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Estimation of Caffeine and Sugar in Some Selected Brands of Energy Drinks Available in Libyan Markets

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Abstract:
Energy drinks are very popular worldwide, especially among teenagers and young adults. The increased consumption of energy drinks raises serious health concerns due to the high content of sugar, caffeine, and other ingredients. This study aims to determine the amount of caffeine and sugar present in some energy drinks available in Libyan markets, and its potential health effects.7 different brands of energy drinks were purchased from random markets in Tripoli. Caffeine was extracted from each drink and analyzed by UV-VIS Spectrophotometric method. Reduced sugar, pH, NaCl, CO_2, Ascorbic acid, and citric acid also were analyzed. the pH values were highly acidic ranging from 1.20 – 2.18, and NaCl% ranged from 0.146% to 0.641% which exceeded the Libyan standard limitation, also CO_2 content was exceeded in most of the samples ranging between 3.46 to 10.16 (g/cm^3). as for the reducing sugar content ranged from 5.5 – 31.11 mg/100ml. The results showed that the caffeine content of the studied drinks ranged from 9.71 to 41.29 ppm. The caffeine concentration in all drink samples analyzed in this study was within the allowable limits established by the FDA.

Keywords: Energy Drink, Caffeine, Reducing Sugar, UV Spectrophotometer.

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تقدير محتوى الكافيين والسكر في بعض مشروبات الطاقة المتاحة في الأسواق الليبية

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الملخص
تحظى مشروبات الطاقة بشعبية كبيرة في جميع أنحاء العالم وخاصة بين المراهقين والشباب. يثير الاستهلاك المتزايد لمشروبات الطاقة مخاوف صحية خطيرة بسبب ارتفاع نسبة السكر والكافيين وغيرها من المكونات الأخرى. تهدف هذه الدراسة إلى تحديد كمية الكافيين والسكر الموجودة في بعض مشروبات الطاقة المتوفرة في الأسواق الليبية وتأثيراتها الصحية المحتملة. تم شراء 7 أنواع مختلفة من هذه المشروبات بطريقة عشوائية من الأسواق بمدينة طرابلس. تم استخلاص الكافيين من كل مشروب وتحليله بطريقة الطيف الضوئي *UV-VIS*, كما تم قياس كمية السكر المختزل والأس الهيدروجيني *pH* ونسبة كلوريد الصوديوم وثاني أكسيد الكربون، وحمض الأسكوربيك (فيتامين سي)، وحمض الستريك. وكانت قيم ال *pH* عالية الحموضة حيث تراوحت بين 1.20 -2.18, كذلك تجاوزت كمية الغاز في المشروبات الحد المسموح به وتراوحت بين 3.46 – 10.16 (جم/سم^3). أما نسبة

الملح *NaCl* فكانت عالية مقارنة بالمواصفات القياسية الليبية فقد تراوحت بين 0.146% -0.641%, أما نسبة السكر المختزل فقد تراوحت بين 5.5 – 31.11 ملغم\100مل. وأظهرت النتائج أن محتوى الكافيين في العينات المدروسة تراوح بين 9.71 - 41.29 *ppm*. حيث كان تركيز الكافيين في العينات في هذه الدراسة ضمن الحدود المسموح بها التي حددتها إدارة الغذاء والدواء *FDA*.

الكلمات المفتاحية: مشروبات الطاقة، الكافيين، السكر المختزل، مطيافية الاشعة تحت البنفسجية.

Introduction

Energy drinks first became popular in Asia and Europe in the 1960s, but since Red Bull® was introduced in Austria in 1987 and in the United States in 1997, there has been a significant increase in the trend of aggressive marketing for these drinks. Since then, the industry for energy drinks has expanded rapidly, with the introduction of about 500 new brands globally in 2006 [1].

Energy drinks are made to promote physical performance, elevate mood, increase alertness and wakefulness, and boost energy [2]. They are consumed for a variety of benefits, including better endurance, a longer time to sleep, relief from weariness, vigor, a boost to memory and concentration, and appreciation of flavor [3].

