

ENERGY DRINK LABELING: SHOULD WE BE CONCERNED?

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Abstract

The consumption of energy drinks among young people, particularly young adolescents, over the last ten years is constantly increasing, along with even greater demands of the European market regarding labeling. There are warning signs about the harmful effects of energy drinks, leaving an open question of labeling control, and consequently, average daily intake of specific components such as caffeine which can be harmful especially for vulnerable groups. The aim of this study was to compare labeled and measured caffeine values of energy drinks available on the market in the Osijek-Baranja County, Eastern Croatia.

During February 2018, a cross-sectional study was conducted in order to determine the caffeine content in 48 commercially available energy drinks in the Osijek-Baranja County, Eastern Croatia using the high-performance liquid chromatography with diode array detector method.

The study revealed that from nine brands of energy drinks, seven of them had small deviation of declared caffeine value (5 - 10%), and two of them had deviation bigger than 10%. Concentration of caffeine, higher than labeled, was determined in 18.8% samples (5 - 10% deviation). For 68.8% samples caffeine content was within a 5% deviation value.

Today, consumers increasingly want to be informed about the food they consume. Products intended for special purpose, such as energy drinks, contain substances such as caffeine, whose daily intake should be controlled due to its possible adverse health effects; therefore, the accuracy of labeling such products is extremely relevant.

Key words: Energy drinks, Labeling, Caffeine, Young people, Health.

1. Introduction

Consumption of energy drinks (EDs) worldwide today is increasing and therefore becoming a growing problem together with public health concern [1, 2]. The production of EDs has grown extremely during the past 20 years and there are doubts how loose regulations of labeling and marketing those products are a trigger for enlarged consumption. This increase is disturbing due to various adverse effects they can cause. Researchers and policy makers should therefore constantly monitor and assess this issue [3]. Promotion, lower price and availability of the product have affected the increase in EDs production [4]. Those non-alcoholic drinks have high caffeine content and are marketed as stimulants for improving energy, performance, mental alertness and relieving fatigue. EDs differ from sport or isotonic drinks, which have carbohydrates and electrolytes as major components, and are intended for athlete rehydration [5], although many athletes take EDs specifically for previously mentioned reasons. EDs are also classified as sugar-sweetened beverages due to which they could be connected with obesity in children and adults and dental erosions [5, 6]. Due to concerns about sugar, some manufacturers have developed variations of non-sugar EDs. Still, no measures were taken regarding the caffeine share in EDs [5]. EDs are beverages that contain stimulants, predominantly caffeine, taurine, guarana and ginseng, that are marked as a provider of energy for improving physical activities and mental alertness [7].

1,3,7-trimethylxanthine known also as caffeine, is a substance naturally found in leaves, beans and fruits of various plants [8]. This bitter compound is consumed worldwide on a daily basis whether through soft drinks, coffee or chocolate [9]. The main active ingredient in EDs is also caffeine and those drinks are widely used. Its reasonable consumption is believed to be safe. Promotion of EDs generally binds up for high caffeine content which manufacturers are not obligated to report on labels [2]. Caffeine is also an ingredient of many popular foods, drinks and medicines. In small, moderate doses it can stimulate nervous system, enhance stamina and concentration in adults. Larger intakes, on the contrary, can cause agitation, anxiety, insomnia, arrhythmias and gastrointestinal problems. The European Food Safety Authority (EFSA) advised how caffeine dose of 200 mg (for a 70 kg adult) and common consumption up to 400 mg per day is not concerning. One energy drink (ED) could contain as much as two cups of coffee [5].

