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THE EFFECT OF ENERGY DRINKS ON TEETH HYPERSENSITIVITY

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ABSTRACT

Background: Considering the current high consumption of energy drinks among university students, the aim of the present study was to evaluate the correlation between increased energy drinks consumption and teeth hypersensitivity by studying the influence of energy drinks in removing the smear layer and exposing dentinal tubules on root surfaces.

Materials and Methods: Self-administered questionnaire were distributed to investigate the two most commonly consumed types of energy drinks in the community of Saudi Arabia then to study the effect of these two drinks on teeth structures. PH value were determined by pH –meter, titratable acidity was measured as described in A.O.A.C., total sugars and identity sugars were also detected by HPLC for the selected energy drinks. 72 teeth specimen were randomly distributed into 3 main groups. Code Red® and Bison® were evaluated, while distilled water was used as a control. Specimens were immersed for 5 minutes, 3 and 12 hours before micrographs were taken by the scanning electron microscope (SEM).

Results: The most commonly consumed types of energy drinks among Saudi young adults were Code Red® and Bison® with a percentage of 68.6% and 37.8%, respectively. Both energy drinks tested were low-acid products, as indicated by comparatively low pH-values; (3.28 ± 0.036) and (2.72± 0.073) for Code Red® and Bison®, respectively. Also, both energy drinks have very low percent of total acidity. They recorded (0.057 ± 0.008) for Code Red® and (0.040 ± 0.006) for Bison®. However, the non-reducing sugars in Code Red® were markedly higher than in Bison® (6.95% in Code Red® vs. 0.97% in Bison®). Cod Red® hence showed stronger erosive potential on teeth surfaces and complete removal of smear layer at CEJ level when compared to Bison® as confirmed by the SEM results. No direct significant correlation between energy drinks consumption and teeth hypersensitivity had been proved, yet; significant results of associated teeth hypersensitivity was found in younger age group students who smoke during drinking energy drinks with a p-value of 0.006.

KEY WORDS: Energy Drinks, Erosion, Teeth Hypersensitivity, Scanning Electron Microscopy

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INTRODUCTION

Energy drinks are non-alcoholic, often lightly carbonated beverages designed to give burst of energy by the addition of a number of energy enhancing ingredients, most notably caffeine.[1] These beverages, when in contact with teeth, will reduce the pH at the tooth surface to a level below the critical value of 5.5 for demineralization of enamel and eventually, dissolution of smear layer at the level of cemento-enamel junction whenever exposed to the oral environment by root caries or periodontal disease.[2-4]

Tooth hypersensitivity caused by exposed dentinal tubules is a common symptom among adult population and mainly results from either removal of the enamel covering the crown of the tooth or denudation of the root surface by loss of cementum and overlying periodontium.[5] Erosive agents such as dietary acids can cause disruption of the smear layer (covering the dentin surface and obturating the dentinal tubules) thereby enhancing dentinal sensitivity.[6,7] In a study by Pinto et al.[8] to evaluate the influence of twelve energy drinks in removing the smear layer and exposing dentinal tubules on root surfaces; scanning electron microscopy revealed significant smear layer removal and they considered energy drinks an important etiological factor for cervical dentine hypersensitivity.

In view of the high consumption of energy drinks among young adults especially university students, as well as the lack of studies in the Saudi community addressing this subject, the present study was conducted aiming first to determine the two most commonly consumed types of energy drinks among young Saudi Arabian adults through self-reported questionnaire supplemented with few questions related to drinking associated habits as well as related symptoms. This is followed by physico-chemical analysis of the pH, titratable acidity, total sugars as well as identity sugars by high performance liquid chromatography (HPLC) for the two selected energy drinks. The effect of these drinks on removing smear layer and exposing dentinal tubules on root surfaces at the level of the CEJ were also evaluated in vitro by scanning electron microscopy.

