

Consumption Pattern of Energy Drinks by University of Ibadan Students and Associated Health Risks Factors

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Abstract

Energy drinks are non alcoholic, carbonated beverages claimed to give extra burst of energy for daily obligation. They contain some form of legal stimulants and vitamins which are meant to give consumers short term boost in energy and increase mental alertness. Energy drinks enjoy patronage especially among higher institution students in Nigeria, but little is known about the consumption pattern and possible health risks to consumers. This study was carried out to determine the contribution of four commonly consumed energy drinks to energy intake of University of Ibadan students and the associated health risk factors. A descriptive cross-sectional survey of energy drinks consumption was carried out using a four-stage systematic random sampling technique to select 307 students from six out of nine halls of residence for Undergraduates and the two Post-graduate halls. A validated semi-structured, self-administered questionnaire was used to collect information on socio-demographic characteristics, consumption pattern and frequency, and factors influencing consumption of energy drinks. Samples of the four most commonly consumed energy drinks by the students (Power Horse, Emerge, Red Bull and Matador brands) were purchased from different stores within and around the University of Ibadan campus. Composite samples of all the four energy drinks (with at least six months expiration date) were analysed for physico-chemical characteristics, gross energy, minerals and B-vitamins content in triplicate using standard methods of AOAC. Data were analysed using descriptive statistics and one way ANOVA, and level of significance set at $p < 0.05$. Respondents mean age was 23.1 ± 4.6 years, 79.2% were undergraduates and 51.1% were female. Majority (74.6%) of respondents had ever taken energy drinks prior to the study, 42.4% reported consuming at least one can in a week, and 52.1% consumed 1 can at a sitting. Reasons for consumption included to increase: energy (48.2%), mental alertness (18.6%) and athletic performance (9.5%). Reported side effects were: insomnia (14.0%), frequent urination (12.2%), dehydration (11.3%), anxiety (9.1%), heart palpitation (3.5%). Frequency of consumption was significantly associated with gender ($p < 0.05$). Titratable acidity, total

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solids and pH of energy drinks ranged between 7.57 ± 0.60 - 8.28 ± 0.08 , 7.57 ± 0.60 - 11.42 ± 0.31 , and 3.36 ± 0.08 - 3.81 ± 0.12 respectively. Glucose, sucrose, and gross energy content ranged between 7.77 ± 0.01 - 7.89 ± 0.01 g, 22.61 ± 0.07 - 23.74 ± 0.09 g, and 43.59 ± 0.38 - 48.89 ± 0.28 kcal/100g respectively. Few respondents knew about the ingredients and potential health risks associated with energy drink consumption. All the four drinks had acidic pH, hence nutrition education on reduction of energy drink consumption is needed among these students.

Keywords

Consumption Pattern, Energy Drinks, Nutrient Composition, Calorie Intake

1. Introduction

Energy drinks are non alcoholic beverages claimed to give extra burst of energy for daily obligation. They are carbonated beverages that contain significant quantities of sugar and caffeine as well as blends of exotic herbal extracts, B vitamins and amino acids meant to give consumers short term boost in energy and increase mental alertness [1] [2].

Energy drinks generally contain methylxanthines (including caffeine [3]), B vitamins, carbonated water, guarana, yerba mate, acai, and taurine, plus various forms of ginseng, maltodextrine, inositol, carnitine, creatine, glucuronolactone, and ginkgo biloba. A common ingredient in most energy drinks is caffeine (often in the form of guarana or yerba mate). They contain about three times the amount of caffeine as cola; for instance, cola contains 35 mg while a monster energy drink contains 120 mg. They have been found to improve attention and/or reaction time, increase energy and indices of alertness; and the combination of caffeine and glucose can ameliorate deficits in cognitive performance and subjective fatigue during extended periods of cognitive demand [4] [5].

The sugar content varies among energy drinks but ranges from 21 to 34 grams per 8-ounce can [6]. A teaspoon of sugar weighs about 4 g, so a typical energy drink contains about 13 teaspoons, or just more than 1/4 cup, of sugar [7]. 16 ounce (454 ml) or 24 ounce (680 ml) energy drink contains approximately 60 to 90 grams of sugar, which is two to three times the maximum recommended daily intake 32 g of 2000 calories. FDA does not recommend a daily allowance for sugar. However, official U.S. guidelines recommend a maximum sugar intake of 32 grams for every 2000 calories, which equates to approximately 7% to 8% of the total daily caloric intake [8].

