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Determination of Sugar Levels of Some Energy and Soft Drinks Marketed in Jos Metropolis, Nigeria

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Abstract

Sugars are the next main ingredients, after water, present in Energy Containing Beverages (ECBs). They are substantial in providing energy and so are present in every drink beverage in distinct proportions. Ten samples each of both soft drinks and energy drinks purchased in Jos metropolis in Plateau state, Nigeria were assessed for their sugar levels primarily in g/100 mL. This assessment was done using the Abbe refractometer to measure the percentage brix values at 22 ◦C, and the Density bottle was used to measure the densities of each sample and their values were used to calculate the mass concentrations of the samples. Sixteen (16) out of the twenty samples showed concentrations (7-14 g/100 mL) within the recommended Standards Organization of Nigeria (SON) regulatory limit. The other four (4) samples fell slightly outside the SON recommended limit; three were below (SF 3: 6.14 g/100 mL, SF 75.10 g/100 mL, and ED 6: 6.13 g/100 mL) and that of one above ED (10: 15.7 g/100mL). The energy drinks (EDs) were found to contain more sugar than the soft drinks (SFs) with mean concentrations of 10.51 g/100 mL and 8.17g/100 mL respectively. The results from the study reveal that majority of energy and soft drinks studied are within the regulatory limits set by SON. However, a few should be placed un the watch list, particularly those that are otherwise recommended for diabetics due to their 'low sugar levels'.

Keywords: Energy drinks, soft drinks, refractometer, Jos metropolis, beverages.

Introduction

Energy drinks represent the fastest growing sector in the beverage industry. The word 'beverage' is derived from the French word 'beivre' which means 'a drink' [1]. Consumption of sugar sweetened beverages, of which energy drinks and regular soft drinks are not exempted, has increased worldwide. The increased consumption of these beverages worldwide can most likely be attributed to their successful marketing strategies, low cost, increased portion sizes, characteristic sweet taste, energizing quality, and high availability [2]. Sugar sweetened beverages are 'non-necessities' associated with decline in health but unfortunately, energy drinks, unlike the other beverages are increasingly marketed to, and consumed by many people, adolescents and teenagers [2]. Despite the side effects, they are still consumed uncontrollably by many age groups, especially minors and adults to boost energy, alertness, performance and prevention of fatigue [3]. It's also sad that no strict prohibitions are being placed on them in most countries, but some interested and non-ignorant countries are already starting to regulate the sale of highly caffeinated and sugar rich drinks to prevent potential health problems [4].

It is very important to note that after water, sugar is the main ingredient in beverages before considering caffeine in energy drinks [5]. It is also important to note that sugar contains little or no nourishment rather it only aids sweet taste and contains calorie which is liable to make people fat. Overweight people are more likely to develop high blood pressure and eventually, heart attack [6]. A researcher [6] also mentioned that for many years, the alternative to sugar is the use of chemicals such as saccharin and cyclamates which are sweeter than natural sugars but do not have the calories of sugar. However, tests on laboratory animals rather suggest that both chemicals are possible causes of cancer.

In 2014, the World Health Organization (WHO) made a reduction in their 2002 standard recommendation. For the purpose of curbing the rate of intake of free / refined sugars below 10 % of total energy, the reduction was made by 5%; an equivalent of 25 g/24 hours for children and 35 g/24 hours for women and men respectively; a calorie equivalent of 1900 Kcal and 2600 Kcal respectively. From recent statistics in 75 countries, consumption of sugar sweetened beverages (SSBs)

has significantly risen from 36 L to 43 L per person per annum in 1997 - 2010 (13 years).

Medically, consumption of energy drinks is significantly associated with a whole lot of ill health conditions, some of which are; poor sleep quality which makes energy drink users have higher odds of having poor sleep quality, basically because of the caffeine and sugar effects on the consumer [7]; Cardiac abnormalities, caffeine toxicity and diabetes [2]; diabetes, dental caries, and dental erosion [9], ovarian increased arterial blood pressure and glucose levels [3] and many more.