MATERIALS AND METHODS:

Survey Analysis

The primary aim of this step was to determine the two most commonly consumed types of energy drinks among Saudi Arabian young adults (aged 19-25 years old). 400 questionnaires were distributed at King Abdul Aziz University, Jeddah, Saudi Arabia to facilitate collecting a sample of this target group. The questionnaire contained demographic data in addition to questions about the most commonly consumed types of energy drinks, some patterns of consumption and related symptoms.

The questionnaire revealed that two types of energy drinks (Code Red®, Alesayi Beverages Corporation) and (Bison®, Abuljadayel Beverages Inc.) were the most commonly consumed among targeted group of young adults in Jeddah, Saudi Arabia. These two were purchased from the local market for physicochemical analysis of pH, titratable acidity, total sugars as well as identity sugars.

Measurement of pH

The inherent pH of each drink was measured immediately on opening. The pH measurements throughout the study were made using pH meter (Jenway Company, model 3510, UK). The pH electrode was calibrated at the start of each session using standard buffers of pH 4.0 and pH 7.0 and was rinsed thoroughly between uses in order to avoid contamination. The pH of each beverage was determined in triplicate at laboratory room temperature (23±2˚C).

Titratable Acidity

The titratable acidity was measured as described in A.O.A.C.[9] Samples were diluted with distilled

water and titrated just below end point with 0.1N NaoH, using phenolphthalein.

Titratable acidity was then calculated using the following formula:

$$\% \text{ acid} = \frac{[\text{mls NaOH used}] \times [0.1 \text{ N NaOH}] \times [\text{milliequivalent factor}]}{\text{grams of sample}} \times [100]$$

Determination of Sugars

Total sugars were extracted from samples by water and clarified by lead acetate. Sodium oxalate was used to precipitate the excess of lead acetate. Total and reducing sugars were determined in the clarified solution as described by Smogyi.[10]

Identification of sugars was done using the high performance liquid chromatography (HPLC) (Agilent 1100 series) equipped with quaternary pump, set at flow of 1 ml/min. Auto sampler, degasser, and column compartment set at 35˚C. Hypersil ODS 5um, 250×4 mm was used.

Pure sugar compounds; Glucose, L-Rhaminose, Manitol, Sorbitol, Mannose, Sucrose, Fructose, Stachyos, Galacturonic, Glucuronic, Arabinose, Galactose, Raffinose and Xylose were used as standards obtained from ELGomhoria–Chemical Company, Egypt. This work was carried out in the Food Technology Research Institute, Agriculture Research Center, Giza, Egypt.

Teeth specimen preparation

In vitro erosive potential of the two selected commercial beverages was evaluated on thirty six extracted human premolar teeth with no signs of caries or developmental defects, collected from young adults presented to the Faculty of Dentistry, King Abdul Aziz University in Jeddah for orthodontic reasons.

Following extraction; teeth were placed in normal saline solution until processing. Each tooth was sectioned longitudinally in a buccolingual direction using a diamond disc to form two halves yielding a total of 72 samples, as described by Houshmand *et al*.[11] The root surfaces and the cemento-enamel junction (CEJ) areas for all teeth samples were scaled using one curette (Gracy curette #5,6) immediately before the immersion in tested drinks or distilled water (control). This step was completed by a single operator (E.Y.F.) to reduce variability.

Specimen were randomly distributed into 3 main groups (n=24 in each group). For subgrouping; specimens were immersed for 5 minutes, 3 hours and 12 hours then rinsed with distilled water for 15 seconds before scanning with electron microscope as described by Pinto *et al*.[8]. Cell culture dishes were filled with 5 ml of the beverages and they were replaced every 30 minutes to maintain fixed pH as possible.

Scanning electron microscopy

For SEM, teeth were placed on a double side carbon tape, dried in air then sputtered with 15 nm thick gold layer using JEOL JFC- 1600 Auto Fine Coater. The electron microscope (JSM-6360LV, Tokyo, Japan) was operated at an accelerating voltage of 20 kV and specimens were examined and photomicrographs were taken.

RESULTS

Questionnaire Results

Out of our hundred questionnaires; 75 questionnaires were excluded from the analysis either because of age (3 questionnaires aged 18, 26 and 32), incomplete data (18), students addressed another kind of drinks (not energy drinks; 12 questionnaires), or with no determined type of energy drinks (42 questionnaires). Finally, only 325 questionnaires were included in this research.