Literature mainly indicates negative health effects of EDs overcoming the beneficial ones [3]. The young population is vulnerable and the most threatened. The childhood and adolescence are important periods of brain development and accelerated growth, so the large consumption of EDs in this period of life is not recommended [5]. EDs are functional beverages and designed for adults. Having in mind that children have lower body weight they have reduced acceptance to caffeine [10]. Products that contain caffeine are inconsistently regulated, do not protect consumers and need modification. This mainly refers to foods and beverages that are not required to include caffeine on the product declaration. Enhanced regulation would definitely prevent side effects associated with caffeine consumption for targeted vulnerable groups [11]. Some authors point how EDs regulation together with labeling content and health warnings vary across countries, with the most tax regulatory in the largest market of EDs, the US market. They even compare effect of EDs on athletic performance not far from nonmedical use of anabolic steroids or some other pharmaceutical stimulants [12]. Consumers are interested in how much caffeine contains product they consume. Extreme caffeine consumption presents certain risks for people with specific diagnoses. For example, kidney patients should avoid electrolytic shifts because it is known how caffeinated drinks cause potassium shifts. Due to interfering insulin sensitivity, caffeine could worsen hyperglycemia in diabetics, so it's recommended for those patients to know amount of caffeine they consume. Children are more susceptible to caffeine than adults. According to the American Academy of Pediatrics, children and adolescents shouldn't intake more than 100 mg of caffeine per day. Energy drink sometimes has twice as much [11]. In adolescents, caffeine is a very popular ingredient due to its health effects such

as vigilance, increased concentration and decrease in tiredness. Also, the recommended caffeine intake for women with a desire to conceive a child is less than 300 mg per day. Pregnant women are suggested not to drink more than two cups of coffee or four cups of tea per day [8].

Giles *et al.*, investigated the effects of caffeine, taurine and glucose in EDs alone and in combination, discovering that only caffeine itself is likely responsible for changes in cognitive performance after consuming ED, improving executive control and working memory, with also psychomotor performance [13]. Just for a comparison, one can of cola has about 35 mg of caffeine, a cup of coffee has about 100 mg and one can, of ED can exceed over 500 mg of caffeine [14]. Of course, serving size is required on the label, and often, the comparison of caffeine content of ED and the brewed coffee is given on the label as well [15]. It is known for a quite long period of time how coffee can be very addictive due to significant caffeine concentrations [9]. Some authors mention how it's an addictive stimulant, which activates the central nervous system and also works as a mild diuretic. Some countries, such for example Bangladesh have a big problem with no regulations on EDs today, with no strict monitoring system, and without labeling all contained ingredients, what sometimes hides the accurate added concentration to the products. Due to that it's difficult to determine caffeine intake as well as the intake of other additives. Those findings indicate that it's time to take required measurements for well-being of all people because otherwise it would be a catastrophe in sector of public health in not so distant future [7]. European Food Safety Authority (EFSA) recommends 3 mg per kg of body weight per day for children and adolescents, 400 mg per day for adults while for pregnant women maximum daily intake level of caffeine of 200 mg per day. The summarized review on caffeine daily intake in all populations (children, adolescents and adults) over the past decade showed how coffee, tea and soft drinks are the most important caffeine sources and that total daily caffeine intake has remained stable in the period of last 10 - 15 years. The review discusses how natural products containing caffeine often do not have to mark caffeine on product declaration while those products that have added caffeine such as EDs do. They point, if caffeine intake is a concern, consumers should be clearly informed through product labels about those content on a product they consume [16].

Mixing EDs with alcohol is especially popular among student populations, which are found then to be at higher risk for specific harmful incidents. It is also likely for them to drink more heavily when they mix EDs and alcohol. The goal of mixing EDs with alcohol has a dual effect, specifically counterbalancing the sedative alcohol effect with caffeine stimulation effect [17]. Rising

trend of EDs and alcohol mixing among children and adolescents creates a new challenge for public health workers as well as for researchers. Solving this issue includes policy makers to create separate regulations for EDs, with caffeine limits, banning sale and posting guidance on present market of EDs [3]. One survey of student population in the United Kingdom examined reasons for mixing alcohol with EDs. They stated how students predominantly pointed out as the main reason "getting drunk". Also, the mixing is preferred during special occasions as for loosen up in groups [18]. Turel, claims that health professionals together with legislators and families should work on reduction of the sale of EDs to people under the age of 18 which will reduce EDs consumption and consequently the caffeine intake. He points that risk of EDs is in high caffeine intake at once [19]. Hammond, Reid and Zukowski mentioned how ingestion of EDs with alcohol and other stimulants may increase caffeine effects [20]. Temple, Ziegler and Epstein showed with their experimental convenience store how regardless of age, purchasers are all sensitive to price, while only younger ones are interested in labels on EDs [21].