The rate of overweight and obesity have increased worldwide over the last three decades, and while genetic factors may play a part in the development of obesity, the recent dramatic increase in its rate suggests that environmental and behavioural factors have contributed to this problem [9]. Lifestyle and diet changes are the most common culprits, but recent research has proposed that the added sugar content of beverages may play a considerable role in weight gain [10].

Energy drinks are enjoying patronage among adolescents and young adults, especially among University students in Nigeria. The amount of sugar provided in one can (or 500 ml) of energy drinks is typically about 54 g [7]. A teaspoon of sugar weighs about 4 g, so a typical energy drinks contains about 13 teaspoons, or just more than 1/4 cup, of sugar [7].

There has been a steady increase in soft drinks and beverages consumption among adolescents and youths globally [11], which has raised a concern about the health effects of soft drinks and beverages. Little is documented on consumption pattern of energy drinks in Nigeria as well as its possible contribution as source of calorie intake of consumers. This study was therefore carried out to determine the nutrient composition and possible contribution of commonly consumed energy drinks to the calorie requirement of the University of Ibadan students.

2. Materials and Method

2.1. Consumption Survey

A descriptive cross-sectional survey was carried out among University of Ibadan students. A four-stage sam-

pling technique involving random and systematic random sampling was used to select 307 students from six out of nine halls for Undergraduates and the two Postgraduate halls. A validated semi-structured, self-administered questionnaire was used to collect information on socio-demographic characteristics, consumption pattern and frequency, and factors influencing consumption of energy drinks.

2.2. Sample Collection and Preparation

Samples of four commonly consumed energy drinks (Power Horse, Emerge, Red Bull and Matador brands) by students were purchased from different stores within and around the University of Ibadan campus. Composite sample of all the four energy drinks (which had at least six months expiration date) were analysed for physico-chemical characteristics (titratable acidity, total solids, pH) and energy content using the standard methods of analyses of AOAC (2005) [12]. Heavy metal content of the drinks were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk United Kingdom (Essien *et al.*, 1992) [13] and compared with absorption of standards of these minerals. All samples were determined in triplicate. The results obtained were analysed using one way analysis of variance (ANOVA), and level of significance was set at $p < 0.05$.

2.3. Chemical Analyses

2.3.1. Determination of Physico-Chemical Parameters

Total solids of the samples was determined by weighing 5 ml of each sample into a flat bottom metal dish and evaporated to dryness on water bath for about 30 minutes and then transferred to an oven maintained at about 100°C. After 2.5 hours, the samples were transferred into a dessicator to cool and then weighed. Total acidity was determined by pipetting 5 ml each of energy drink samples into two flasks and 1 ml of the Rosaline working solution to one of the flask and stirred. 1 ml of Phenolphthalein solution was added to the second flask and titrated with 0.1 M sodium hydroxide solution until the colour matched that of the first flask. Then acidity of the drink was calculated as % citric acid multiplied by the volume of the 0.1 M in ml sodium hydroxide solution required. The pH of the samples was determined using Jenway pH meter

Ash of the samples was determined using muffle furnace set at 550°C for four hours.

2.3.2. Determination of Sugars

One gramme of the sample was weighed into a boiling tube, and 25 ml of hot 80% ethanol was added and shaken on a vortex mixer. The material was allowed to settle for 30 minutes and then filtered through a Whatman No. 41 filter paper into a beaker. The above steps were repeated again for complete extraction of glucose for 3 times. The extract boiled till the ethanol was evaporated. Ten millilitres of water was added to dissolve the content and transferred into 100 ml volumetric flask. The beaker's content was washed 3 times and added to the volumetric flask and made up with distilled water to 100 ml mark. The sugar (sucrose) was determined by anthrone method, and the absorbance read on spectrophotometer (Spectronic 21D) at a wavelength of 595 nm against the blank [12]. Glucose was determined by anthrone method by measuring the absorbance of the bluish colour solutions of sample and glucose standards on a Spectronic21D Spectrophotometer at a wavelength of 490 nm against the blank solution. Gross energy of the samples was determined using ballistic bomb calorimeter (Manufacturer: Cal 2k-Eco, TUV Rheinland Quality Services (Pty) Ltd., South Africa).