The age of 88.0% of the students ranged from 19 to 22 years old, whereas the second age group (23-to 25y) represented only 12%. Male students represented 52.9% of the study sample, while

females were about 47.1% of the total sample of the study. (188 students) 57.8% of the participants confirmed consuming energy drinks (39.1% males and 18.8% females) whereas 42.2% (137 students) responded that they never consumed energy drinks. Table (1) is showing the most commonly consumed types of energy drinks among the study population, and it is obviously seen that the majority of the participants (68.6%) drink Code Red®, while 37.8% of the students drink Bison®.

Regarding the rate of drinks consumption; only 8.5% of the students consume energy drinks daily, whereas 31.9% consume them weekly, 11.2% consume them monthly, and 48.4% only sometimes consume energy drinks. The number of the bottles consumed daily was also variable, 73.4% consumes only one bottle per day, 20.7% drinks two bottles daily, and 5.9% can drink three bottles or more.

When the students were asked if they do consume water directly after the drink, only 11.7% confirmed consuming water directly after the drinks, 41.5% answered that they sometimes do, while 46.8% don't. Also, when they were asked if they do brush their teeth after the energy drink or not, only 37.2% confirmed that they do brush their teeth after the energy drinks, whereas 27.1% said they sometimes do, and 35.6% don't brush their teeth after the energy drinks (or don't brush at all).

One of the most important associated habits with energy drinks consumption is smoking, and the questionnaire revealed that 18.1% of the participants confirmed smoking with energy drink, whereas 5.3% sometimes do, and 76.6% are non-smokers. Regarding any other additives to energy drinks, only 16.5% do add things to energy drinks, 70.2% don't add any other additives to energy drinks and 13.3% sometimes do that. These additives included; ice, mint (Halls®), lemon, strawberry, soft drinks, Panadol® and/or chocolates.

Questions about any associated symptom of teeth hypersensitivity during drinking energy drink were also included in the questionnaires. 23.4% of the students confirmed that they suffer from teeth sensitivity, whereas 18.6% responded that sometimes they have this feeling but not markedly, whereas 58.0% of the total participants confirmed they don't suffer from teeth hypersensitivity at all times. We conducted a correlation between different types of energy drinks listed by the students and the sensation of associate teeth hypersensitivity

TABLE (1): Different types of energy drinks consumed by university students

Energy Drinks	Yes		No	
	frequency	Percent %	frequency	Percent %
Red bull	44	23.4	144	76.6
Code Red	129	68.6	59	31.4
Bison	71	37.8	117	62.2
Power Horse	33	17.6	155	82.4
Boom Boom	2	1.1	186	98.9
Bugzy	7	3.7	181	96.3
Rock Star	1	0.5	187	99.5
Red Rocket	2	1.1	186	98.9
Black	1	0.5	187	99.5

using Chi-Square test as shown in table 2. There were no significant direct correlation between teeth sensitivity and consuming all types of energy drinks (all P-values were greater than the significant level 0.01). Noteworthy that the only significant results with associated symptom of teeth hypersensitivity was found in younger age group students (19-22 years old) who smoke during drinking energy drinks with a p-value of 0.006 as shown in table (3).

TABLE (2): Correlation between different types of energy drinks and teeth hypersensitivity

Energy drinks	Teeth hypersensitivity	
	Chi-Square	P-Value
Red Bull	0.941	0.63
Code Red	2.869	0.24
Bison	4.85	0.09
Power horse	0.69	0.71
Boom Boom	1.57	0.46
Bugzy	0.56	0.76
Rock Star	0.73	0.70
Red Rocket	1.565	0.46
Black	4.40	0.11

PH-values, Titratable Acidity and Total Sugars of Selected Energy Drinks:

Some physiochemical quality parameters of Code Red® and Bison® are listed in Tables (4). Both energy drinks tested were low-acid products, as indicated by comparatively low pH-values and low percentage of total acidity (% expressed as citric acid).

