Journal of Research in Medical and Dental Science
2022, Volume 10, Issue 4, Page No: 17-21

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Effect of Energy Drinks in Relation to Enamel Dissolution

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ABSTRACT

Background: dental erosion has become a significant public health issue, and it has been linked to an increase in the intake of energy drinks which containing besides calories, other ingredients that effect on general and oral health.

Aim of the study: this study was conducted to determine the effect of energy drinks on enamel dissolution in relation to their pH and calcium content.

Materials and methods: The sample of this study was consisted of (40) sound maxillary first premolars teeth extracted for orthodontic purpose. The experiment included three study groups which were treated with different types of energy drinks depending on its chemical composition and one control group treated with deionized water .Each group included 10 enamel samples for weight change measurement. PH and calcium content of selected EDs were measured.

Result: Enamel samples which were treated with type (C) ED showed the highest percent of weight loss, while control group exhibited slightly weight gain, the statistical difference among different groups was significant. All tested energy drinks were acidic with statistical differences was not significant different. The statistical differences of calcium ion were significant among different types.

Discussion: significant weight loss percentage among enamel samples treated with tested energy drinks that might be due to low pH of these drinks cause demineralization .while, high calcium level in energy drinks could aid to reduce the risk of tooth erosion.

Conclusion: Energy drinks with a low pH can damage teeth, but high calcium concentrations can help to minimize enamel demineralization.

Key words: Energy drinks, Dental erosion, Weight change, Enamel dissolution

HOW TO CITE THIS ARTICLE: Ali Qasim Mohabies, Nibal Mohammad Hoobi, Effect of Energy Drinks in Relation to Enamel Dissolution, J Res Med Dent Sci, 2022, 10 (4):17-21.

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Received: 02-Apr-2022, Manuscript No. JRMDS-22-59330;
Editor assigned: 05-Apr-2022, Pre QC No. JRMDS-22-59330 (PQ);
Reviewed: 19-Apr-2022, QC No. JRMDS-22-59330;
Revised: 23-Apr-2022, Manuscript No. JRMDS-22-59330 (R);
Published: 29-Apr-2022

INTRODUCTION

Energy drinks (EDs) are non-alcoholic beverages with caffeine, taurine, glucuronolactone, vitamins, herbal extracts, proprietary mixes, and/or amino acids that are promoted to increase mental alertness and physical stamina. They come with or without sugar, and they can be carbonated or not, so the options are varied. Importantly, athletes, service members, and secondary school students all indicate frequent intake of energy drinks. Up to 80% of college athletes say they utilize them to perhaps improve their performance [1]. They differ from traditional sports drinks by containing more caffeine and fewer carbohydrates [2]. Caffeine and sugar are the main active ingredients in EDs [3]. They contain high proportions of free sugars and have a very low pH; these have implications for oral and general public health in terms of dental caries, dental erosion and overweight and obesity [4]. The popularity of EDs has been mostly witnessed among young adults, whereby more than 50% of the global consumer market consists of adolescents and young adults under the age of 35 years [5]. Energy drinks were introduced to the world as actual energy booster in 1949 by the name of 'Dr. Enuf' in United States [6]. The high rates of ED consumption recorded in Middle Eastern countries raise considerable concerns about the possible health and safety consequences of this drinking behavior for young individuals. [7]. The intake of energy drinks is linked to a 2.4-fold increase in tooth deterioration. This has been attributed to EDs' high sugar content and low pH [8]. It was noted that calcium had the ability to influence the down regulation of demineralization [9]. as far as there is no Iraqi study available about the effect of energy drinks on enamel dissolution.

MATERIAL AND METHODS

The protocol was authorized by the scientific committee at the Department of Pediatric and Preventative Dentistry/College of Dentistry/University of Baghdad, as well as the Central Ethical Committee in the same college, before beginning this in vitro study.

Sample

The sample of this study was consisted of (40) sound maxillary first premolars teeth extracted from (11-14) years old patient for orthodontic purpose. They were divided randomly into four groups each one included 10 enamel samples for weight change measurement. The experiment included three study groups which were treated with different types of energy drinks depending on its chemical composition and one control group treated with deionized water.

Enamel specimen preparation

Forty enamel samples were sectioned from buccal surface of maxillary first premolars(approximately 7mm*5mm*2.5mm) by handpiece and diamond disc and the dimension was measured to 0.01mm by digital caliper [10]. All enamel samples were stored individually in labeled plastic graduated containers with screw cap contain 5ml of deionized water with 0.02% sodium azide.

