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Full Length Research Paper

Quantitative estimation of the caffeine content in some energy drinks on the Ghanaian market

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The consumption patterns of energy drinks in the Tema Municipality of the Greater-Accra region of Ghana were investigated via a cross sectional survey and the caffeine contents of these energy drinks were determined by iodimetry. The survey showed that more males than females consume energy drinks. Five types of energy drinks; Lucozade (LU), Rush (RU), Red Bull (RB), Five Star (FS) and Monster (MT) were revealed. MT was not available on the market at the time of the survey. RU was the most consumed whereas RB was the least consumed. LU had a higher consumption rate than FS. The energy drinks were normally taken for enhanced performance. The caffeine contents of the various brands of energy drinks were as follows: LU- 0.192 mg/ml, RU- 0.245 mg/ml, FS- 0.139 mg/ml and RB- 0.089 mg/ml. Most of the correspondents (148 out of 156) consumed one to three cans or bottles of energy drinks per day and this led to an intake of caffeine which was less than the recommended daily allowance of 400 mg. Some, however, ingested more than 400 mg and experienced some side effects.

Key words: Energy drinks, caffeine, cross sectional survey, iodimetry.

INTRODUCTION

Caffeine is one of the most extensively studied ingredients available in food and food supplements that has garnered a lot of interest over the centuries. Although a lot of information and knowledge have been gathered over the years on the safe consumption of caffeine in foods and beverages, there are still misperceptions and questions regarding its potential health effects (International Food Information Council Foundation, 2007).

Caffeine is a white and bitter crystalline compound and is chemically called 1, 3, 7- trimethyl xanthine. It can also be called a theine, mateine, guaranine, or methyl theobromine (Agyemang-Yeboah and Oppong, 2013). Caffeine can be obtained naturally from many plant sources like coffee, tea leaves, yerba mate, cola nuts, cocoa and guanara. Though the main source of caffeine may vary globally, coffee and tea are usually the main sources (Nonthakaew et al., 2015; Heckman et al., 2010). It may also be obtained from beverages like soft drinks and energy drinks that are made with synthetic caffeine to promote arousal, alertness, energy and elevated mood (Temple et al., 2017).

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Whether in the natural or synthetic form, caffeine produces the same effects of increased alertness, energy and arousal (Smith, 2002). A lot of people have the misconception that, when caffeine is added to a medication, the negative effects are eliminated or the duration of those negative effects are considerably shortened. It is the most ingested psychoactive substance but unlike other psychoactive substances, caffeine intake is legal. Due to its popularity, it has been the subject of a lot of research (Meredith et al., 2013).

Caffeine is a central nervous stimulant that works mainly by blocking adenosine receptors in the brain (Addicott et al., 2009). Adenosine is understood to cause drowsiness and by blocking its effects, caffeine keeps the body and brain active and prevents sleep (Lodato et al., 2013).

Medically, caffeine is added to some analgesics to enhance their effects and it is also used to treat apnea in infants. It is known also to possess diuretic activity when administered in controlled amounts to people who lack tolerance for it. People with heart problems are advised against taking caffeine because it increases heart rate. It can also cause heart burns because it increases gastric acid production (Hodgson et al., 2013). Taken in high amounts, caffeine can also cause insomnia, tremors, nervousness and headaches (Smith, 2002).

In Ghana, drivers and conductors of commercial buses, students, artisans and traders are high consumers of energy drinks. Advertisements of energy drinks have pervaded both print and electronic media and are partly or fully responsible for the high consumption of energy drinks by people (Buxton and Hagan, 2012).

This research is therefore aimed at investigating the types of energy drinks available in the Tema Municipality of the Greater- Accra region of Ghana, their consumption patterns and caffeine contents with a view to inform and caution consumers as to how much caffeine they ingest following their consumption patterns. The outcome of the study could also inform regulatory agencies to carefully monitor advertisements in print and electronic media and to take measures to ensure that the public are duly informed about the correct intake of these energy drinks to avert health problems. Since most of the energy drinks did not have their caffeine contents stated, the study could further accentuate the need for regulatory agencies to ensure that only energy drinks with their caffeine contents stated should be allowed on the markets so consumers are aware of the amounts of caffeine they ingest when they take these energy drinks. This could go a long way to reduce excessive caffeine consumption in energy drinks.