Energy drinks are described as “a class of products in liquid form that typically contains caffeine, with or without other added ingredients” by the Food and Drug Administration (FDA). Large doses of caffeine, additional sugars, other ingredients, and safe stimulants like taurine, L-carnitine, and guarana are usually found in them. [4,5]

Energy drinks commonly contain caffeine as an ingredient. It is purposefully included to give the drinks flavor and increase their addictiveness. When weakness or drowsiness arises, caffeine activates the central nervous system, lowering physical weariness and restoring mental attentiveness.[6] Caffeine is alkaloid produced organically in tea leaves, coffee seeds, cocoa and kola fruit, and it can also be added to energy beverages. Because of its physiological function, it has attracted greater attention.[7] Because it stimulates the neurological system, there is a momentary rise in the risk of miscarriage, disturbed sleep, vasoconstriction, and myocardial ischemia.[8], and raises blood pressure and blood flow [9]. It’s critical to determine the precise caffeine concentration of beverages because of the possible consequences associated with caffeine consumption. [10]

The maximum caffeine content in carbonated drinks is set by the US Food and Drug Administration (FDA) at 200 ppm, or 0.2 mg/ml. [11] The NSDA permits a soft drink’s caffeine level to be between 8.45 and 20.28 mg/100 ml or 30 and 72 mg/355 ml.[12] The Natural Health Products (NHP) Regulations (2008) state that an energy drink contains 80 mg of caffeine per 250 ml serving. [13]

Refined sugar is another typical component in energy drinks. Energy drinks are notorious for having a lot of sugar. According to a thorough analysis of energy drinks, the average amount of sugar in an 8 oz serving of sugar-sweetened energy drinks was 27 g, which is greater than that of flavored water and sports drinks but similar to sodas and fruit drinks. Energy drinks can contain different amounts of high-fructose corn syrup, glucose, sucrose, or fructose. In young, healthy adults, fructose appears to have the strongest autonomic effect, markedly raising blood pressure (BP) two hours after ingestion. Thirty minutes after consuming fructose, blood pressure jumped quickly, peaking at 6.2 ± 0.8 mmHg above baseline [14]. Consuming sugary beverages increased systolic blood pressure in youngsters between the ages of 11 and 12 by 0.8 mmHg, a minor but substantial increase that was probably produced by sympathetic nervous system activation [15].

There are no systematic, long-term research that show the effects of regularly using energy drinks. On the other hand, a number of anecdotal accounts link energy drinks to harmful cardiovascular events such myocardial infarction, ventricular arrhythmia, atrial fibrillation, and sudden death. Even in generally healthy individuals with anatomically sound hearts, events like atrial fibrillation can happen. [16] The effects could be behavioral, like drinking alcohol or going to school, psychological, like anxiety, or physical, like headaches.[17] The systematic reviews that are now available present a variety of results, including beneficial benefits on athletic performance.[18]

Though the popularity of energy drinks is increasing a numeral of these energy drinks have been introduced to the Libyan market for the young adult consumers claims to improve performance and boost energy. This could further increase the health risk to consumers. This study aims to determine the amount of caffeine and sugar present in various energy drinks and their potential health effects. The results of this analysis can help consumers make informed decisions about their beverage choices and encourage manufacturers to reduce the unhealthy contents in their products.

Material and methods

Sample Collection: Seven brands of energy drink samples were obtained from local Libyan markets in July 2023 and were coded as shown in Table (1) below, after collection samples were kept in the refrigerator.

Table 1 Energy Drink Samples.

SN.	Brand	Serving size (ml)	Origin
E1	X-R	250	Turkey
E2	Boom Boom	250	Egypt
E3	CluBe[FC]	250	Turkey
E4	Izem	250	Algeria
E5	Power horse	250	Austria
E6	Blue Power	250	UAE
E7	Wild Power	250	Turkey

Determination of PH: by using a PH meter (HANA HI 8314) the pH values of the energy drinks were determined directly by dipping the electrode into liquid samples.