Preparation of artificial saliva

The composition of the used artificial saliva was 0.9 mm phosphate and 1.5mM of calcium in buffer solution 0.1mm of tris (hydroxymethyl) amino methane at pH of 7.0.

Energy drinks cycle exposure and measurement of weight change

Each specimen was weighed to 0.001g. Then teeth samples were subjected to exposure cycle of selected ED. The sample were immersed in energy drinks and artificial saliva in order to simulate consumption. Each exposure cycle consisted of 15 minutes immersion in 5 ml of tested Energy drink followed by two hour immersed in freshly prepared artificial saliva without rinsing. The sample underwent four cycle per day for five days and were stored in fresh artificial saliva when not being subject to pH cycling. After completed the 5 days of exposure cycle then each enamel sample was washed with deionized water for seconds and weigh the samples again to detect any weight change. the change in the weight of each sample was calculated as percent weight loss [11].

Measurement of pH and calcium ion concentration on tested energy drinks

The pH of tested energy drinks was measured by a digital pH meter; the pH was measured immediately after an opening. Calcium ion concentration in the selected energy drinks was measured using complex metric titration method.

Statistical analysis

Data description, analysis and presentation were performed using Statistical Package for social Science (SPSS version -22, Chicago, Illionis, USA), Statistical analysis can be classified into two categories:

Descriptive analysis

- ✓ Mean, Standard deviation (SD) and Standard for quantitative variable.

Inferential analysis

- ✓ Levene test: Test the homogeneity of variance for the quantitative variable among groups.
- ✓ One Way Analysis Of Variance (ANOVA): test the difference between k independent groups and using Tukey honestly Significant Difference, Tukey's HSD (equal variance assumed) and Dunnett T3 post hoc tests (unequal variance).
- ✓ Pearson correlation: test the linear correlation between two quantitative normally distributed variables.

Level of significance as: Not significant P>0.05, Significant P<0.05.

RESULTS

Measurement of weight change percentage

The mean and standard deviation of weight of enamel samples before and after treatment with different ED presented in Table 1, It was demonstrated that the weight loss was found in enamel samples in study groups after treatment, however, the weight was slightly increase in group treated with deionized water. Statistical difference of weight of enamel samples before and after treatment was not significant in group treated with deionized water, while, the difference was significant with other groups.

The mean and standard deviation of weight change percentage after treatment of enamel samples with different EDs are presented in Table 2, enamel samples which were treated with type (C) ED showed the highest percent of weight loss,while the least one was noted for type (B) ED treated group .control group exhibited slightly weight gain, the statistical difference among different groups was significant.

It was shown that the statistical difference of weight change percent was significant between the group

Table 1: Weight of enamel samples (g) before and after treatment (Mean ± SD) and statistical difference among various groups.

Groups	Before		After		Paired T test	P value
	Mean	±SD	Mean	±SD		
Energy drink A	0.14	0.013	0.136	0.013	22.568	0.00000*
Energy drink B	0.148	0.015	0.146	0.015	14.832	0.00000*
Energy drink C	0.148	0.014	0.143	0.014	2.694	0.0492*
Deionized water D	0.141	0.021	0.142	0.021	1.456	0.1793

*=significant at p<0.05.

treated with type (A) ED and control group, also between type (C) ED treated group and control group ,while, the difference was not significant between other groups (Table 3).

Measurement of pH values of selected energy drinks

Table 4 describes that mean value of pH was highest in type (C) ED ,while, the least mean value was noted with type (B) ED. the statistical differences was not significant among different tested energy drinks.

Measurement of calcium ion concentration in selected energy drinks

Mean value of calcium ion concentration in different energy drinks is illustrated in Table 5. It was found that the type (B) ED had the highest concentration of calcium ion, then type (C), while the least concentration was detected in type (A) ED. The statistical differences was significant among different types, ($p<0.05$).

Correlation coefficient of pH and Calcium ions concentration content of tested EDs with percentage of weight change is shown in Table 6. Not significant negative correlation was found between pH and percentage of weight change in types A and B of EDs; also it was not significant positive correlation in type C of EDs. Regarding the Correlation coefficient of percentage of weight change with Calcium ions concentration content of tested EDs. Not significant negative correlation was found between Calcium ion concentration and percentage of weight change in all types of EDs.

DISCUSSION

Dental erosion is a condition that damages the hard tissues of the teeth. Tooth erosion has recently been documented as a result of the consumption of a lot

Table 2: Weight change percentage of enamel samples (mean ±SD) and statistical difference among study and control groups.