Furthermore, both energy drinks (Code Red® and Bison®) have a high total content of sugars but in Code Red® there is no marked difference between reducing and non-reducing sugars content. On the other hand, Bison® has marked difference between reducing and non-reducing sugars (9.60% reducing and 0.97% non-reducing sugars). Nevertheless, the non-reducing sugar in Code red was markedly higher than in Bison® (6.95% in Code Red vs. 0.97% in Bison®).

TABLE (4): Determination of pH- values, total acidity and sugars of the tow tested energy drinks

Parameter	Cod Red®	Bison®
pH-value	3.28	2.72
Total Acidity (% as citric acid)	0.057	0.040
Reducing sugars (%)	6.40	9.60
Non-reducing sugars (%)	6.95	0.970
Total sugars (%)	13.35	10.57

Table (3): Correlation between associated smoking and teeth hypersensitivity

	Age	Sample size	Mean rank	Sum of ranks	Man Whitney Test	P-values
Do you smoke with energy drink?	19-22	163	97.65	15916.50	1524.5**	0.006
	23-25	25	73.98	1849.50		
Do you suffer from teeth sensitivity?	19-22	163	96.68	15759.0	1682.0	0.11
	23-25	25	80.28	2007.0		

***** The difference is significant at the (0.01) significant level.***

Identification of identity sugars in Code Red® and Bison® using HPLC are presented in table (5). A total of eight sugars were detected in Code Red® and Bison®, the major sugar in both drinks was glucose (41466 and 69571 mg/100g in Code Red® and Bison®, respectively). From HPLC chromatograms peaks 2 and 3 are known as fructose and galacturonic. Peaks 4, 5, 6 and 7 are known as stachyose, sucrose, glucoronic and manitol. Sorbitol was recorded as the lowest sugar detected in the two types of energy drinks.

TABLE (5): Identification of identity sugars in Code Red® and Bison® (mg /100g)

Saccharide	Code Red®	Bison®
Glucuronic	425.42	452.62
Stachyose	1625.9	1065.3
Galacturonic	2686.8	2287.8
Sucrose	18998	1387.8
Glucose	41466	69571
Fructose	32872	58534
Manitol	87.289	86.809
Sorbitol	1.5652	47.857

Dental Results

Gross Changes

As shown in figure (1), teeth samples from the control group (distilled water) didn't show any gross changes either in color or surface texture after immersion with different time intervals, whereas in samples from the first tested group (Code Red®), it is obvious that red color changes had taken place especially in the longest duration of immersion (12 hrs.) as well as a tactile sensation of some surface roughness. As for the second tested group (Bison®) a yellow color and matt appearance were more dominant.

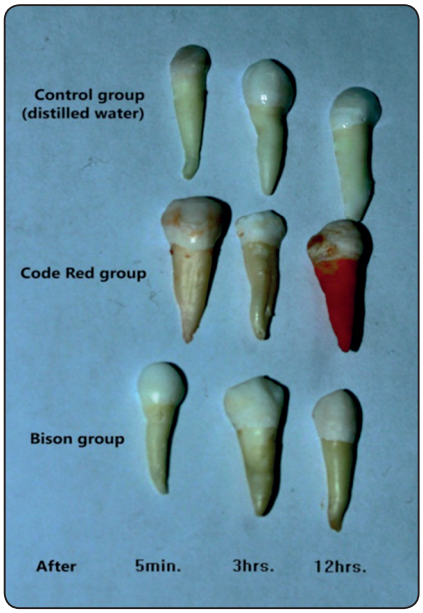

Fig. (1) Gross Changes of the Teeth

Electron Microscopic Changes

Scanning electron micrographs of the outer teeth surfaces at CEJ level after 12 hours of immersion in the three tested groups are shown in figure (2) with low magnification (x80). No changes can be detected in control group samples, while notable external surface defects and total absence of smear layer and debris are noticed in Code Red® group. Less damaging effect can be seen with Bison® but still with total absence of smear layer and debris.

