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Research Article

The Caffeine Content of Energy Drinks in accordance with the Information on the Package Label

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Six different brands of energy drinks (EDs) were analyzed to determine the concentration of caffeine in accordance with the information on the package label. Approximately 28.1 milligrams per 100 milliliters (mg/100 ml) of caffeine was present in the Mo energy drink brand, which was nearly 1.5 times the caffeine concentration listed on the product label. The energy drink with the highest caffeine content was Dragon, which contained 30.1 mg/100 ml, or a total of 150.5 mg per 500 ml bottle. Manufacturers of energy drinks (EDs) should accurately list the amount of caffeine and other ingredients on the product label so that consumers know how much of each ingredient they are taking. Taking too much caffeine can be bad for your health.

1. Introduction

Energy drinks (EDs) are nonalcoholic, sugary beverages that contain variable amounts of caffeine, taurine (amino acid), glucuronolactone, herbal extracts, minerals, and vitamins in order to increase physical and mental endurance [1]. The majority of people who consume EDs are engaged in strenuous physical activity, as well as those who prefer to remain alert for longer durations, such as athletes, drivers, and students. Because EDs are marketed for their perceived or actual benefits as stimulants, performance enhancers, and energy boosters, this is the case [2]. EDs were first introduced in Asia and Europe around 1960 [1]. In 1987, when the most well-known brand, Red Bull, was introduced, its consumption became very popular [3].

Due to the widespread and long-term consumption of beverages containing caffeine naturally, such as coffee and tea, the regulation of beverages containing added caffeine has been complicated [4]. Nevertheless, a number of nations have enacted regulations governing the labeling, distribution, and sale of energy drinks containing significant amounts of caffeine [4]. The European Food Safety Authority mandates that energy drinks with a caffeine content greater than 150 parts per million (ppm) or 150 mg per liter must be labeled as having "high caffeine content" and the exact amount must be specified [5]. Australia has banned energy drinks with more than 320 ppm of caffeine and wants to put them in the same category as drugs. Countries such as Denmark, Uruguay, and Turkey have banned energy drinks entirely, and Sweden has prohibited the sale of energy drinks to minors [5]. The maximum recommended daily caffeine intake varies between 2.5 mg/kg/day and 6 mg/kg/day for children, 100 mg/day for adolescents, and 400 mg/day for adults [6]. Tolerance to caffeine varies between individuals, with the majority of people developing toxic symptoms at doses of 200 mg [7].

A study conducted by CSE [4] to determine the caffeine content of energy drinks revealed deviations from the amount of caffeine listed on the label, as shown in (Table 1).

Joo et al.found that the health risks associated with ED consumption are primarily attributable to their caffeine content. An overdose of caffeine can cause palpitations,

hypertension, dieresis, stimulation of the central nervous system, nausea, vomiting, marked hypocalcemia, metabolic acidosis, convulsions, and, in rare cases, death [9]. There is also an increased risk of arterial hypertension and Type 2 diabetes in adults due to the fact that high caffeine consumption reduces insulin sensitivity [10]. Caffeine consumption increases the risk of late miscarriages, small-for-gestational-age infants, and stillbirths among pregnant women. Frequent caffeine consumption may impair cognition in general and long-term memory and learning in particular [11]. Caffeine at a dose of 400 mg increases anxiety, particularly when combined with a stressful task. Some studies suggest that EDs can trigger the onset of the first seizure and contribute to stroke [12].

Caffeine overconsumption is linked to a variety of additional health issues. Caffeine overdose, for instance, has been reported as a potential cause of rhabdomyolysis [13]. Due to their diuretic effect, EDs can cause hypokalemia as well as high creatinine kinase levels and renal impairment [14]. Individuals who do not regularly consume large quantities of caffeine may experience an increase in diuresis after consuming EDs. Therefore, dinks have an overall dehydrating effect [15]. In addition, Hasselkvist et al. [16] found a significant relationship between EDs and dental erosion. The low pH of energy drinks is largely responsible for their high demineralization potential [17]. According to Vos and Lavine [18]; increased consumption of sugar-sweetened beverages, including ED, is associated with overweight and obesity, as well as an increased risk of diabetes mellitus and cardiometabolic diseases because beta cells are unable to secrete enough insulin to maintain normal blood glucose levels when exposed to excesses of simple sugars for extended periods of time.