Determination of the weight and volume of CO_2: The weight of the gas in the can containing the energy drink was measured by weighing the can with the solution before opening it, then opened the can and poured the solution from it, and stirred using the magnetic stirrer to allow carbon dioxide gas to exit the liquid, then the solution was weighed with the can and recorded the difference in weight, which represents the weight of the gas. [19]

The CO_2 volume was calculated by the following equation:

$$\text{Gas Vol} = \frac{Gas\ \ weight}{0.0019\ x\ \ \ Actual\ \ liquid\ Vol.} \ldots Eq\ (1)$$

Where 0.0019: the density of CO_2 (g/cm^3).

Determination of NaCl: Sodium chloride was estimated by titration with a standard solution of silver nitrate ($AgNO_3$), where this method relies on the formation of a precipitate that has a distinctive color at the equivalence point, the chromate ion was used as an indicator with the appearance of a red-brown silver chromate precipitate.

The percentage of NaCl was calculated with the following equation:

$$\text{Sodium Chloride (C\%)} = \frac{AgNO3\ Average\ Vol.\ \text{x N x } 0.0584}{Weight\ of\ sample} x\ 100 \ldots Eq\ (2)$$

Determination of reducing sugar: the amount of sugar dissolved in the energy drink was measured by using the density measurement. [20], which is summarized in finding the standard curve obtained by drawing the relationship between the density of the standard sugar solutions against their concentration, and by calculating the density of beverage samples using the density bottle and the equation of the straight line of the standard curve, the percentage of sugar is found in the samples.

Determination of Ascorbic acid: The number of grams of ascorbic acid in the sample was calculated by the following equation:

Ascorbic acid (g) = Average Vol. of Iodine used in titration x 0.008807 …. Eq (3)

Where 0.008807 is the number of grams of ascorbic acid equivalent to 1ml of I_2 (0.1M)

Determination of Citric acid: Citric acid is estimated in a given volume of beverages by titration with a standard sodium hydroxide solution NaOH (0.1M) to form salt and water. [21]

The weight (g) of citric acid in the sample was calculated from the following equation:

$$\text{W (g)} = \frac{M.wt\ of\ citric\ \ x\ V\ of\ NaOH}{3} \ldots Eq\ (4)$$

The percentage of citric acid in samples is calculated from the following equation:

$$\text{Citric acid \%} = \frac{weight\ of\ citric\ \ in\ sample}{weight\ of\ sample}\ x\ 100 \ldots Eq\ (5)$$

Determination of Caffeine: Caffeine is extracted from energy drink samples using a separation funnel by chloroform solvent. 100 ppm Caffeine stock solution was prepared by dissolving 0.01g caffeine powder in100ml of pure chloroform in volumetric flask.

Estimate the amount of caffeine in samples by UV-VIS spectrophotometer, by preparing a standard curve of caffeine as shown in table (2) and figure (1):

Table 2 UV adsorption of standard Caffeine solutions.

Concentration (ppm)	Adsorption	Concentration (ppm)
2	0.075	2
4	0.187	4
6	0.257	6
8	0.338	8
10	0.448	10

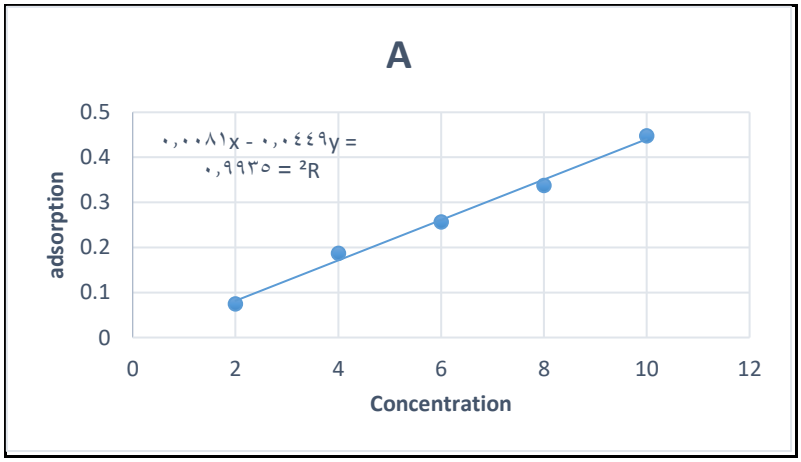

Figure 1: Caffeine Standard calibration curve**.**

Sample preparation: Carbon dioxide gas was removed from the samples, 5ml of each sample was taken and placed in separation funnel. 10 ml of distilled water was added to it, then 1ml of 20%

sodium carbonate (Na_2CO_3) was added to it. Then add 20ml of chloroform, close the separation funnel and shake the mixture well for 5 minutes, the separation funnel is left to settle until the organic layer separates from the aqueous layer. The organic layer was then collected in a volumetric flask. The absorption of the samples as well as the standard solutions of different concentrations were measured at a wavelength 270 nm.