By group selection, the most revealing micrographs at a magnification of (x2500) were selected to be displayed. Figure (3) is showing changes in teeth surfaces at the level of CEJ after 5min, 3hrs and12hrs, respectively. The 2 tested beverages (Code Red® and Bison®) showed varying degrees of damage on the specimen surfaces as verified by SEM. The degree of damage was greater on Code Red® group more than Bison®. Specimen immersed in distilled water had no visible differences between the surfaces before and after immersion.

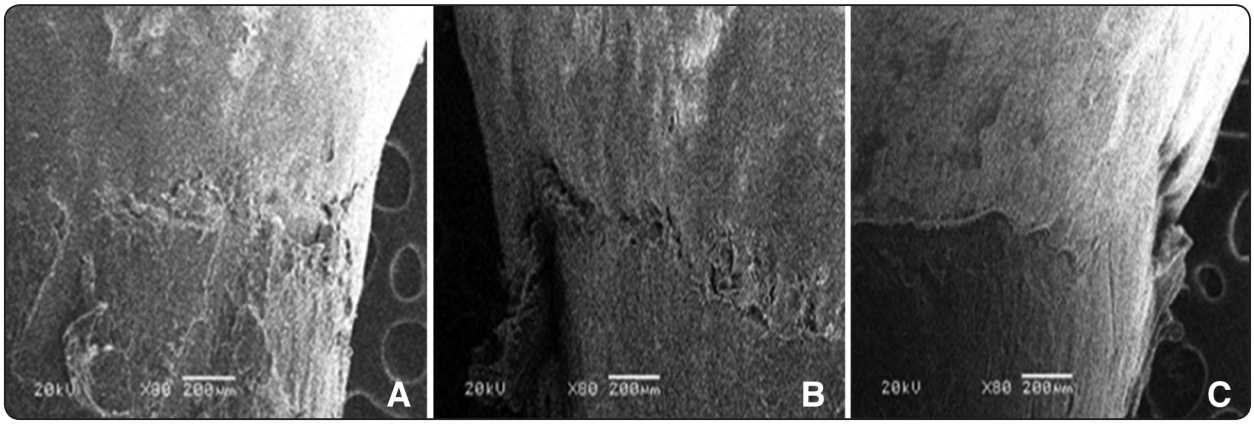

Fig. (2) Scanning electron micrograph with a magnification of (×80) showing the outer tooth surface at CEJ level after 12 hours of immersion in the three groups. A: debris and smear layer are still present in a sample from the control group. B: Total absence of smear layer and debris in a sample from Code Red® group with notable external surface defects. C: Total absence of smear layer and debris in a sample from Bison® group

