 for Bisleri and 6.6 for Aquafina, 2.4 for Pepsi, and 2.5 for Coke, 3.1 for Monster, and 3.6 for Sting.

- Titratable acidity not calculated for Group 1 because of its brutal pH
- Titratable acidity of Group 2 – Pepsi 3.2 ml at pH 5.5 and 5.4 ml at pH 7 and Coke 3.6 ml at pH 5.5 and 5.6 ml at pH 7
- Titratable acidity of Group 3 – Monster 4.2 ml at pH 5.5 and 6.4 ml at pH 7 and Sting 4.4 ml at pH 5.5 and 7.4 ml at pH 7.

Pepsi (2.4) has the lowest pH compared to other drinks, followed by Coke which has a pH of 2.5 and then Monster (3.1) and Sting (3.6). According to this, carbonated drink is most acidic than energy drink.

Buffering capacity is the amount of NaOH needed to raise the pH to neutral. Dissolution of organic components of the tooth will occur at pH 5.5; hence, pH 5.5 and pH 7 are choosing for buffering capacity. Table 5 shows that 3.2 ml was required to raise the pH of Pepsi to 5.5 and 5.4 ml required to raise the pH to 7. The maximum amount of NaOH was required for Sting. Hence, more basic was required to neutralize Sting.

There was a statistical difference between Group 1, Group 2, and Group 3 which was mineral water, carbonated drinks, and energy drinks, respectively.

DISCUSSION

Dental erosion is defined as their reversible loss of tooth structure due to chemical dissolution by acids and not of bacterial origin.[9] Various intrinsic and extrinsic factors influence dental erosion. Epidemiological studies have shown that younger adults from the last 20 years have signs of dental erosion.[17] The pH of the extrinsic solution and its contact tooth is primarily responsible for dissolution and softening of the surface of the tooth by acidic beverages composed of week acids.[18] Several studies have shown that isotonic drinks are regularly consumed by most athletes.[19] Erosion initially affects the enamel which is asymptotic and, if left unchecked, may proceed to the underlying dentin which causes symptoms such as sensitivity. Even though pH is used to measure acidity, the titratable acidity or buffering capacity may indicate the potential of a beverage to erode tooth structure.

The ways in which acidic drinks affect enamel depend on the complex interaction of the following components:[20]

- Chemical properties like (fluoride level, pH, titratable acidity, and calcium and phosphate content)
- The physical properties of beverages (like adhesiveness)
- Biological factors such as composition of consumers' saliva and consumers' saliva flow, buffering capacity, pellicle formation, and tooth composition
- Behavioral factors such as drinking habits, frequencies of consumption, duration, and timing of exposure.

The pH at the time of exposure is the important parameter compared to the titratable acidity due to the limited exposure of dentin with ingested liquids during each drinking and swallowing episodes.[21] The acidic beverages are been neutralized by the bicarbonate ions from saliva.

Table 4: Titratable acidity of various beverages up to pH 5.5 and 7

Beverages	pH	Titratable acidity (amount of NaOH required) up to pH 5.5	Titratable acidity (amount of NaOH) up to 7
Bisleri	7.2	-	-
Aquafina	6.6	-	-
Pepsi	2.4	3.2 ml	5.4 ml
Coke	2.5	3.6 ml	5.6 ml
Monster	3.1	4.2 ml	6.4 ml
Sting	3.6	4.4 ml	7.4 ml

NaOH: Sodium hydroxide

Table 5: *P* values comparing the amount of sodium hydroxide in milliliter to raise the pH to 5.5 and 7

Titratable acidity	Groups	Mean	SD	*P*
PH 5.5	Mineral water (control group)	0.0000	0.0000	<0.05
	Carbonated drink (test group)	3.4000	0.28284	
	Energy drink (test group)	4.3000	0.14142	
PH 7	Mineral water (control group)	0.0000	0.0000	<0.05
	Carbonated drink (test group)	5.5000	0.14142	
	Energy drink (test group)	6.9000	0.70711	

Kruskal–Wallis test ($P<0.05$). SD: Standard deviation

Increased consumption of soft drinks or energy drinks is associated with dental erosion, but there is a widespread ignorance on this. Intrinsic dental erosion is known as perimolysis which is caused due to the gastric reflux of the acid present in the stomach. Intrinsic dental erosion occurs in a patient with diseases such as anorexia nervosa and gastroesophageal reflux disease. It has been documented that the oral pH of <5.5 has demineralization of dental hard tissue leading to dental erosion.[4] Several studies have shown that isotonic drinks are regularly consumed by most athletes.[21]

Results of this *in vitro* study show that the drinks within any one group have similar fashion due to their acid content. The mean value of Group 1 is 0 as their pH is neutral and the buffering capacity is 0. The mean value of Group 2 at pH 5.5 is 3.4 and at pH 7 is 5 and the buffering capacity at pH 5.5 is 0.28 and pH 7 is 0.14. The mean value of Group 3 at pH 5.5 is 4.3 and pH 7 is 6.9 and the buffering capacity at pH 5.5 is 0.14 and pH 7 is 0.7.

The pH of the beverages tested in this study can be ranked as follows: Carbonated drinks > energy drinks > water. The buffering capacity of the beverages in this study can be ranked as follows: Energy drinks > carbonated drinks > water.

Since the buffering capacity of energy drink is higher, which means that NaOH required to neutralize energy is more compared to carbonated drinks, energy drink causes greater loss of enamel compared to the consumption of sports drinks.

A similar study showed that the pH of sports drinks was comparatively higher than energy drinks and the buffering capacity of energy drink was higher than sports drink.[20] There is a statistically significant difference in mean pH and buffering capacity of all three groups using the Kruskal–Wallis test.

CONCLUSION

In this current generation, the dietary habit of young adults has been modified.

Consumption of energy drinks and sports drinks among young adults has been more common.

This study states that the commercially available energy drink has a significantly higher buffering capacity. Hence, dental professionals should bring awareness among their patients. The pH of the carbonated and energy drinks studied is significantly different; however, the mean pH values were below 5.5 for both the drinks. The effect of titratable acidity on enamel dissolution varies with the pH of the drink and increases as the pH decreases.

Awareness should be created on the harmfulness of sports and energy drinks on dental erosion and other medical problems (Kruskal–Wallis test, $P < 0.05$).

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