Naturally occurring caffeinated drinks like coffee and caffeinated soft drinks like Coca-Cola are not considered as energy drinks. This is because; energy drinks are more than just caffeine, but a combination of caffeine, amino acids, vitamins, and often, herb supplements. Some major types of energy drinks, common in Nigeria, are: Lucozade Boost Original, Red Bull, Monster, Fearless, Power Horse, Climax Energy Drinks and many others. These are but a few that are found in Nigeria. Several other brands are available around the globe and are uncommon to many.

There has been a violation of the alcoholic and non-alcoholic drinks recommended regulatory limits set by Standards Organization of Nigeria (SON), and Joint Food and Agriculture Organization and World Health Organization (Joint FAO/WHO) for sugar and sulphite levels. In their research paper [1] mentioned how a supposed sugar-free drink (Club Soda) was found to contain as much sugar as a regular sugar sweetened soft drink. With this violation, diabetic patients to whom such drinks have been recommended have suffered sugar balance upset.

Glucose and sucrose are major sources of energy for all living things and there is uncontrolled consumption of these drinks alongside carbohydrate-rich Nigerian diets which is most likely one of the major causes of high calorie levels in the system and adverse health implications [1]. Due to their high energy production and characteristic reactions in the body, they in many ways determine the body's efficiency and productivity. Also, currency in sugar level updates and sensitization in Jos city may serve as a basis for strict government policy enforcement.

This work is aimed at determining the sugar levels of carefully selected energy and soft drinks samples in Jos, Plateau State Nigeria, West Africa using the Abbe refractometer and density apparatus to obtain their refractive Index, percentage brix and density values of the Solid Soluble Contents (SSC) in the various samples and comparing the values with the standards established for pure sugar compounds by regulatory bodies.

Materials and Methods

Description of study area

The study was carried out in Jos, Plateau State (9° 53' 47.4972" N and 8° 51' 29.9916" E. At an altitude of 1,217 m (3,993 ft) above sea level, Jos enjoys a more temperate climate than much of the rest of Nigeria. Average monthly temperatures range from 21–25 °C (70–77 °F), and from mid-November to late January, night-time temperatures drop as low as 11 °C (52 °F). Hail sometimes falls during the rainy season because of the cooler temperatures at high altitudes. These cooler temperatures have, from colonial times until the present day, made Jos a favourite holiday location for both tourists and expatriates based in Nigeria.

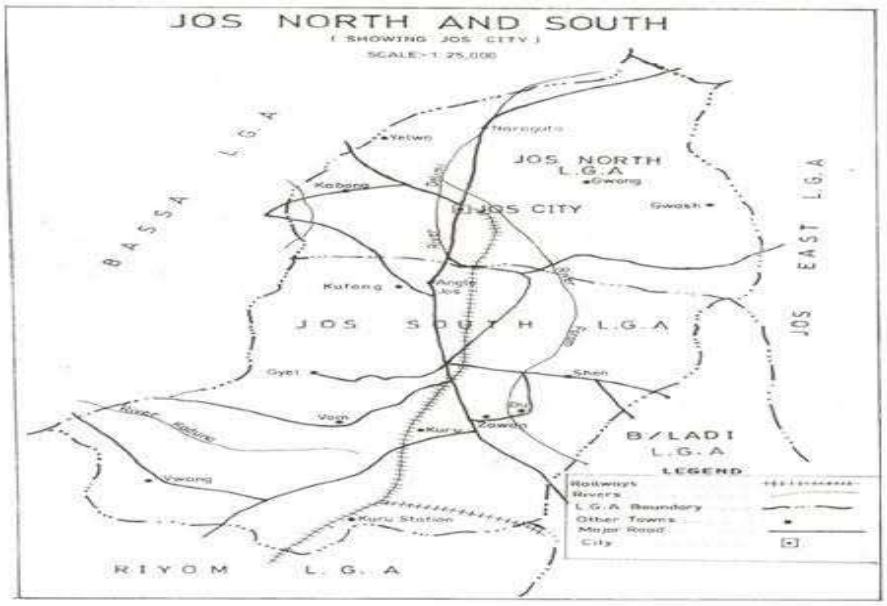

Figure 1: Map of the city of Jos, Plateau state, Nigeria West Africa.