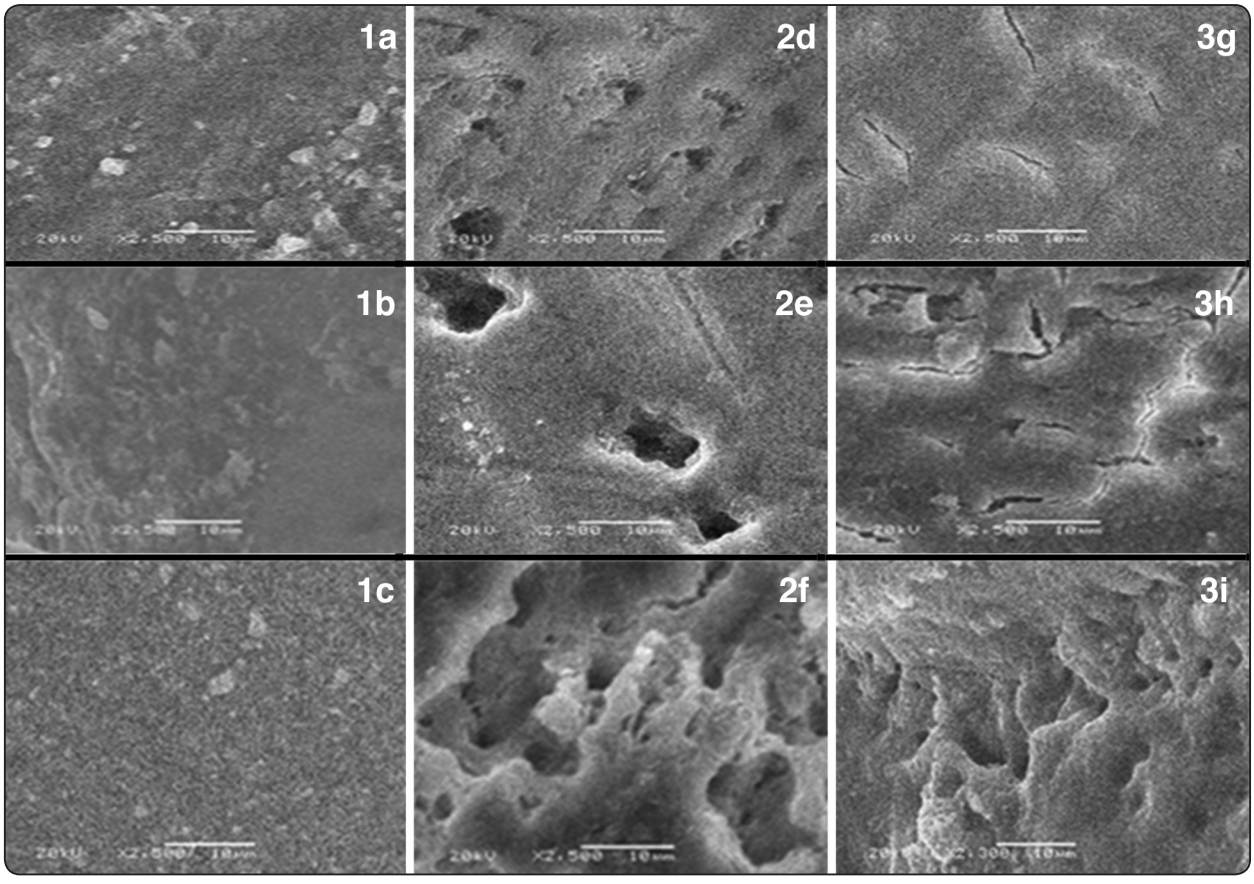

Fig. (3) Scanning electron micrographs with higher magnification (×2500) showing the outer teeth surface changes at CEJ level after 5min (a-b-c), 3hrs (d-e-f) and 12hrs (g-h-i), in the three groups.

1: Distilled water showing smooth non defective root surfaces and presence of smear layer and t issues debris at all times (1a, 1d, 1g).

2: Code Red group showing deep generalized pitting and widely opened dentinal tubules (2b and 2e) and extensive defective surface with marked irregularity (2h)

3: Bison group showing total absence of smear layer with shallow cracks (3c, 3f) followed by well-developed erosive defects (3i).

DISCUSSION

The effect of soft drinks in general and energy drinks in particular; on dental structures has been the focus of extensive research in recent years. [12] The present study was conducted aiming to evaluate the effect of the most commonly consumed energy drinks in Saudi community on teeth surface changes and to investigate some physicochemical characteristics of relevance in these two selected drinks that may be a direct causative factor for the sensation of teeth hypersensitivity.

For this aim to be fulfilled, a questionnaire was designed to determine the two most commonly consumed types of energy drinks by young Saudi adults from King AbdulAziz University and to point out some related drinking habits. The results of this questionnaire revealed that more than half of the students in the tested sample consume energy drinks (57.8%). Male students who consumed energy drinks represented about 39.1% compared to 18.8% females. Code Red® and Bison® were found to be the most commonly consumed types of these drinks among the study sample and this may be explained on the basis of low price and availability of these two types in the local Saudi market.