Caffeine, the primary component of the drinks, stimulates sympathetic nerves, which can cause adverse health effects, such as sudden death .

Despite an increase in the number of industries in Tanzania producing various brands of EDs and the presence of imported products, there are no published studies in Tanzania assessing the concentration of caffeine in ED products in accordance with the information on the package label. The study's overarching objective is to determine the amount of caffeine used in energy drink products in accordance with the labeling information.

2. Materials and Procedures

2.1. Estimation of Sample Size for Energy Drinks. Purposeful sampling was used to collect twelve energy drink samples, two from each of six brands sold in Tanzanian grocery stores and convenience stores. Two grocery stores were visited and the shopkeepers were asked to select six samples of EDs beverages that were most likely preferred by customers. The other three must consist of brands produced in Tanzania, and the other three must consist of brands imported from outside the country; this was done in both grocery stores.

2.2. Data Collection. The samples were randomly obtained by visiting two grocery stores and asking the shopkeepers to select six samples of EDs beverages that were most likely preferred by customers. Three of the samples had to be Tanzanian brands, and the other three had to be foreign brands; this was done in both grocery stores. The samples were placed in a cool box with icepacks and transported within one to two hours to the Food Science and Technology Laboratory at Sokoine University of Agriculture (approximately 2.5 km from the sample collection sites), where they were stored at a temperature of 1.6°C until analysis.

2.3. Procedures for Caffeine Extraction and Sample Measurements. Each working standard and sample solution yielded 1.0 mL of homogenized beverage. This sample was placed in a separating funnel, 1 ml of 20% (w/v) methanol and 5 ml of chloroform were added, and the mixture was shaken for five minutes. The absorbance of the lower (organic) layer containing caffeine was measured at 274 nm using a UV Vis spectrophotometer (X-ma 3000, England). The extraction method was performed twice for each sample (Table 2).

A 1000 ppm standard stock solution was prepared by dissolving 0.1 g of pure caffeine in 100 ml of chloroform. We prepared serial dilutions of 1 to 25 ppm, measured absorbance, determined a linear regression equation, and used Microsoft Excel to tabulate measurement data and conduct a linear regression analysis. This allowed for the calculation of a concentration factor, which was then used to quantify the caffeine. The final caffeine content of the tested beverage was then calculated using the concentration of the extracted sample solution and the following equation (Figure 1):

$$\text{Caffeine content in milligrams} = \text{Conc (ppm)} \times (\text{total sample volume (ml)2}).\ \text{Sample volume (ml) multiplied by 1000.} \quad (1)$$

3. Results

3.1. Analyses of the Actual Amounts of Caffeine Found in Energy Drink Ingredients. The six different brands of ED beverages in duplicates (a total of 12) consisted of three brands that were produced in Tanzania (Azam energy drink, Mo energy drink, and Power energy drink) and three that were imported from abroad (Kungfu energy drink, Dragon energy drink, and Monster energy drink). Of the six samples tested, the sample of Dragon energy drink had the highest caffeine content at 30.1 mg/100 ml, resulting in a total of 150.5 mg of caffeine per bottle (Table 3).

Table 1: The caffeine content of popular energy drinks.

S. No.	Brand name	Caffeine concentration detected (ppm)	Concentration on the label (ppm)	Percent deviation from the claim on the label	No of times above the PFA standard of 145 ppm
1	XXX-1 (rejuve)	112.23	100	12.23	Within limit
2	XXX-2 (rejuve)	122.05	100	22.05	Within limit
3	XXX-2 (nicofix)	119.48	100	19.48	Within limit
4	XXX-2 (nicofix)	123.94	100	23.94	Within limit
5	Red Bull 1	308.80	320	Within limit	2.1
6	Red Bull 2	311.35	320	Within limit	2.1
7	Burn-1	294.34	300	Within limit	2.0
8	Burn-2	289.12	300	Within limit	Within limit
9	XXX-1 (minus)	153.69	Not given	—	Within limit
10	XXX-2 (minus)	152.90	Not given	—	Within limit
11	Cloud 9 (wild berry)	148.05	Not given	—	Within limit
12	Cloud 9 (premium)	136.44	Not given	—	Within limit
13	Monster-1(ripper)	314.45	300	14.45	2.2
14	Monster-2 (ripper)	313.72	300	13.72	2.2
15	Tzinga-1	259.68	300	Within limit	1.8
16	Tzinga-2	257.05	300	Within limit	1.8

Table 2: Absorption of final solutions at 274 nm.