Sample collection

Ten different brands of energy drinks (ED) and ten different brands of regular non-alcoholic carbonated soft drinks / beverages (SF) were purchased from Terminus market and different stores in Jos Plateau State, Nigeria to a total number of twenty (20) samples. The entire samples used were unexpired, duly registered and licensed by their respective companies and all had NAFDAC registration numbers. The soft drinks were coded SF 1 to SF 10, and the energy drinks as ED 1 to ED 10. The samples collected in 500 mL unit bottles were analyzed without further sample pretreatment.

Determination of refractive index

Samples were degassed by turning the bottles holding 500 mL of the samples into 500.00 mL beakers and with the aid of a magnetic rod and magnetic stirrer, the different samples were stirred for 10 minutes in warm water to allow the escape of gases from the respective samples [6]

The refractometer was calibrated by placing drops of distilled water on the sample prism. The scale was read at 0.00 (dark area is visible inside the eyepiece on the scale then turn the dial until the shadow falls on zero). After calibration, the prism was flushed with portions of sample and dapped clean with tissue paper. Few drops of the sample were placed on the glass prism using the dropper pipette. The refractometer flip was closed, and the reading taken at steady value. The analysis was carried out in triplicates to ensure reproducibility and precision [6].

Determination of density of samples

The dried empty density bottles were weighed on the analytical balance and their respective weights recorded. The weighed bottles were filled with the respective samples, avoiding bubbles. 1/3 of the neck was covered with the sample. With the stopper and thermometer aligned properly, and the capillary tube filled up, some of the samples were displaced out of the bottle. The outer surface of the stopper and density bottle were dried carefully with tissue paper. In a thermostatic bath, the temperature of the bottle and its contents were adjusted to 20.00 ^{0}C. The filled bottles were then placed on the balance respectively, and their weights recorded from the analytical balance [6].

Calculations

The density of the sample is calculated by the formula in equation (1)

$$Z = \frac{M2-M1}{V} \quad (1)$$

Where M_1 = Mass of filled density bottle; M_2 = Mass of empty density bottle; V = Volume of density bottle; z = Density of the liquid sample.

From the volume of the soft drinks, the values obtained from refractometer and densitometer, the mass of sugar is obtained as described [6]. The mass of sugar in a bottle of soft drink is calculated using equation (2)

$$\text{Mass of sugar per bottle} = \frac{mass\ of\ soft\ drink\ x\ \%of\ sugar\ in\ drink}{100} \quad (2)$$

Results and Discussion

For both soft drinks and energy drinks, their refractometry, and densitometry experiments were carried out in triplicates and their mean values determined and recorded in Tables 1 and 2. Both refractive index and % brix readings were taken from the refractometer. No standard deviations or errors were calculated because all three readings were equal. This could be attributed to the religious observance of the experimental procedure and the efficiency of the Abbe refractometer used.

The same procedure was used for all the drink samples in this study. The results for the measured sugar levels in the various brands of energy and soft drinks are depicted in Tables 1 and 2.