In accordance, a similar questionnaire was carried out in University of Dammam in Saudi Arabia; from October to December 2010. This questionnaire was mainly concerned about reasons for use of energy drinks, benefits and side effects experienced. Frequencies of responses and differences between male and female students were analyzed. A total of 412 students responded, out of whom 54.60% males and 26.15% female students were energy drink users. The commonest reasons for use were company of friends, to keep awake, for more energy and for better performance in driving, sports or exams. The students reported a number of adverse effects; increased urination and insomnia were the commonest in males and females respectively.[13]

When the students were asked if they complain of hypersensitive teeth in association with drinking beverages; no significant correlation had been proved. On the other hand, significant result of associated teeth hypersensitivity was found between younger age group (19-22) who smoke during drinking energy drinks with a p-value of 0.006. Other reported additives of significance that may aggravate the acidic effect and increase the feeling of hypersensitivity included; ice, mint (Halls®), lemon, strawberry, soft drinks, Panadol® and/or chocolates.

The SEM results of the present study showed that the effect of both drinks increased with time, being minimum at 5 minutes and more prominent at 12 hours. In dental erosion, tooth structure is lost through chemical means not related to bacteria; accordingly, an in vitro model was convenient in this study design. Regarding the length of test periods, we used 5 minutes interval to simulate the short sipping method, 3 hours simulating the holding method and the 12 hours interval, as in cases of frequent drinking and improper oral hygiene practice. Von Fraunhofer and Rogers [14] calculated test intervals very accurately based on an average daily consumption of 25 ounces of soft drink and a residence time in the mouth of five seconds. They found that the total exposure time to beverages would equal 22,750 seconds (380 minutes or 6.3 hours) per year.

Energy drinks are thought to participate in teeth hypersensitivity because of two inherent properties –first, the low pH and titratable acidity, and secondly the fermentable carbohydrates in drinks that can be metabolized to generate organic acids,[15] therefore; we assessed the pH, titratable acidity and sugars as total and identity sugars in the selected energy drinks in his study. Researches have demonstrated that drinks with a pH of 5.5 or less tend to erode and soften teeth surfaces and eventually remove the protective smear layer on the root.[15] The results of the present study showed that both tested drinks were

low acid products, however, Code Red® showed higher total sugar content, higher total acidity and hence stronger erosive potential on different teeth surfaces (enamel, dentin and smear layer at the level of CEJ) when compared to Bison®. Similar results were found in another energy drink (Red Bull®) with a high buffering capacity and strong erosive potential and it was explained on the basis that metabolism of the refined carbohydrates in this drink and their low initial pH levels have the potential to initiate and propagate the erosive effect with subsequent dentinal hypersensitivity. [16, 17]

Even though pH has been used to measure acidity, the titratable acidity, or buffering capacity, may truly indicate the potential of a beverage to erode tooth structure. Drinks with a high titratable acidity may have a high buffering capacity, resisting the ability of saliva to alter pH producing a prolonged time of acidity and sustaining the low pH status. [17]

Reports on the level of sugars in sugar-sweetened energy drinks are scanty. Moreover, new energy drinks are being released into the market daily and the need for continuous monitoring of these substances is a necessity. Our results showed that Code Red® contained the highest percentage of total sugars (13.35% VS. 10.57% in Bison®). The non-reducing sugar content of Code Red was 6.95 compared to 0.97 in Bison® and the sucrose level was also markedly higher in Code Red® (18998 VS. 1387.8 Bison®). In a similar study, Cavalcanti *et al*.,[4] assessed the sugar content of nine different energy drinks in their local market and concluded that Flying Horse™ showed the highest non-reducing sugar content (sucrose 54.3%) and subsequently the most erosive potential when compared with the other energy drinks evaluated. Gimba *et al*.,[18] also evaluated sugar contents of selected energy drinks using HPLC and UV spectrophotometry and the results showed very wide range of sugar concentration in the sampled energy drinks ranging from 91.05 ppm – 1686.73 ppm.

In an attempt to link the students drinking habits with any associated clinical symptoms of teeth hypersensitivity; we found that 23.4% of participants confirmed suffering from teeth hypersensitivity in association with the consumption of cold or hot drinks or food. However; important clinical findings such as periodontal health, caries diagnosis and/or presence or absence of defective restorations were not recorded in this study, accordingly direct cause-related effect of energy drinks on teeth hypersensitivity cannot be established except with prospective interventional study that cannot be done on human teeth for ethical reasons.