2.3.3. Pantothenic Acid (Vitamin B5) Determination

Standard solution of sample was prepared by dissolving 1g of sample in a 250 ml volumetric flask with distilled water. The solution was filtered through whatman No. 42 filter paper into a 100 ml volumetric flask. 5 ml of aliquot of the sample filtrate was pipette into a 2 ml beaker, 5 ml potassium bromide (12%), and 10 ml of KMnO_4 were added and mixed thoroughly. The mixture was boiled for 10 minutes. The hot solution was cooled in ice for 5 min and 20% freshly prepared H_2SO_3 was added drop wise to decolonize the excess KMnO_4 to colourless solution. Ten millilitres of 2,4-dinitrophenyl hydrazine (5 g/l) was added, mixed thoroughly and heated for 15 minutes and then cooled to room temperature. The yellow precipitate obtained was dried for 30 minutes in an oven at 100°C. The dry precipitate was dissolved in hot pyridine solution and mixed thoroughly to homogenous suspension. The suspension was filter thorough a Whatman No. 42 filter paper into a 50 ml volumetric flask and made up to mark with pyridine solution. Absorbance of sample and standard pantothenic and solution

of range 10 µg/ml - 50 µg/ml prepared from stock panthothenic acid was read on a spectronic spectrophotometer at a wavelength of 570 nm. Panthothenic acid was calculated in µg/100 g.

2.3.4. Determination of Cyanocobalamin (Vitamin B12)

One gramme of each sample was weighed into a 250 ml volumetric flask. 100 ml of distilled water was added and spinned or shaken for 45 min and made up to mark with distilled water. The sample mixture was filtered into another 250 ml beaker, rejecting the first 20 ml that has been filtered. Another 20 ml filtrate was collected. To the filtrate, 5 ml of 1% Sodium Dithionite solution was added to decolorised the yellow colour. Standard cyanocobalamin solutions of range 0 - 10 µg/ml were prepared from stock cyanocobalamin. A sample blank made up to distilled water was also prepared. The absorbance of sample and standards was read at a wavelength of 445 nm on a spectronic 21D spectrophotometer.

2.3.5. Caffeine Determination

Five millilitres of sample was pipetted into a 250 ml separating funnel, and 5 ml of 1 M NaOH solution and 30 ml of chloroform were added. The funnel was stoppered and the content shaken for 5 minutes. The aqueous layer was discharged leaving the organic chloroform layer. Five millilitre of 1 M NaOH and 15 ml of 0.1 M KMnO₄ solutions were added to the chloroform layer in the funnel and the whole mixture shaken for 10 minutes. The chloroform was charged into a 250 ml Beaker containing 20 g of anhydrous magnesium sulphate to dry the extract. The chloroform was removed from extract by distillation at 80°C. The residue was dissolve in 50 ml of hot deionized water in a 100 ml volumetric flask. Working standard of range 0 - 50 ppm of caffeine solutions were prepared from 100 ppm stock caffeine and treated similarly like sample. The absorbance of sample extract and caffeine standard solutions was read on a UV spectrophotometer at a wavelength of 274 nm. Concentration of sample caffeine was determined from the calibration curve of standard caffeine solutions.

3. Results and Discussion

3.1. Socio-Demographic Characteristics of Respondents

Mean age of respondents was 23.1 ± 4.6 years, 79.2% were undergraduates and 51.1% were female. Majority (74.6%) of respondents had ever taken energy drinks prior to the study, 42.4% reported consuming at least one can in a week, and 52.1% consumed one can at a sitting. Reasons for consumption were to increase: energy (48.2%), mental alertness (18.6%) and athletic performance.

3.2. Physico-Chemical Characteristics of Energy Drink

Table 1 shows the physico-chemical characteristics of energy drinks. There were significant differences in the titratable acidity and total solids value of the samples ($p < 0.05$). Matador had the highest titratable acidity followed by Red Bull, while Emerge had the lowest value. Red Bull was highest in total solid followed by Matador, while Power horse had the least value.

The pH value of the energy drinks was low and in the acidic medium with Emerge having lowest value, and hence, most acidic. The Power horse value was not significantly different from that of Matador, but was significantly different from that of Emerge and Red Bull. The result obtained for the pH values of the drinks in this study was in line with the findings of [14] who quantified the acid content of commercial yoghurt drinks in Nigeria. Dental erosion is commonly caused by dietary factors, especially food or drinks that contain citric acid which may chelate as well as dissolve calcium ions [15] [16]. Beverages with low pH values generally have greater erosive effects on tooth structure. However, carbonated cola beverages, sports and energy drinks have been reported to have low pH and high buffering capacity, sweetened with highly refined carbohydrates and contain additional additives which together with sugar substitutes can contribute to enamel surface dissolution [17] [18]. All the energy drinks evaluated had pH on opening below the critical pH (5.5) of enamel dissolution [14]. Their low pH values call for caution in their regular consumption.