MATERIALS AND METHODS

Reagents and samples

Sulphuric acid (Daejung Chemicals and Metals Company Limited), iodine, potassium iodide and potassium iodate (all obtained from Fisher Scientific, UK); sodium thiosulphate pentahydrate and starch mucilage powder (both from Qualikems Fine Chemicals. PVT Limited) and distilled water. All the chemicals used were of analytical grade. Four brands of energy drinks - Five Star (FS), Rush (RU), Lucozade (LU) and Red Bull (RB) were assayed for their contents of caffeine.

Instrument

A structured questionnaire with both close ended and open ended questions were used in a cross sectional survey to collect data. The questionnaire was structured to gather information to better explain results of the quantitative assay of caffeine in the energy drinks. The questionnaire was reviewed by the Ethics Committee of Central University which subsequently gave the approval for the research.

Data collection

Prior to the conduct of the actual cross-sectional survey, the questionnaire was tested in a municipality which was similar in many ways to the survey area to enable the necessary modifications and corrections to the questionnaire to be made before the start of the actual work. This pretesting informed the sample size of 200 which was deemed appropriate.

The questionnaires were thus administered to 200 correspondents who were mainly university students, commercial bus drivers and hawkers in the Tema Municipality of the Greater-Accra region, Ghana in March 2017. The data collected revealed five different brands of energy drinks and their consumption patterns. Four were available on the market at the time of the study whereas one, Monster (MT), was not available on the market in the survey area.

Data analysis

Data entry was made using Statistical Package for Social Scientists (SPSS) version 23.0 and descriptive statistic tests were done for the items which were summarized by frequencies and percentages (Buxton and Baguune, 2012).

Assay of energy drinks

The amounts of caffeine in the energy drinks were determined by iodimetric back titration because it is cheap, accurate and can be done routinely. A 25 ml solution of 0.01 M iodine solution was acidified and reacted with caffeine in 25 ml of the energy drink and the excess iodine solution was then titrated against a standard 0.02 M thiosulphate solution using starch as indicator. A blank determination involving only the iodine and thiosulphate solutions was done and the difference between both determinations was used to determine the caffeine content of the energy drinks (Olaniyi and Ogungbamila, 1998). The assay was done in triplicates and the caffeine content in each energy drink was given as the mean and standard deviation.

RESULTS AND DISCUSSION

From the survey, most of the correspondents were from the ages of 21 to 25 yr while correspondents within the ages of 26 to 30 yr were the least (Table 1). Overall, far more males than females took part in the study with the number of males nearly twice the number of females

Table 1. Age groupings of correspondents.

Age group (Yr)	Number of correspondents (n= 200)	Percentage
16-20	43	21.5
21-25	142	71
26-30	3	1.5
31-35	8	4
35 and above	4	2

Table 2. Proportion of males and females who took energy drinks.

Gender	Number surveyed (n = 200)	Number who took energy drinks	Percentage
Male	135	108	80
Female	65	48	73

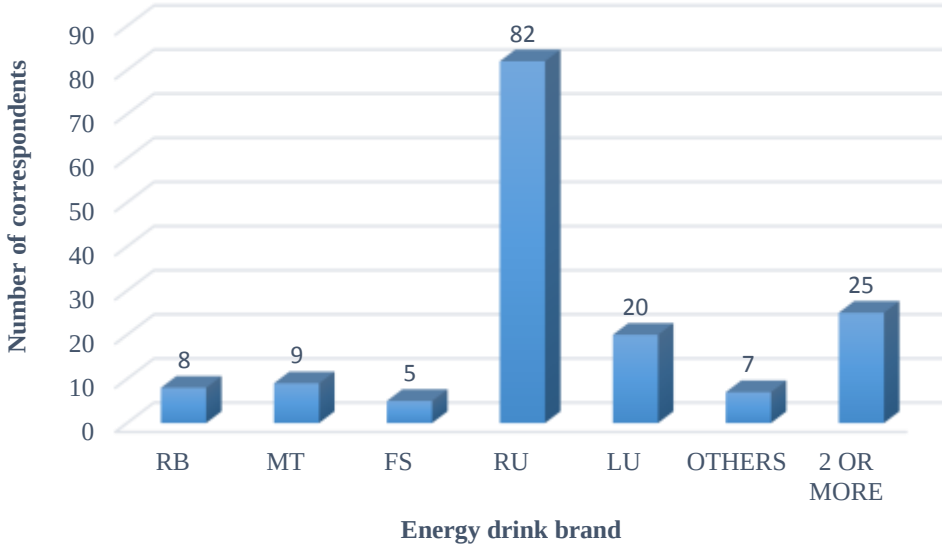

Figure 1. Number of correspondents who took the various brands of energy drinks.