The aim of this study was to compare the labeled caffeine concentrations of commercially available EDs with actual, measured concentrations and to explore possible differences between labeled and measured caffeine concentrations in EDs according to brand, price, volume and energy content.

2. Materials and Methods

48 commercially available energy drinks were purchased in the five largest supermarkets in Osijek Baranja County, Eastern Croatia during February 2018.

A couple of milliliters from each collected ED was transferred individually into 10mL vial afterwards the sample was appropriately marked. Prior to analysis, the samples were degassed on the ultrasonic bath ELMA, Elmasonic P 120 H for ten minutes and filtered through a 0.2 μm syringe filter. The prepared samples were transferred to smaller 1.5 mL vials for the analysis.

Identification and quantification of caffeine content in ED was done according to Alves *et al.*, [22], with slight modifications. Analysis was performed on reverse-phase High Performance Liquid Chromatography Infinity 1260 Agilent Technologies (USA) using diode array detector - DAD. The instrument configuration had a Vialsampler G7129A, Quaternary Pump G7111B and Detector DAD G7117C. A Zorbax C18 column that was used was 150 mm x 4.6 mm and packed with 5 μm diameter particles. Gradient mobile phase of 1% formic acid and acetonitrile (95 : 5) was used, with flow set to 1ml/min and run time of 13 minutes. Temperature of the column was set to 30 °C. In the beginning, mobile

phase was set to 1% formic acid and acetonitrile (95 : 5) for 9 min. after which was (20 : 80). In the end, up till 13 minutes it was again set to starting conditions. Injection volume was 20 μL and the wavelength was 276 nm. Five different calibration standard concentrations were prepared from the caffeine stock solution which was in the measurement range. Correlation factor of calibration curve was 0.999 respectively. Limit of the detection (LOD) was calculated to be 3.97 mg/L and limit of the quantification (LOQ) 12.04 mg/L, respectively. The analysis was conducted in three replications. All solvents for the analysis were of analytical grade and purchased from J. T. Baker (PA, USA). Caffeine standard was purchased from Dr. Ehrenstorfer GmbH, lot br. G130131, weight and diluted in water.

Upon confirming normality of data distribution with a Kolmogorov-Smirnov test, all data were processed by the methods of descriptive statistics. The numerical variables were described as the mean and standard deviations. The Mann-Whitney U test and Kruskal-Wallis test were used for the comparison of numerical variables among the groups. The categorical variables were described in absolute and relative frequencies. The level of statistical significance was set at $p < 0.05$. Statistical analysis was done using the Statistica for Windows 2010 statistical package (version 10.0, Stat-Soft Inc., Tulsa, OK).

3. Results and Discussion

There were nine brands of commercially available EDs found on the Osijek Baranja market during February 2018. According to the sugar content, 16.66% (8/48) were labeled as "zero free" or "sugar free" EDs, and 83.33% (40/48) were labeled as "containing sugar" EDs. Considering the price, 33.33% (16/48) were in the high price class, 20.83% (10/48) were in the medium price class while most of them, 45.834% (22/48) belonged to low price class EDs. According to the volume, 70.83% (34/48) were smaller volume EDs (250 and 355 mL) while 29.16% (14/48) were bigger volume EDs (500 and 1000 mL). Considering the energy value there were 18.75% (9/48) of EDs with lower energy value (2 - 19kcal) and 81.25% (39/48) of EDs with higher energy value (44 - 66kcal).