Table 1: Sugar Concentrations Measured in Selected Brands of Soft Drinks

Sample ID	Volume of bottle (mL)	Refractive Index at 22°C	%Brix at 22°C	Density (g/mL	Mass of Sugar in 100mL sample	Mass of Sugar (g/bottle content)
SF 1	330	1.3502	11.6	1.0433	12.10	39.94
SF 2	350	1.3432	7.0	1.0295	7.21	25.24
SF 3	350	1.3412	6.0	1.0238	6.14	21.49
SF 4	350	1.3432	7.0	1.0290	7.20	25.20
SF 5	500	1.3482	10.0	1.0361	10.36	51.80
SF 6	330	1.3502	11.5	1.0487	12.06	39.80
SF 7	350	1.3402	5.0	1.0195	5.10	17.85
SF 8	350	1.3432	7.0	1.0285	7.20	25.20
SF 9	350	1.3442	8.0	1.0295	8.24	28.84
SF 10	500	1.3492	11.0	1.0442	11.49	57.45

Table 2: **Sugar Concentrations Measured in Selected Brands of Energy Drinks.**

Sample ID	Volume of bottle (mL)	Refractive Index at 22°C	%Brix at 22°C	Density (g/mL)	Mass of Sugar (g/100mL)	Mass of Sugar (g/bottle content)
ED 1	250	1.3482	10.5	1.0449	10.97	27.43
ED 2	500	1.3482	10.5	1.0387	10.91	54.55
ED 3	250	1.3452	8.5	1.0366	8.81	22.03
ED 4	500	1.3482	10.5	1.0436	10.96	54.80
ED 5	250	1.3482	10.5	1.0424	10.94	27.35
ED 6	500	1.3422	6.0	1.0247	6.13	30.65
ED 7	400	1.3432	7.0	1.0241	7.17	28.68
ED 8	440	1.3492	10.5	1.0425	10.95	48.18
ED 9	250	1.3512	12.0	1.0421	12.50	31.25
ED 10	400	1.3552	15.0	1.0498	15.75	63.00

The sugar levels are represented graphically in g/100 mL by the Figures 1.