3.3. Nutrient Composition of Energy Drinks

The result of the nutrient and energy content of the four commonly consumed energy drinks among students is as shown in **Table 2(a)**. The total sugar content (glucose and sucrose) was relatively high and significantly

Table 1. Physico-chemical characteristics of selected energy drinks (%)^{*}.

Energy Drinks	Parameter		
	Titrateable Acidity (%)	Total Solid (%)	pH (25°C)
Power Horse	7.93 ± 0.07	7.57 ± 0.60	3.63 ± 0.25
Emerge	7.57 ± 0.60	10.61 ± 0.03	3.36 ± 0.08
Red Bull	8.00 ± 0.07	11.42 ± 0.31	3.81 ± 0.12
Matador	8.28 ± 0.08	11.29 ± 0.45	3.66 ± 0.03

^{*}Values are means ± Standard deviation of triplicate determinations. Can Size: Power Horse: 330 ml; Emerge: 250 ml; Red Bull: 250 ml; Matador: 330 ml.

Table 2. (a) Nutrient composition of selected energy drinks (/100 ml)^{*}; (b) Nutrition information declared by manufacturers (/100 ml).

(a)

Parameter	Energy Drink			
	P. Horse	Emerge	Red Bull	Matador
Glucose (g/)	7.89 ± 0.01	7.77 ± 0.01	7.82 ± 0.01	7.84 ± 0.05
Sucrose (g/)	23.74 ± 0.09	22.61 ± 0.07	23.03 ± 0.07	23.46 ± 0.05
Ash (g/)	0.22 ± 0.01	0.11 ± 0.00	0.28 ± 0.03	0.12 ± 0.01
Vitamin B ₅ (mg/)	2.50 ± 0.01	1.59 ± 0.01	1.84 ± 0.01	2.24 ± 0.01
Vitamin B ₆ (mg/)	2.52 ± 0.01	1.57 ± 0.02	2.05 ± 0.02	2.64 ± 0.02
Vitamin B ₁₂ (µg/)	1.85 ± 0.03	1.75 ± 0.03	1.71 ± 0.03	2.64 ± 0.02
Caffeine (mg/)	28.76 ± 0.05	24.19 ± 0.09	25.81 ± 0.08	27.80 ± 0.17
G. Energy (kcal/)	48.89 ± 0.28	43.59 ± 0.38	44.83 ± 0.29	46.32 ± 0.39

^{*}Values are means ± Standard deviation of triplicate determinations. Can Size: Power Horse: 330 ml; Emerge: 250 ml; Red Bull: 250 ml; Matador: 330 ml

(b)

Parameter	Energy Drink			
	P. Horse	Emerge	Red Bull	Matador
Carbohydrates (g/)	10.7	10.0	11.3	10.9
Vitamin B ₅ (mg/)	2.0	2.0	2.0	2.0
Vitamin B ₆ (mg/)	2.0	0.6	2.0	2.0
Vitamin B ₁₂ (µg/)	2.0	0.5	2.0	2.0
Caffeine (mg/)	32.0	30.0	30.0	30.0
G. Energy (kcal/)	45.0	42.0	45.0	46.0

Calorie contribution to energy intake of consumers of 250 ml of selected energy drinks ranged from 105 kilocalories in Emerge to 122.23 kcal in power Horse.

different in all samples ($p < 0.05$). Power horse contained highest amount of total sugar (31.63 g/100ml) while emerge contained lowest value with no statistically insignificant difference. Consumption of a can of Red Bull (250 ml) will deliver 19.6 g of glucose and 57.58 g sucrose, with total sugar content of 77.18 g.

Energy contribution from 100 ml of Power horse was significantly higher than that of other brands, followed by that of Matador. The gross energy content of Emerge and Red Bull were closely related, Red Bull being slightly higher. On the basis of can liquid content of 250 ml, various brands of the energy drinks can provide calories as follows: Power Horse 122.23 kilocalories, Emerge 108.98 kilocalories, Red Bull 112.08 kilocalories, and Matador 115.80 kilocalories of energy. On liquid content only, Power Horse (330 ml) can provide 161.34 kilocalories while Matador (330 ml) can provide 152.86 kilocalories of energy.