Groups	Mean	±SD	F	P value
Energy drink A	-2.696	0.374	6.796	0.001 Sig.
Energy drink B	-1.138	0.257		
Energy drink C	-3.351	3.799		
Deionized water D	0.17	0.347		

*=significant at p<0.05.

Table 3: Multiple comparisons of weight change percentage of enamel samples.

(I) Groups	(J) Groups	Mean Difference (I-J)	P value
Energy drink A	Energy drink B	-1.558	0.284
	Energy drink C	0.655	0.871
	Deionized water D	-2.866	0.010*
Energy drink B	Energy drink C	2.213	0.065
	Deionized water D	-1.308	0.435
Energy drink C	Deionized water D	-3.521	0.001*

*=significant at p<0.05.

Table 4: pH values (mean ±SD) and statistical differences of different tested energy drinks.

Groups	Mean	±SD	F	P value
Energy drink A	5.57	0.221	0.461	0.636
Energy drink B	5.49	0.251		
Energy drink C	5.58	0.215		

Table 5: Calcium ion concentration (mg/L) and statistical differences.

Type of Energy drink	Mean	±SD	F	P value
Energy drink A	25.29	5.488	3396.266	0.000*
Energy drink B	451.2	20.725		
Energy drink C	37.5	7.721		

*significant at p<0.05

Table 6: Correlation coefficient of percentage of weight change with Calcium ion and pH among tested energy drinks.

Type of energy drink	Variable	Percentage of weight change	
		r	p value
Energy drink A	Ca	-0.008	0.983
	pH	-0.047	0.898
Energy drink B	Ca	-0.282	0.43
	pH	-0.202	0.576
Energy drink C	Ca	-0.185	0.608
	pH	0.109	0.765

of acidic beverages.. Dental erosion is the permanent loss of dental hard tissue caused by acid's chemical activity without the presence of bacteria; it starts with the demineralization of the enamel surface, resulting in compromised tooth structure.. When abrasion or attrition action is included, loss of dental hard tissue accelerates and once the dentin is exposed, more severe tooth loss occurs. Frequent intake of acidic foods and drinks [12]. Due to its content, energy drinks have the potential to cause dental issues such as tooth caries and erosion.

In this study, pH of selected EDs and calcium ions concentration were investigated because of their importance in relation to enamel dissolution by increasingly consuming energy drinks. The tested energy drinks in this study were chemically different, widely available in the markets and popularly consumed in Iraq.

The data in this study found that EDs caused enamel dissolution with statistically significant difference between sample weight before and after immersion. This finding is in agreement with result of previous research [10], in which high levels of enamel dissolution from EDs were reported.

the weight change result revealed a significant difference between the group of enamel samples treated with type A ED and the control group, as well as between the group of enamel samples treated with type C ED and control group, while the group of enamel samples treated with type B ED and the control group had no significant difference. This could be due to high calcium concentrations that favor remineralization of enamel. This can be confirmed by inverse relation between weight change percent and calcium ion concentration in type B ED that recorded in present study. Also came in agreement with previous research [13], which proved that minimal differences in mineral contents (calcium) of beverages might have an impact on the erosive potential.

The pH value recorded for the selected EDs in the present study was acidic and with no statistically significant difference between them .The pH of the solution has essential role in the dissolution capacity and there is an inverse relation between the pH of the drink and the solubility of hydroxyapatite [14]. This is confirmed by the inverse relation between weight loss and pH of EDs. However it should be taken in consideration that pH of the solution is just one of many factors to be considered in enamel dissolution [15] like mineral contents in the solution as demonstrated in the current study by presence of no significant difference between pH of different tested ED , but they cause different weight loss with significance difference due to the effect of the mentioned factors other than pH on the erosive ability of EDs .like mineral contents, titratable acidity, frequency of consumption .

The current study found that mean Ca concentration in the selected EDs was the highest in type B ED and the statistical difference was significant among different types. An interesting result was the least weight loss of the enamel samples treated with type B ED compared with other groups. This was an indication that the addition of Ca decrease the rate of enamel dissolution by remineralization of the tooth due to availability of Ca ion at the enamel surface and this is confirmed by the current study which demonstrated an inverse relation between Ca ion concentration and percentage of weight loss of enamel samples.

CONCLUSION

All tested energy drinks were acidic. Energy drinks with a low pH can damage teeth. The mean of weight loss was lowest in group treated with energy drinks type B, although high calcium concentrations can help to reduce enamel demineralization.

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