Results and discussion

The results obtained are shown in Table (3) for the energy drink samples analyzed in this study.

Table 3 The results obtained for studied energy drinks:

sample	pH	CO_2	NaCl %	Reducing sugar (mg/100ml)	Ascorbic acid % (Vit. C)	Citric acid%	Caffeine Conc. (ppm)
E1	1.68	7.82	0.146	22.2	0.22	0.07	9.71
E2	1.90	5.62	0.440	26.11	0.45	0.14	41.29
E3	1.94	6.32	0.273	10.0	0.69	0.22	21.32
E4	2.09	10.16	0.224	31.11	0.93	0.29	24.11
E5	2.18	5.03	0.233	9.4	1.19	0.36	24.67
E6	1.20	3.46	0.641	25.0	1.47	0.45	26.67
E7	1.96	8.74	0.201	5.5	2.33	0.60	14.29

Energy drinks are acidic having lower pH values. The lower pH value is due to the presence of CO_2 gas or other acids such as phosphoric acid, malic acid, ascorbic acid, citric acid and tartaric acid used as preservatives by the manufacturer of these energy drinks [22]. These acids inhibit the growth of microorganisms such as bacteria, mould and fungi which may contaminate beverages. Studies showed that drinking acidic beverages over a long period can cause erosion of tooth enamel and predisposition of the consumer to dental disease [23].

The results obtained for the pH values shown in Table (3) and Figure (2) below, showed that pH ranged from 1.20 in sample E6 (Blue Power) to 2.18 in sample E5 (Power horse). All samples were within the permissible limit of the Libyan standard specifications (2013).

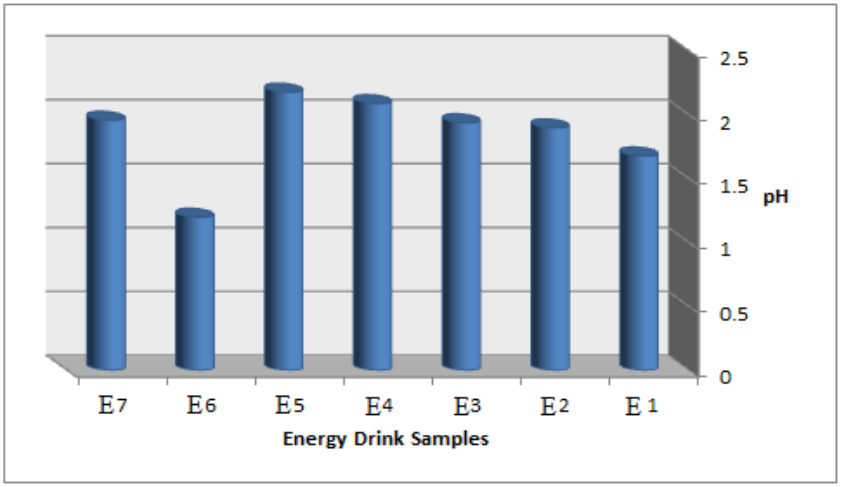

Figure 2: pH Values of Energy Drink Samples**.**

Through table (3) and figure (3), the results showed that the volume of carbon dioxide gas in the studied samples ranged from 3.46 to 10.16 (g/cm^3). Where the lowest value was in sample E6 (Blue Power), while the highest was in E4 (Izem). From these results, we note that most of the samples exceeded the permissible limit, which estimated at (1.0 – 3.6 g/cm^3).