Caffeine equivalent conc. (mg/L)	Absorbance at 274 nm
0	0.091
5	0.365
10	0.583
15	0.821
20	0.996

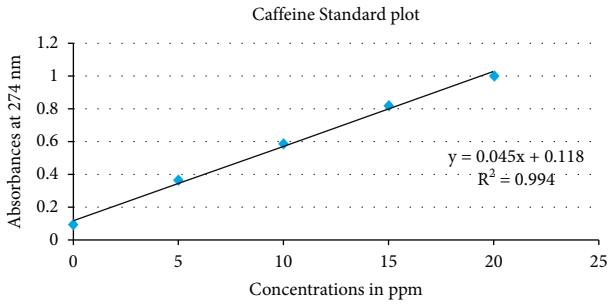

Figure 1: Standard calibration curve.

Caffeine content samples (BEVERAGES) analyzed in duplicate (S1 and S2) during a 2018-2019 study of energy drink consumption rate, knowledge, and perceived side effects among long-distance car drivers in Morogoro municipality, Morogoro, Tanzania (Table 3).

Monster energy drink had the highest caffeine content per serving (per packaged bottle), followed by Dragon energy drink and Kungfu energy drink, followed by Power energy drink and Azam energy drink, with Mo energy drink having the least amount of caffeine indicated on its package label (Tables 4 and 5).

4. Discussion

Since caffeine is the main ingredient in energy drinks, caffeine overdoses are the leading cause of adverse health effects [19]. Due to its higher caffeine content, some nations, including Turkey, have banned its consumption [20]. Referring to the current FDA regulation, "dietary ingredients that are specifically added to products must contain 100 percent of the volume or weight declared on the label (with the exception of an analytical method-attributable deviation), and whereas naturally occurring dietary ingredients must be present at 80 percent of the declared value" [21, 22]. In our study, we compared the caffeine concentrations of six EDs samples (Azam, Dragon, Kungfu, Mo, Monster, and Power) with the caffeine content listed on the product's label. Five of the examined EDs contained less caffeine than indicated on the product label. However, the Mo energy drink contained approximately 1.60 times the amount of caffeine as indicated on the product label. This study's findings are comparable in some ways to those reported by Consumer Reports [23]; which examined the caffeine content of 16 energy drinks and found that 10 of the samples had values within 20% of the actual numbers listed on the label, while 5 of the product samples had caffeine amounts greater than 20% above what was indicated on the label, and 1 product had caffeine amounts 70% below what was indicated on the label. Similar research [24] revealed that the majority (89%) of the EDs samples they analyzed contained caffeine within 20% of the labeled amounts. A study [20] found that 100 ml of EDs contains between 80 and 242 mg of caffeine, which is equivalent to consuming eight cups of strong coffee per day, thereby increasing the risk of toxicity and disrupting the overall health structure.

Table 3: Results on caffeine contents samples (beverages) analyzed in duplicate (S1 and S2) during a study to assess energy drink consumption rate, knowledge, and perceived side effects among long-distance car drivers in Morogoro municipality, Morogoro, Tanzania, 2018-2019.