All samples of EDs were imported from another country (Netherlands, Poland, Germany, Serbia, Hungary and United Kingdom, respectively). By observing the labels of those tested EDs samples, we should point out how labels of every specific ED had "high caffeine content" highlighted, together with the warning that it's not recommended for children, pregnant women and women who are breast-feeding. Some EDs brands (brand No. 7, specifically), has even stated how consuming large amounts of ED combined with intense exercise or alcohol consumption cannot exclude

negative effects, while other one (brand No. 1, specifically, but not every sample, and brand No. 3) stated how balanced and various nutrition habits and healthy way of life are of exceptional importance. They even recommend to “consume responsibly”. Also, they point out how the drink is not recommended for people who are caffeine sensitive and that it’s not allowed to mix ED with alcohol. Brand No. 8 for instance, on their labels compares caffeine content of one can with espresso coffee (one or one and a half cup of espresso, depending on caffeine content in the can). It is also mentioned how it’s not advisable to drink more than one can per day. Brand No. 1 on the other hand, in some of his labels explicitly states that the maximum daily intake of that specific ED is 500 mL (what is one can for that brand, specifically).

Brand No. 4, has a good advertisement on its label, regardless of the type, which says “vitalizes body and mind” together with note “appreciated among the top sportspersons, students and anyone who performs demanding jobs as well as long driving”. They also point that this ED should be moderately consumed.

Among other ingredients on product declarations except caffeine (content presented in Table 1), there

were: water, sugar, carbon dioxide, taurine, natural or artificial flavorings, dyes, inositol, vitamins (niacin, pantothenic acid, B6 and B12 mostly), acidity regulators, antioxidants, and other (depending on the taste, different concentrates of juices, various extracts etc.). If it was “sugar free” ED type, instead of sugars, there were artificial sweeteners added (most common were acesulfame K, aspartame and sucralose).

Results presented in Table 1 show that from nine brands of tested EDs, only three brands had small deviations (< 5 mg/L) between labeled and measured caffeine concentration while two brands had deviations between 5 and 10 mg/L. Also three brands had deviations bigger than 10 mg/L, leaving one brand with deviation from 30.440 mg/L, respectively, which is the biggest deviation in this study and exceeding labeled value. The mean measured caffeine concentration for all brands in this study was 322.718 mg/L.

Table 2 shows that there was statistically significant difference in labeled and measured mean caffeine values of EDs considering “zero free” or “sugar free” EDs and in those “containing sugar” ($p = 0.024$).

Results point to slight deviation in both groups considering that in group 1, “zero or sugar free” the mean

Table 1. Caffeine content in commercially available energy drinks in the Osijek-Baranja County during February 2018

Brand	Number of samples	Medium volume (mL)	Labeled mean caffeine value (mg/L)	Measured mean caffeine value (mg/L)	Deviation from labeled value (mg/L)
1	7	500.000	314.286	304.952 ± 0.323	-9.334
2	2	355.000	320.000	333.272 ± 0.235	13.272
3	3	500.000	300.000	330.440 ± 0.506	30.440
4	4	276.250	320.000	317.802 ± 0.365	-2.198
5	3	250.000	320.000	303.673 ± 0.609	-16.327
6	9	277.780	313.333	314.159 ± 0.426	0.825
7	11	386.360	300.000	302.425 ± 0.381	2.425
8	7	250.000	356.571	363.392 ± 0.546	6.821
9	2	375.000	320.000	334.343±0.646	14.343

Table 2. Differences in measured and labeled caffeine concentrations between groups of energy drinks considering product label

Group of energy drinks considering product label	Number of samples (%)	Labeled mean caffeine value (mg/L)	Measured mean caffeine value (mg/L)	p*
Group 1 (labeled as “zero free” or “sugar free”)	8 (16.667)	310.000	304.179	0.024
Group 2 (labeled “contains sugars”)	40 (83.333)	318.900	322.697	

Legend: *Mann-Whitney U test.

caffeine concentrations were lower than labeled, while in group 2 those “containing sugars” were slightly higher than labeled.