Finally, and within the limitations of this in vitro study; we can conclude that dental erosion, removal of protective smear layer at exposed tooth cervix and the eventual feeling of hypersensitivity seems to have a relationship with energy drinks consumption mainly represented by their low pH and total acidity as well as high total sugar content. Information and recommendations to patients at risk should include advice to reduce the consumption of acidic drinks and to avoid any additives (mainly smoking) that could cause lower pH values and exaggerate the side effects.

REFERENCES

1. Alford C, Cox H, Wescott R: The effects of Red Bull energy drink on human performance and mood. Amino Acids 2001;21(2):139–150

2. Hemingway CA, Parker DM, Addy M, Barbour ME: Erosion of enamel by non-carbonated soft drinks with and without tooth brushing abrasion .Brit dental J 2006;201:447–450

3. Lussi A, von Salis-Marincek M, Ganss C, Hellwig E, Cheaib Z, Jaeggi T: Clinical study monitoring the pH on tooth surfaces in patients with and without erosion. Caries Res 2012;46:507–512

4. Cavalcanti AL, Costa Oliveira M, Florentino VG, dos Santos JA, Vieira FF, Cavalcanti CL: Short communication: in vitro assessment of erosive potential of energy drinks. Eur Arch Paediatr Dent 2010;11:254–257

5. Shetty S, Kohad R, Yeltiwar R: Hydroxyapatite as an in-office agent for tooth hypersensitivity: A clinical and scanning electron microscopic study. J Periodontol 2010;81:1781-1789.

6. Pashley DH: Smear layer: Physiological considerations. Oper Dent Suppl 1984;3:13-29.

7. Brännströmm M, Garberoglio R: Occlusion of dentinal tubules under superficial attrited dentine. Swed Dent J 1980;4:87-91

8. Pinto SCS, Bandeca MC, Silva CN, Cavassim R, Borges AH, Sampaio JEC: Erosive potential of energy drinks on the dentine surface, BMC research notes 2013;6:67.

9. A.O.A.C.: Official Methods of Analysis of the Association of Official Analytical Chemists. 2010; 18th ED. Gaithersburg, Maryland, U.S.A. Method No. 942.15.

10. Somogyi M: Notes on sugar determination. J Biol Chem 1952;195:19-23.

11. Houshmand B, Ghandi M, Nekoofar M, Gholamii G, Tabor RK, Dummer PMH: SEM analysis of MTAD efficacy for smear layer removal from periodontally affected root surfaces. Journal of Dentistry (Tehran, Iran) 2011; 8(4):64-157

12. Manaf ZA, Lee MT, Ali NHM, Samynathan S, Jie YP, Ismail NH, Yahya NA: Relationship between food habits and tooth erosion occurrence in Malaysian university students. Malaysian Journal of Medical Sciences 2012;19:56–66.

13. Alsunni AA and Badar A: Energy drinks consumption pattern, perceived benefits and associated adverse effects among students of university of Dammam-Saudi Arabia. J Ayub Med Coll Abbottabad 2011; 23(3): 3–9.

14. Von Fraunhofer JA and Rogers MM: Dissolution of dental enamel in soft drinks. General Dentistry 2004;52:308–312.

15. Goel I, Navit S, Mayall SS, Rallan M, Navit P, Chandra S: Effects of carbonated drink and fruit juice on salivary pH of children: An in vivo study. International Journal of Scientific Study 2013; 01(03): 60-69.

16. Owens BM: The potential effects of pH and buffering capacity on dental erosion, Gen Dent 2007;55:527–531.

17. Owens BM and Kitchens M: The erosive potential of soft drinks on enamel surface substrate: An in vitro scanning electron microscopy investigation, Journal of Contemporary Dental Practice 2007;8:110–020.

18. Gimba CE, Abechi SE, Abbas NS, Gerald IU: Evaluation of caffeine, aspartame and sugar contents in energy drinks, Journal of Chemical and Pharmaceutical Research 2014; 6(8):39–43.