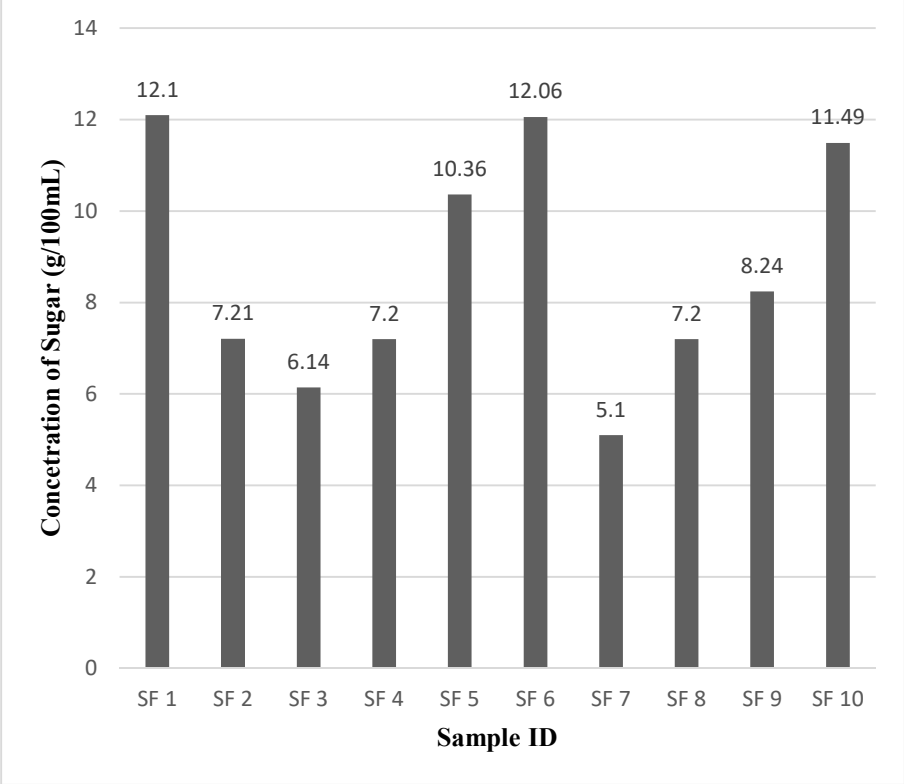

Figure 1: Concentration of Refined Sugars in Selected Brands of Soft Drinks

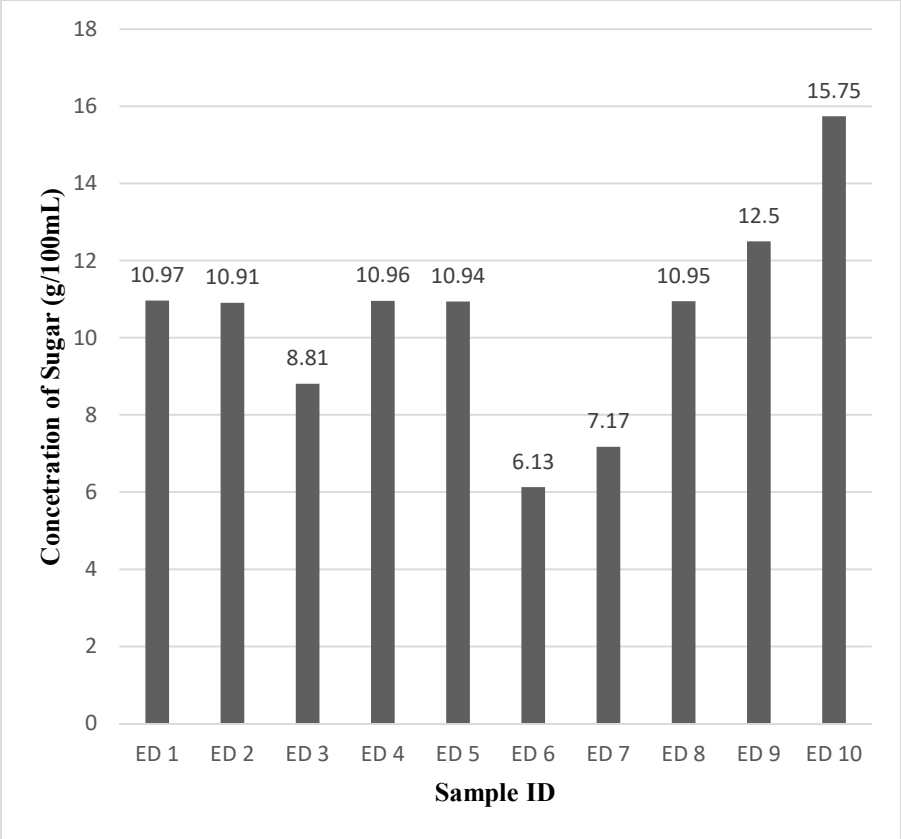

Figure 2: Concentration of Refined Sugars in Selected Brands of Energy Drinks.

The results for the sugar concentrations / levels in the soft drinks under study ranged from 5.10 g /100 mL in SF 7 to 12.10 g/100 mL in SF 1, with a mean concentration of 8.71 g/100 mL. Significantly, the sugar concentrations in the various brands analyzed were of the order: SF 7 < SF 3 < SF 4 = SF 8 < SF 2 < SF 9 < SF 5 < SF 10 < SF 6 < SF 1. A Similar work carried out in Port Harcourt Nigeria by [9] which agrees with the fact that sugar levels in various drinks differ except for the concentrations of SF 4 and SF 8 which showed to be equal (at 7.20 g/100 mL). The variations in sugar levels could be attributed to the differences in composition and methods for the preparation of the soft drinks by the different manufacturers. The resultant concentrations of the drinks fell within the recommended limit stated by the Standards Organization of Nigeria (SON) which is 7- 14 g/100 mL, except for SF 3 (at 6.14 g/100 mL) and SF 7 (at 5.10 g/100 mL) which fell slightly below the range. This exception could be attributed to the manufacturing defect due to improper quality control [10].