Measured and labeled caffeine concentrations between groups of energy drinks considering product price are presented in Table 3.

Table 3 shows also statistically significant difference in measured and labeled caffeine concentrations between groups of EDs considering product price ($p = 0.024$) where EDs from medium price class appeared to have the lowest deviation from labeled caffeine value while low and high price class both had higher measured caffeine values than labeled.

Results regarding measured and labeled caffeine concentrations between EDs considering product volume are presented in Table 4.

Opposed to previously mentioned results, Table 4 shows that there was no statistically significant difference in measured and labeled caffeine concentrations between EDs considering product volume ($p = 0.212$), although the measured values were slightly higher for both smaller and bigger volume EDs.

Measured and labeled caffeine concentrations considering product declared energy values are shown in Table 5.

Table 5 shows statistically significant difference ($p = 0.009$) in measured and labeled caffeine concentrations considering product declared energy values. Those EDs with lower energy values showed lower mean caffeine concentration while EDs with higher energy values revealed slightly higher measured caffeine concentrations compared to labeled values.

This work is consistent with the study of Attipoe, *et al.*, [23], who also examined caffeine concentrations in nine EDs together with other ingredients listed and found how the caffeine amounts of tested EDs were within $\pm 15\%$ and that these results do not meet FDA guidelines. They also found how beverages which haven’t listed caffeine amounts on their labels consistently had higher amounts of caffeine than those who listed their values. Srđenović *et al.*, [24], also found a strong correlation between the declared and determined values of caffeine in four selected EDs and stated how all samples were in the confidence interval of 95%. Ballus *et al.*, [25], examined caffeine concentrations from seven

Table 3. Differences in measured and labeled caffeine concentrations between groups of energy drinks considering product price

Group of energy drinks considering product price	Number of samples (%)	Labeled mean caffeine value (mg/L)	Measured mean caffeine value (mg/L)	p^*
Group 1 (high price class)	16 (33.333)	313.750	316.483	0.024
Group 2 (medium price class)	10 (20.833)	345.600	345.477	
Group 3 (low price class)	22 (45.834)	307.273	310.127	

*Kruskal Wallis test.

Table 4. Differences in measured and labeled caffeine concentrations between groups of energy drinks considering product volume

Group of energy drinks considering product volume	Number of samples (%)	Labeled mean caffeine value (mg/L)	Measured mean caffeine value (mg/L)	p^*
Group 1 (smaller volume; between 250 and 355 mL)	34 (70.833)	320.471	322.960	0.212
Group 2 (bigger volume; between 500 and 1000 mL)	14 (29.167)	310.000	311.476	

*Mann-Whitney U test.

Table 5. Differences in measured and labeled caffeine concentrations between groups of energy drinks considering product declared energy value

Group of energy drinks considering product declared energy value (on 100mL)	Number of samples (%)	Labeled mean caffeine value (mg/L)	Measured mean caffeine value (mg/L)	p^*
Group 1 (lower energy value; 2 - 19 kcal)	9 (18.750)	311.111	303.897	0.009
Group 2 (higher energy value; 44 - 66 kcal)	39 (81.250)	318.872	323.236	

*Mann-Whitney U test.