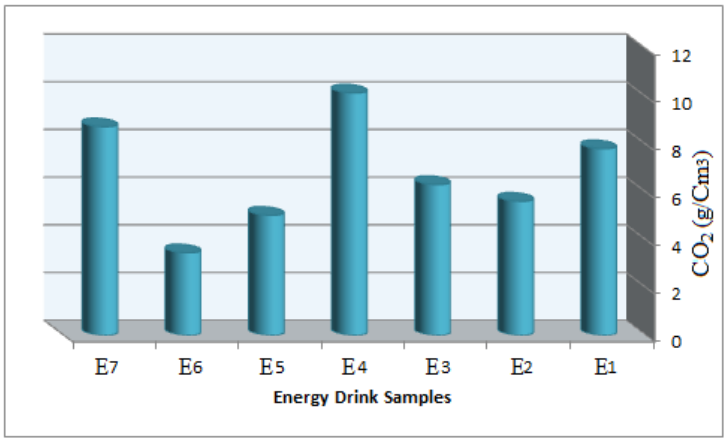

Figure 3: CO_2 Values in Energy Drink Samples.

The percentage of NaCl in energy drink samples ranged from 0.146% in sample E1 (X-R) to 0.641% in E6 (Blue Power). We note that most of the samples, (with the exception of E1) exceeded the permissible limit, which does not exceed 0.1%.

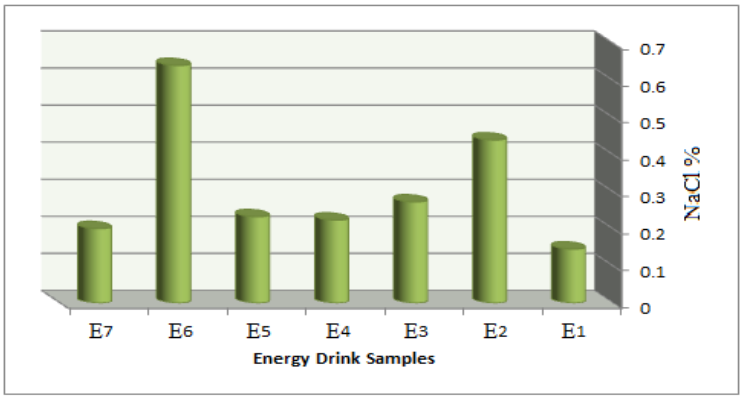

Figure 4: NaCl % in Energy Drink Samples**.**

Sugar in drinks gives it a great sweetness to motivate the consumer to resort to it when they needs sugars. The results of sugar estimation in the samples studied in the table (3) and figure (5) showed that the amount of reducing sugars ranged from 5.5mg/100ml in E8 to 31.11 mg/100ml in E4. most of the samples exceeded the permissible limit (7-12 ppm).

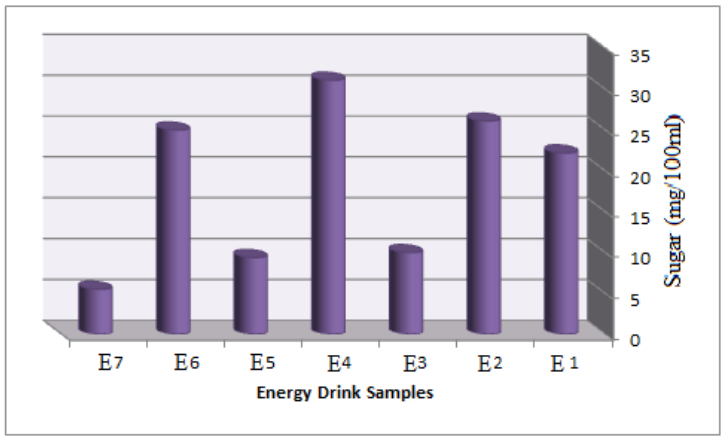

Figure 5: Reducing Sugar Values in Energy Drink Samples**.**

The results showed that the percentage of ascorbic acid ranged between 0.22% and 2.33%. By comparing the results obtained in this study with the Libyan standard specifications, which allow the addition of ascorbic acid in an amount not less than 0.01%, it is noted that all the samples studied contained percentages that exceeded permissible limit.