It is generally believed that SF 10 and its likes contain less sugar because of their slight bitter taste, compared to the obviously sweet and flavoury SF 3, 4, 7 and 9, but the results from this experiment have shown otherwise, confirming the research reported by [1]. It has revealed that the 'less sugar' SF 10 contains 3-6 g/100 mL or 15-30g/500 mL more sugar than the 'Sweet High Sugar' SF 3, 4, 7 and 9. This should therefore caution consumers who desire low sugar drinks not to ingest multiple bottles of the drink in the name of running away from sugar. This result also shows that the malt drinks SF 1 and SF 6 contained more sugar (12.10 and 12.06 g/100 mL respectively) than every other soft drink analyzed in this study. This could be due to the large constitution of carbohydrates in the drink [11]. Malt drinks are then said to be energy-without-caffeine drinks [10].

From the results of regular soft drinks reported above, the sugar levels of these energy drinks under study were largely higher, though still within the recommended sugar limits by SON. This is because of their design / make; they are designed/made with higher amounts of simple reducing sugars to help the consumer regain lost energy quickly, as the name implies. The sugar concentrations ranged from 6.13 g/100 mL and SF 6 to 15.75 g/100 mL in SF 10, with a mean concentration of 10.51 g/100 mL. The various concentrations of the energy drinks are in the order: ED 6 < ED 7 < ED 3 < ED 2 < ED 5 < ED 8 < ED 4 < ED 1 < ED 9 < ED 10. This result further confirms that different drinks contain different sugar levels, based on their composition and preparation methods. All these data from the drinks fall within the recommended sugar limits but for ED 6 which fell slightly below 7.0 g/100 mL (at 6.13 g/100 mL) and ED 10 which is 1.75 g/100 mL above the SON maximum recommended limit (14 g/100 mL). Five of the energy

drinks under study (ED 1, ED 2, ED 4, ED 5 and ED 8) show very similar mass concentration values around 10.9 g/100 mL, and correspondingly equal brix value (at 10.5 % brix). This relatedness is most likely a result of the similarity of the constituents and proportion of ingredients in each drink, and similar methods of preparation while cautiously taking precautions. It further confirms the proposition that an average portion of energy drink contains 10 g of sugar per 100 mL liquid [1]. The sugar contained in each bottle is also represented on Table 2 above. The bottle equivalent for ED 10 as shown above is 63.00 g which is statistically equivalent to 16 cubes/teaspoons of sugar (1 cube ≈ 1 teaspoon ≈ 4 g). This is far above the World Health Organization (WHO) sugar recommendation of between 20 - 40 g per day. This means a person who takes a 500 mL bottle of energy drink would have taken in sugar meant for two days, this is aside the regular carbohydrate rich and regular sugar-containing-diets, especially for Africans. This of course is a major factor in the development of various health complications like obesity, dental caries, and dental erosion [8], diabetes, cardiovascular diseases, among others. Energy drinks, because they contain high sugar, high caffeine and other stimulants which predispose consumers to adverse health complications, and it is no news that no prohibitions or restrictions are placed on them in many countries and nations. All kinds of soft drinks are acidic [11]. This is because they are carbonated, and this gas reacts with water to form carbonic acid (H_2CO_3). The ingestion of these drinks increases the acidity of the body because of the reaction of the carbonic acid in the drinks and the hydrochloric acid in the stomach.

Conclusion

The employment of refractometry, coupled with densitometry has shown to be an effective and justifiable method for the determination of sugar levels and concentrations in beverages and by extension, sugar solutions. This study shows that energy drinks contain more amount of sugar than soft drinks obviously because of their function - to provide energy to the consumer. Sugar is a carbohydrate saccharide which is reducible by the body to release energy. The soft drinks had mean concentrations which agree largely with the recommended standard set by the Standards Organization of Nigeria. The study also reveal that some soft drinks touted as low sugar drinks (recommended for diabetics) are in the actual sense not so as they turn out to contain more sugar in reality.

Declaration of conflicting interests

The authors declared no potential conflicts of interest

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