(Table 2).

The research also showed that, 80% (108 out of 135) and 73% (48 out of 65) respectively of male and female correspondents took energy drinks. More males than females took energy drinks probably because of hormonal differences and the fact that males are generally more active than females (Telford et al., 2016; Demura et al., 2013) (Table 2).

The number who took energy drink was expressed as a percentage of the total number of male and female surveyed.

The survey revealed five brands of energy drinks; four (FS, RU, LU and RB) were available on the market and MT, after an extensive and exhaustive search was not found on the markets in the survey area at the time of the survey. RU was the most consumed energy drink while FS was the least consumed. Seven correspondents were taking brands of energy drinks that were not among the list of popular energy drinks provided on the questionnaire and were also not on the market. The consumption patterns of the various brands of energy drinks can be found in Figure 1.

The survey also showed that the correspondents took varying amounts of the energy drinks on a daily basis (Figure 2).

The correspondents also consumed energy drinks at different times. Those correspondents who took energy drinks anytime were the highest number. The figures for those who took it when studying and during work were comparable (32 and 34 respectively) and the smallest number (4) of correspondents took it as a daily snack. Also, 20 correspondents usually took energy drinks at parties and 8 took it before work (Figure 3). Though the consumption patterns differed among correspondents,

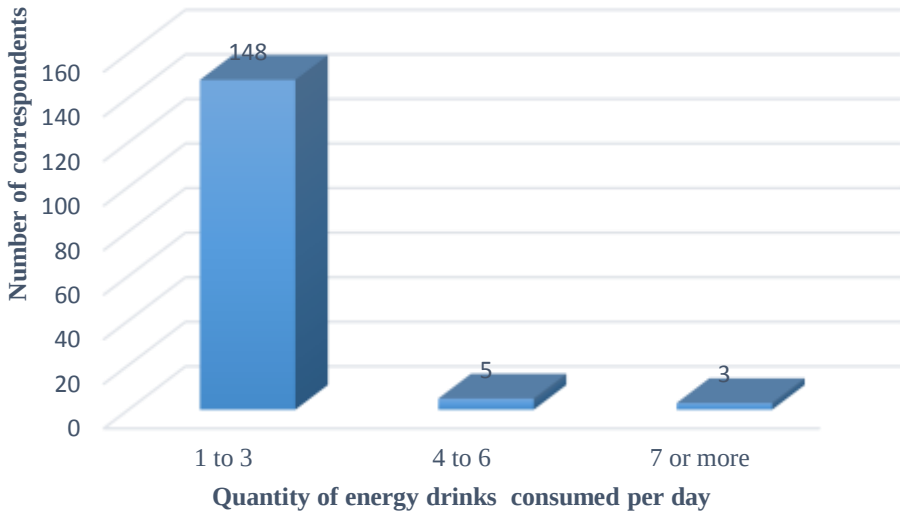

Figure 2. Quantity of energy drinks consumed by correspondents daily.

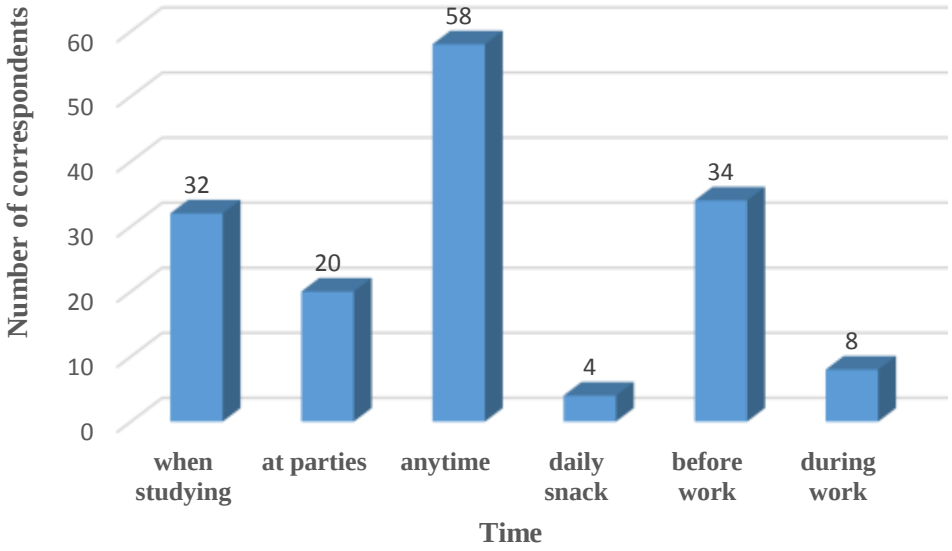

Figure 3. Time of intake of energy drinks by correspondents.

majority (61%) of them took energy drinks for enhanced performance (Figure 4) (Cabezas-Bou et al., 2016). This clearly resonated with data collected elsewhere to show that caffeine is a stimulant
and a performance enhancing drug (Reissig et al., 2009).