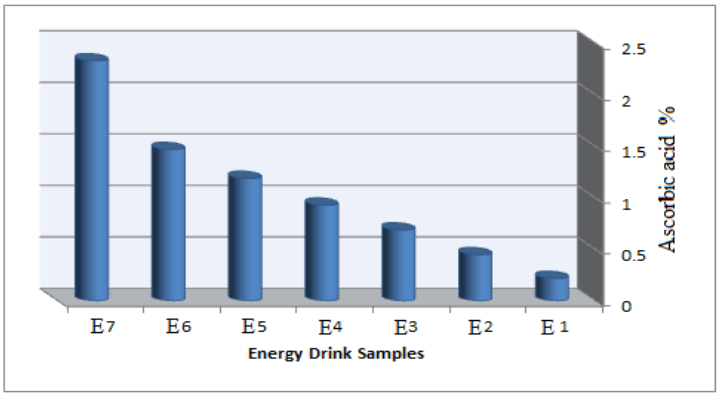

Figure 6: Ascorbic acid Values in Energy Drink Samples**.**

The percentage of citric acid in energy drink samples ranged from 0.07% to 0.60%. It is noted that all samples were within the permissible limits according to Libyan standard specifications, except for sample E7, which exceeded the permissible limit of 0.5%.

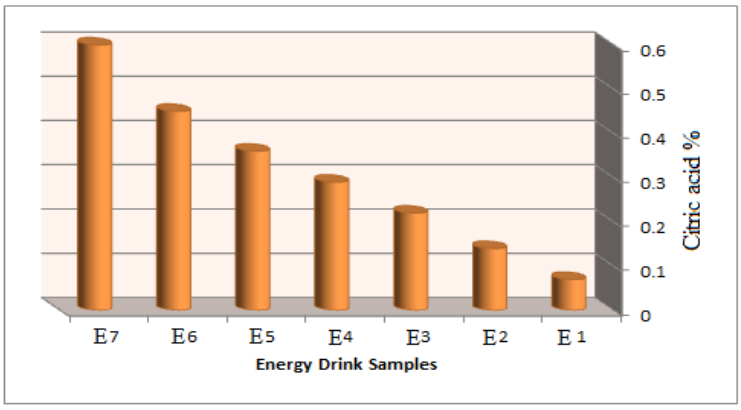

Figure 7: Citric acid Values in Energy Drink Samples**.**

The caffeine content in energy drink studied samples as presented in figure (8) ranged from 9.71 to 41.29 ppm. The highest concentration was in E2 (Boom Boom). Generally regarded as safe to consume up to 300 mg of caffeine per day [24,25]. This amount usually equates to four energy drink cans. It is clear that the caffeine concentrations in the drink samples examined for this study are far lower than the maximum allowable limits established by the food regulatory organizations.

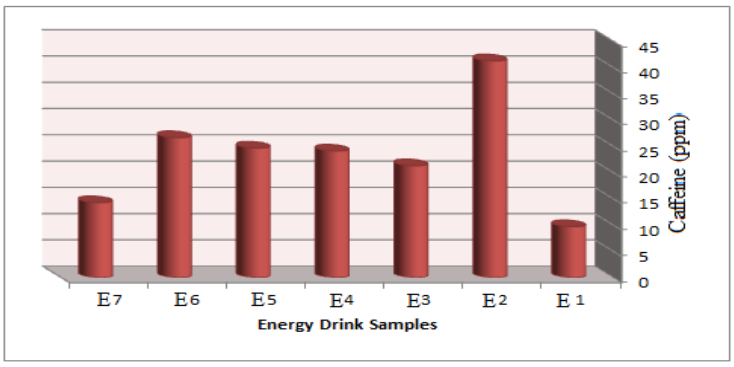

Figure 8: Caffeine Values in Energy Drink Samples**.**

Conclusion

Energy drinks contain high levels of caffeine and a high sugar content which can lead to negative health effects such as increased heart rate, high blood pressure, and anxiety. It is important to consume these drinks in moderation and be aware of their potential impact on overall health. While energy drinks can provide a quick boost of energy, it is important to note that they often contain high levels of caffeine and other stimulants that can have negative effects on the body. It is recommended to consume these drinks in moderation and be aware of their caffeine content.

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