B Vitamins are touted as ingredients necessary to convert the added sugar to energy, hence, the B vitamins are commonly used as ingredients in energy drinks; and the content varies in brands. The values of vitamins B₅, B₆ and B₁₂ of the four samples of energy drinks were significantly different from each other ($p < 0.05$). Power Horse had the highest value of vitamin B5 followed by Matador, while Emerge had the least. Matador was

highest in vitamin B6 and B12 followed by Power Horse. A 250 ml can of energy drinks can deliver more than RDA for vitamins B5, B6 and B12 which is 5 mg, 1.3 mg and 2.4 µg respectively [19].

Long-term exposure of the body to excess of simple sugars is associated with the development of obesity and insulin resistance. Over time, in many individuals the beta cells become unable to secrete sufficient insulin to maintain normal blood glucose levels, leading to the development of diabetes [20]. Regular consumption of two or more cans of energy drinks at a sitting or long term usage may result in high blood glucose level, increase risk of diabetes and obesity.

Table 2(b) shows the nutrition information as declared by manufacturers. The energy content declared by the manufacturers was closely related, though this study's results were slightly higher. The energy content of Power Horse and Emerge was significantly higher than what was declared on the cans ($p < 0.05$). The selected B-vitamin values were lower than that determined in the laboratory for Power Horse and Matador for B₅ and B₆, but higher than those for Emerge and Red Bull. The reported value of B₆ and B₁₂ for Emerge were significantly lower than their determined value.

The declared values for caffeine of the selected energy drinks were significantly higher than determined values ($p < 0.05$). This observation might have resulted in the methods of analysis which was not contained on the can label.

Table 3 shows the mean concentrations of heavy metals in the different brands of canned energy drinks. Significant differences existed between the heavy metals' values in the four samples ($p < 0.05$). The observed variation in the heavy metal content could be due to their heterogeneity, sources of raw materials, origin, manufacturing and packing processes. The highest mean level (µg/100ml) of lead (0.48), cadmium (0.02), arsenic (0.71), chromium (60.89) and mercury (0.07) in the four energy drinks samples were observed in Emerge, Power Horse and Matador, Emerge, Matador, and Red bull respectively.

Heavy metal content of carbonated soft drinks were reported for lead and cadmium as 0.04 and 0.002 ppm, respectively, while 0.06 and 0.003 ppm were reported for lead and cadmium content of fruit juice in Nigeria [21]. In Turkey, Bingöl *et al.* [22] reported the mean values of lead, cadmium and arsenic as: 0.029; 0.005; and 0.037 mg/kg and respectively. The reported values for the heavy metals are significantly lower than the ones obtained in this study. The chromium content of the energy drinks was high, higher than the recommended value of adequate intake of this metal. In a similar study by Iwegbue [23], high chromium content in canned beer above drinking water permissible level was also reported.

Lead can cause kidney damage and renal failure, damage to haemoglobin production, and to the nervous and gastric systems, while other metals can cause nephritis, anuria and extension of lesions in the kidney [24]. The permissible level for lead and cadmium in drinking water is 0.1 mg/L and 0.005 mg/L respectively [25]. Adequate Intake (AI) for chromium is 35 µg/day for males aged 19 - 50 years and 25 µg/day for females of the same age group [26].

The lead content of the four samples were below the permissible limit while the cadmium and chromium content was above the permissible level for drinking water, hence, caution has to be taken in consumption of energy drinks, as excessive intake can lead to increased level of heavy metal accumulation in the body. Heavy metal accumulation can predispose people to non communicable diseases such as cardiovascular diseases and cancers of various types.

4. Conclusion

Sugar and caffeine are the primary ingredients common in energy drinks and they are present at various levels of

Table 3. Heavy metal content of energy drinks (µg/100 ml).

Metal	Energy Drink			
	P. Horse	Emerge	Red Bull	Matador
Lead	0.46	0.48	0.16	0.24
Cadmium	0.02	0.01	0.01	0.02
Arsenic	0.29	0.71	0.22	0.21
Chromium	54.98	54.51	53.43	60.89
Mercury	ND	ND	0.07	ND

Values are means ± Standard deviation of triplicate determinations. ND = Not detected at microgramme level. Can Size: Power Horse: 330 ml; Emerge: 250 ml; Red Bull: 250 ml; Matador: 330 ml.

concentrations in the brands. All the four energy drinks had pH well below the pH 5.5 of dissolution of enamel. Improper consumption and overuse of energy drinks over a long period of time may cause additional calorie intake of consumers that may not be accounted for, thereby leading to additional weight on consumers, as well as dental erosion (especially on immature teeth). Excess of refined sugars as used in energy drinks and high level of heavy metals may serve as risk factors for non communicable diseases such as diabetes, obesity, coronary heart disease and cancers if consumed excessively on regular basis.

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