The percentages of correspondents who took energy drinks just for the fun of it and for the pleasant taste were similar. This can be attributed to the unchecked and inadequate regulatory control/ oversight of advertisements of caffeinated energy drinks in Ghana (Emond et al., 2015). It could also possibly be due to the addictive nature of caffeine (Pohler, 2010). A small number of correspondents said they took energy drinks for reasons not provided on the questionnaire (Figure 4).

Correspondents were asked if they got their intended benefit(s) or satisfaction after consuming energy drinks and 89 out of 156 (57.1%) who took energy drinks responded in the affirmative. Fourteen said no, 44 (28.2%) did not fully get their satisfaction (somehow) and 9 were not sure (Figure 5). Surely, the energy drinks contained caffeine and the 89 correspondents who had the effects they desired may have taken a lot (about 3 or more cans or bottles) of energy drinks to achieve it. The 44 correspondents who did not fully attain satisfaction may have taken inadequate amounts of the caffeine and therefore did not experience the effects fully. The 9 who were not sure and the 14 who did not get the desired effects may have been taking it for fun or just for the taste

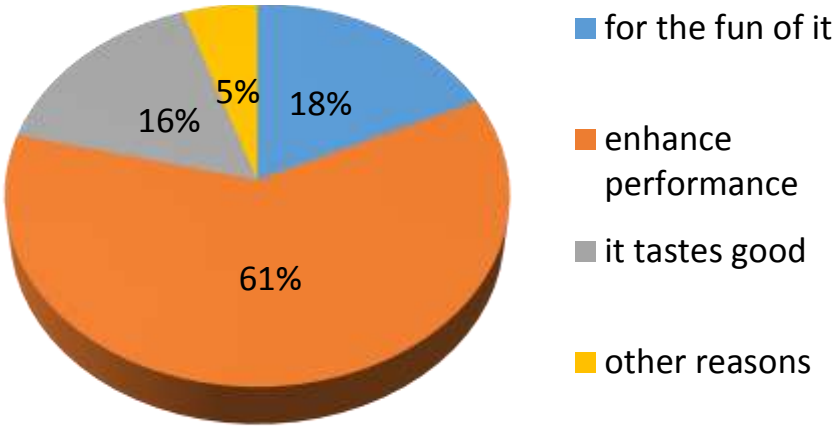

Figure 4. Reasons why correspondents took energy drinks.

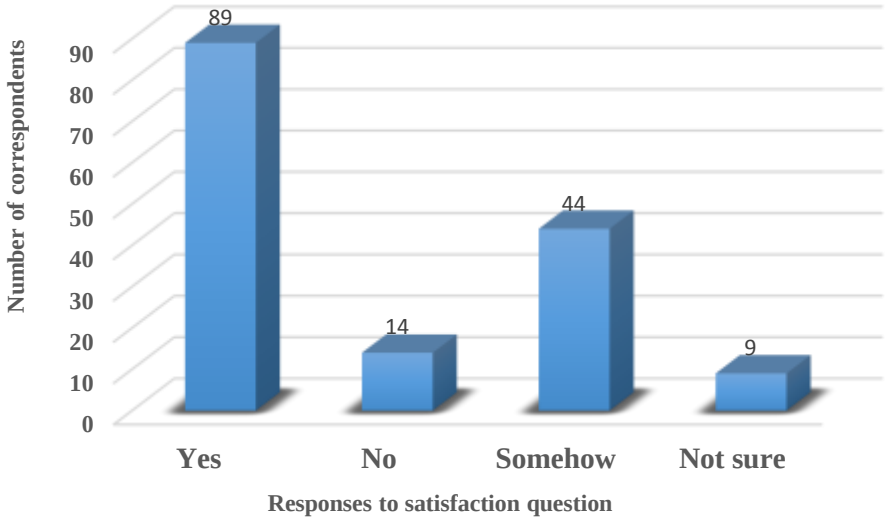

Figure 5. Correspondents' responses to whether they derived the intended benefit/satisfaction after consuming the energy drinks.

and may have not been aware of the effects of caffeine. Furthermore, some of those who responded 'no' could have been taking very small amounts of caffeine in the energy drinks since caffeine effects are dose dependent (Kaplan et al., 1997).