S/N	Samples	Volume (ml)	Extraction vol.	Anal. vol.	ABS	Conc. (mg/L)	Av. conc. (mg/L)	Conc. (mg/100 ml)	Av. conc. (mg/100 ml)	Caffeine content (mg/100 ml)
1	Dragon S1	1	100	1	3.105	298.7	299.3	29.87	29.33	30.1
		1	100	1	3.117	299.9		29.99		
	Dragon S2	1	100	1	3.206	308.8	303.55	30.88	30.355	
		1	100	1	3.101	298.3		29.83		
2	Azam energy drink S1	1	100	1	2.952	283.4	283.95	28.34	28.395	28.4
		1	100	1	2.963	283.5		28.45		
	Azam energy drink S2	1	100	1	2.965	283.4	284.2	28.34	28.42	
		1	100	1	2.968	285		28.5		
3	Monster energy S1	1	100	1	2.966	284.8	284.6	28.48	28.46	28.5
		1	100	1	2.962	284.4		28.44		
	Monster energy S2	1	100	1	2.971	285.3	285.2	28.53	28.52	
		1	100	1	2.969	285.1		28.51		
4	Mo energy S1	1	100	1	2.938	282	281.4	28.2	28.14	28.1
		1	100	1	2.926	280.8		28.08		
	Mo energy S2	1	100	1	2.931	281.3	281.4	28.13	28.14	
		1	100	1	2.933	281.5		28.15		
5	Power energy S1	1	100	1	2.932	281.4	279.9	28.14	27.99	28.0
		1	100	1	2.902	278.4		27.84		
	Power energy S2	1	100	1	2.911	279.3	279.8	27.93	27.98	
		1	100	1	2.921	280.3		28.03		
6	Kungfu 1	1	100	1	2.926	280.8	280.9	28.08	28.09	28.1
		1	100	1	2.928	281		28.1		
	Kungfu 2	1	100	1	2.922	280.4	280.4	28.04	28.04	
		1	100	1	2.922	280.4		28.04		

Table 4: Caffeine concentration per serving for various energy drinks according to their package labels.

S/N	Energy drink brand	Total volume per serving (ml)	Caffeine concentration as per product label (mg/100 ml)	Caffeine content per serving
1	Monster energy drink	500	32	160 mg/500 ml
2	Dragon energy drink	500	30	150 mg/300 ml
3	Kungfu energy drink	500	30	150 mg/400 ml
4	Power energy drink	400	30	120 mg/500 ml
5	Azam energy drink	300	90	120 mg/400 ml
6	Mo energy drink	400	17.6	(mg/500 ml)

Table 5: Laboratory results for the caffeine content of the beverage samples and the published caffeine content according to the manufacturer's package label Morogoro municipality, Morogoro, Tanzania, 2018-2019.

S/N	Energy drink brand	Caffeine content as per lab results (mg/100 ml)	Caffeine content declared by the manufacturer on the package label (mg/100 ml)
1	Dragon energy drink	30.1	30
2	Monster energy drink	28.5	32
3	Azam energy drink	28.4	30
4	Mo energy drink	28.1	17.6
5	Kungfu energy drink	28.1	30
6	Power energy drink	28.0	30

5. Conclusion

Manufacturers should accurately label the caffeine concentration on their energy drink products, and consumers are advised to use the recommended amount of caffeine in order to avoid adverse health effects that may result from excessive consumption. Additionally, consumers should avoid energy drink products that do not adhere to the caffeine concentration indicated on the package label.

5.1. Recommendations. The government and responsible agencies should take the necessary steps to ensure that all energy drinks sold in the United States contain the recommended amount of caffeine, which will be specified on the packaging label, in order to reduce the risk of caffeine-related side effects.

Data Availability

All data generated or analyzed during this study are included in this published article.

Conflicts of Interest

There are no conflicts of interest declared by the authors.

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References

[1] C. J. Reissig, E. C. Strain, and R. R. Griffiths, "caffeinated energy drinks: a growing problem," *Drug and Alcohol Dependence*, vol. 99, 2009.

[2] J. Barbara, C. Piotr, W. Ewelina, S. Patryk, and C. Piotr, "Energy drink consumption and awareness among medical university of lublin students," *Current Issues in Pharmacy and Medical*, vol. 29, no. 4, pp. 190–194, 2016.

[3] K. E. Miller, "Wired energy drinks: athlete identity, masculine norms, and risk-taking," *American College Health Journal*, vol. 256, no. 5, Article ID 481489, 2008.

[4] The Center for Science and the Environment, "The amount of caffeine in energy drinks," 2011, https://cdn.cseindia.org/attachments/0.76847600/1505198579.PMLreport caffeine content.in energy.drinks.pdf.

[5] India's Food Safety and Standards Authority, "Regulatory proposals for energy drinks and caffeine (revised)," 2010, https://www.fssai.gov.in/portals/o/energy-drink-standards.pdf.

[6] M. A. Heckman, J. Weil, and E. G. Mejia, "Caffeine (1,3,7,-trimethylxanthine) in food: an exhaustive review of consumption, functionality, safety, and regulatory issues," *Food Science*, vol. 75, 2010.