brands of EDs and found three of them to be statistically different among the batches (95% confidence). They explained that the reason might be the possibility of fault in the quality control of caffeine addition during processing of ED as a formulated product. Only two brands were in agreement with the labeled amounts. In this study, 72% (15/21) of EDs samples had lower caffeine content than labeled what was in disagreement with the Brazilian Health Regulatory Agency (Agência Nacional de Vigilância Sanitária - ANVISA) regulations since the caffeine amount in EDs must agree with the labeled value and with 20% variation admitted for other components. Other study [26], investigated caffeine in three EDs available in Sudanese local markets and gained average caffeine concentration of 255.4 mg/L but didn't specify the comparison with declaration of the products. Keaver *et al.*, [27], examined labeled caffeine and sugar content, price and volume of available EDs in Ireland during 2015 and discovered how mean caffeine content of EDs was 307 mg/L what is slightly lower mean value than in this study. In study conducted in Ireland, 75.64% (59/78) of EDs were full sugar/regular while 24.35% (19/78) were diet/light/sugar-free. The mean sugar content in all their EDs samples was 10.6 g/100 mL with minimum of 2.9 and maximum of 15.6 g/100 mL. They stated how the package size, which ranged from 250 to 500 mL, had a significant impact on the caffeine and sugar content. Rudolph *et al.*, [28], examined different caffeine-containing products including 21 EDs also by HPLC and found how measured caffeine values had considerably lower variations with average caffeine concentration of 303 mg/L. One other study [29] investigated four EDs on local market in Pakistan and discovered 299.91 mg/L to be the mean caffeine value and that 50% of samples had lower caffeine values than labeled (76,96%, 80,13%), one sample was exceeding labeled value (113%) while one was consistent to labeled caffeine value (99,98%). Ayala *et al.*, [30], compared labeled caffeine with measured values in 11 EDs. The mean caffeine concentration was 357,182 mg/L what is higher mean caffeine concentration than in this study. They revealed how the beverages tested in that study had considerably higher values while one brand gave excellent agreement with declaration. Prasad Rai *et al.*, [31], examined 10 EDs in Nepalese market and found measured caffeine values from not detected to 357.8 mg/L and stated how only 60% of tested samples had caffeine content as per claimed on label. Nour *et al.*, [32], discovered mean caffeine concentration of 10 EDs on Romanian market to be 309.600 mg/L and based on their analytical data caffeine levels were within or significantly lower than the maximum authorized levels. Sanchez [33], investigated methylxanthine concentrations in different foods and beverages, caffeine, theobromine and theophylline respectively. He concluded that caffeine was predominantly found methylxanthine in the samples.

Investigated samples showed caffeine content similar as espresso coffees. In 23 samples of EDs from four brands, labeled caffeine content was 320 mg/L what is consistent to our study, and the results showed that there were no significant differences between measured and labeled caffeine concentrations when all samples were analyzed together. However, when analyzing each brand separately, it was showed that three of them did not yield any significant difference while one of them had significantly higher caffeine content than declared. Sanchez pointed that this similarity in caffeine content implies how this substance was artificially added to the samples. McCusker, *et al.*, [34] gained 271.730 mg/L for "containing sugar" of one ED and 263.59 mg/L for sugar free EDs of the same brand, what is consistent with this study (lower mean caffeine concentration in sugar free and zero sugar group of EDs). In that time there was no caffeine content on labels so the values couldn't be compared.

4. Conclusions

- Eastern Croatian market has a great variety of different ED products. Considering the obtained results for examined EDs, we can generally conclude that labels of those EDs are sufficient, thorough with giving enough details. The caffeine concentrations were listed on all cans of tested EDs and were predominantly consistent with the labeling values, with also some other ingredients expressed. All cans had "high levels of caffeine" listed on labels with required caution. Some of them had even noted maximum or recommended intake. A few EDs had no warning concerning the ED mix with alcohol.
- Considering the health hazards due to high concentration of caffeine, and also the mix of ED and alcohol, we can highlight how labels clearly state and alert to them with accurate values regarding caffeine concentrations. Today, consumers increasingly want to be informed about the food they consume. Products intended for special purpose, such as EDs, contain substances such as caffeine, whose daily intake should be controlled due to its possible adverse health effects; therefore, the accuracy of labeling such products is extremely relevant. The decision remains on consumers how much EDs will they consume. It would certainly be advisable for them to read products labels before consuming specific products like EDs.
- We also recommend further research based on population surveys, especially in vulnerable populations such as young people, to get better insight OF the consumption patterns of EDs that will enable better regulation of the usage of these products in all potentially vulnerable populations.

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5. References

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