From the study, a total of 86 correspondents experienced one or more side effects when they took caffeine in energy drinks while 70 claimed they did not notice or experience any side effects. Some correspondents experienced two or more side effects and a few others had side effects other than those captured on the questionnaire. A breakdown of caffeine mediated side effects experienced by correspondents is given in Figure 6.

Caffeine mediated side effects are dose dependent (Mohammed et al., 2015). Correspondents who experienced side effects may have been taking more energy drinks than those who did not (Kaplan et al., 1997).

The energy drinks revealed by the survey contained different levels of caffeine and had different volumes per container (Table 3). From the assay results in Table 3, RU had the highest concentration of caffeine (0.245 mg/ml) while RB had the smallest concentration of caffeine (0.089 mg/ml). The amount of caffeine in RU was higher than that in LU. The concentrations of caffeine were given as mg/ml to aid comparison since the amounts of caffeine in the energy drinks assayed were not stated and also because their volumes were different.

Correspondents who took RU were the highest consumers of caffeine and those who took RB were the lowest consumers of caffeine per millilitre (Table 3). The caffeine content in RU was nearly three times that in RB and nearly twice the caffeine amount in FS. The caffeine

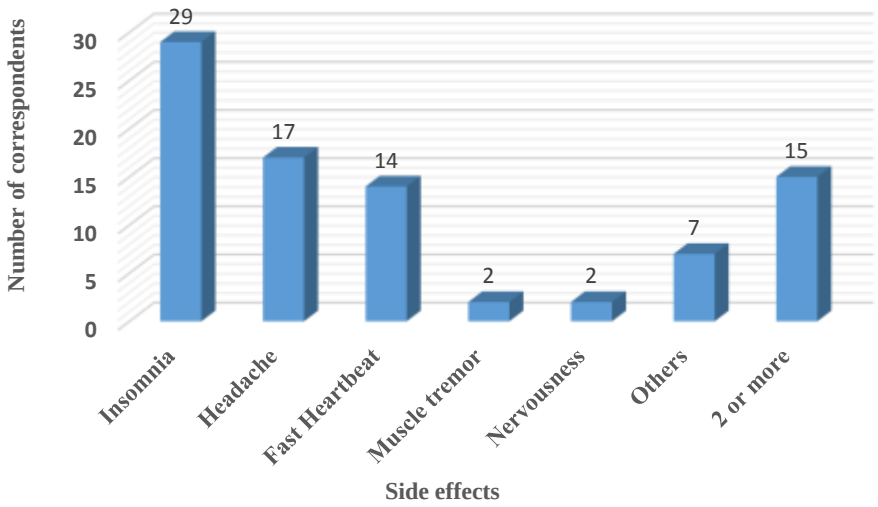

Figure 6. Side effects experienced by correspondents who took energy drinks.

Table 3. Caffeine contents of energy drinks.

Energy drink type	Caffeine content (g/ml)	Caffeine content (mg/ml)
FS (350 ml)	0.000139±0.000	0.139±0.001
RU (350 ml)	0.000245±0.000	0.245±0.001
LU (380 ml)	0.000192±0.000	0.192±0.001
RB (250 ml)	0.000089±0.000	0.089±0.003

Caffeine contents given as mean±SD.

amounts of caffeine in the energy drinks assayed were not stated and also because their volumes were different.

Correspondents who took RU were the highest consumers of caffeine and those who took RB were the lowest consumers of caffeine per millilitre (Table 3). The caffeine content in RU was nearly three times that in RB and nearly twice the caffeine amount in FS. The caffeine content in FS was just a little under twice the caffeine amount in FS whereas that in LU was more than twice the caffeine in RB (Table 3). From Figure 1, 82 correspondents took RU and only 8 took RB. It is therefore possible that most of those who experienced the side effects took RU and those who had little or no side effects took RB. Consuming high amounts of LU could also produce side effects since its caffeine content was relatively high.