[7] C. L. Lesson, M. G. Ma, and S. M. Bryson, "Clinical toxicology," *Journal of Toxicology*, vol. 26, no. 5, pp. 407–415, 1988.

[8] J. B. Joo, H. W. Stephen, E. Ricardo et al., "Energy drink consumption in Europe: a review of the risks, negative health effects, and policy responses," *Journal of the Frontiers of Public Health*, vol. 2, p. 134, 2014.

[9] Who Basic Analytical Toxicology, "The world health organization," 2005, https://www.who.int/ipcs/publications/training poisons/basic analytical tox/en/index.html.

[10] J. E. James, "Maternal caffeine consumption and pregnancy outcomes: A narrative review with implications for advice to mothers and mothers-to-be. BMJ Evidence-Based Medicine," vol. 26, no. 3, pp. 114-115, 2021.

[11] T. M. McLellan, J. A. Caldwell, and H. R. Lieberman, "A review of caffeine's effects on cognitive," *physical and occupational performance. Neuroscience & Biobehavioral Reviews*, vol. 71, pp. 294–312, 2016.

[12] S. Dikici, A. Saritas, F. H. Besir, A. H. Tasci, and H. Kandis, "Do energy drinks cause epileptic seizures and ischemic strokes?" *The American Journal of Emergency Medicine*, vol. 31, no. 1, p. 274, 2013.

[13] W. F. Chiang, C. J. Liao, Cheng, and S. H. Lin, "Rhabdomyolysis is brought on by excessive coffee consumption," *Human Experimental Toxicology Journal*, vol. 33, 2013.

[14] L. E. Armstrong, D. J. Casa, C. M. Maresh, and M. S. Ganio, "Caffeine, fluid-electrolyte balance, temperature regulation, and tolerance to exercise-induced heat," *Exercise and Sport Sciences Reviews*, vol. 35, no. 3, pp. 135–140, 2007.

[15] T. Hew-Butler, J. G. Verbalis, and T. D. Noakes, "Updated fluid recommendation: international marathon medical directors association position statement (IMMDA)," *Clinical Journal of Sport Medicine*, vol. 16, no. 4, pp. 283–292, 2006.

[16] A. Hasselkvist and A. K. Johansson, "Dental erosion and consumption of soft drinks among Swedish children and adolescents, as well as the development of a simplified erosion partial recording system," *Sweden's Dental Journal*, vol. 34, no. 4, pp. 187–195, 2010.

[17] H. Li, Y. Zou, and G. Ding, "A meta-analysis of dietary factors associated with dental erosion," *PLoS One*, vol. 7, no. 8, Article ID e42626, 2012.

[18] M. B. Vos and J. E. Lavine, "Fructose in the diet and non-alcoholic fatty liver disease," *Hepatology*, vol. 57, no. 6, pp. 2525–2531, 2013.

[19] K. S. Rashid, "Energy drink Consumption Rate," *Knowledge and Perceived Side Effects Among Long Distance Car Drives in Morogoro Municipality Tanzania*, 2019.

[20] R. R. McCusker, B. A. Goldberger, and E. J. Cone, "Energy drinks, carbonated beverages, and other beverages' caffeine content," *Journal of Analytical Toxicology*, vol. 30, no. 2, pp. 112–114, 2006.

[21] N. Alwan, S. Boylan, J. E. Cade et al., "Caffeine consumption during pregnancy has been linked to late miscarriage and stillbirth," *European Journal of Epidemiology*, vol. 25, no. 4, pp. 275–280, 2010.

[22] Chapter IV of the US, "Food and drug administration's dietary supplement labeling guide: nutrition labeling," 2005, https://www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/dietary supplements/ucm070597.htm.

[23] Consumer Reports Magazine, "Caffeine in energy drinks. consumer reports," 2012, https://www.consumerreports.org/cro/magazine/2012/12/the-buzzon-energy-drink-caffeine/index.htm.

[24] K. W. Andrews, A. Schweitzer, and C. Zhao, "The caffeine content of commonly purchased dietary supplements in the United States: an analysis of 53 products containing caffeine-containing ingredients," *Analytical and Bioanalytical Chemistry*, vol. 389, no. 1, pp. 231–239, 2007.