Studies show that, caffeine is safe when taken in low to moderate amounts. Generally, the recommended daily intake of caffeine is 300 to 400 mg (Heckman et al., 2010). High doses of caffeine (> 400 mg) may cause unpleasant effects like insomnia, muscle tremors, anxiety, restlessness, increased heart rates and stomach upset (Smith, 2002). From the study, correspondents who were consuming one to three bottles per day of any of the energy drinks assayed were taking the recommended daily dose of caffeine (≤ 400 mg). It can also be seen that since RB had the lowest caffeine content, correspondents who were taking RB were not ingesting too much caffeine and therefore never exceeded the recommended daily allowance. The maximum of 400 mg of caffeine per day would only be exceeded if people took 18 or more cans of RB daily. FS also had a low caffeine content. The limit of caffeine per day would be exceeded if more than 8 cans or bottles of FS were taken a day. The maximum caffeine intake per day 400 mg would be exceeded for RU and LU if more than 4 and 5 cans or bottles were respectively consumed (Table 4).

Since most of the correspondents were consumers of RU and LU (Figure 1), it is possible that most of the side effects experienced were due to excessive intake of RU and LU. To avert this, RU and LU should be taken in low amounts to reduce caffeine ingestion.

Conclusion

A lot of people take energy drinks with more being males than females. The popular brands of energy drinks on the Ghanaian market were just few with Rush energy drink being the most popular and most consumed and Red Bull

Table 4. Estimated caffeine contents in cans or bottles of energy drinks consumed per day.

Energy drink	Caffeine content (mg)		
	Number of bottles per day		
	1-3	4-6	7 or more
RU (350 ml)	85.8-257.2	343.0-514.5	≥600.2
LU (380 ml)	72.9-218.8	291.8-437.7	≥510.7
FS (350 ml)	48.7-146.1	194.6-291.9	≥340.5
RB (250 ml)	22.3-66.8	89.0-133.5	≥155.7

The mean caffeine contents were used to determine the total caffeine consumed in bottles of energy drinks.

being the least consumed according to the survey. Lucozade energy drink was a more consumed brand than Five Star from the study. Rush (RU) energy drink had the highest caffeine content and Red Bull (RB) contained the least amount of caffeine among the energy drinks assayed. Lucozade (LU) had a higher caffeine content than Five Star (FS). Most of the correspondents consumed 1 to 3 energy drinks. This delivered a caffeine amount well within the recommended daily allowance. Most of those who experienced side effects probably ingested in excess of 400 mg as a maximum daily requirement of caffeine. Most people used energy drinks mostly for enhanced performance. A few others also consumed them because they tasted good and also for other personal reasons.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Addicott MA, Yang LL, Peiffer AM, Burnett LR, Burdette JH, Chen MY, Laurienti PJ (2009). The effect of daily caffeine use on cerebral blood flow: How much caffeine can we tolerate? Human Brain Mapping, 30(10):3102-3114.

Agyemang-Yeboah F, Oppong SY (2013). Caffeine : The wonder compound , chemistry and properties. Topical Series in Health Science, 661(2):27-37.

Buxton C, Baguune B (2012). Knowledge and practices of people in Bia District, Ghana, with regard to iodine deficiency disorders and intake of iodized salt. Archives of Public Health, 70(1):1-9.

Buxton C, Hagan JE (2012). A survey of energy drinks consumption practices among student -athletes in Ghana: Lessons for developing health education intervention programmes. Journal of the International Society of Sports Nutrition, 9(9):1-8.

Cabezas-Bou E, De León-Arbucias J, Matos-Vergara N, Álvarez-Bagnarol Y, Ortega-Guzmán, J, Narváez-Pérez K, Díaz-Ríos M (2016). A Survey of Energy Drink Consumption Patterns Among College Students at a Mostly Hispanic University. Journal of Caffeine Research, 6(4):154-162.

Demura S, Aoki H, Mizusawa T, Soukura K, Noda M, Sato T (2013). Gender Differences in Coffee Consumption and Its Effects in Young People. Food and Nutrition Sciences, 4(7):748-757.

Emond JA, Sargent JD, Gilbert-Diamond D (2015). Patterns of Energy Drink Advertising Over US Television Networks. Journal of Nutrition Education and Behavior, 47(2):120-126.

Heckman MA, Weil J, De Mejia EG (2010). Caffeine (1, 3, 7-trimethylxanthine) in foods: A comprehensive review on consumption, functionality, safety, and regulatory matters. Journal of Food Science, 75(3):77-87.

Hodgson AB, Randell RK, Jeukendrup AE (2013). The Metabolic and Performance Effects of Caffeine Compared to Coffee during Endurance Exercise. PLoS ONE, 8(4):1-12.

International Food Information Council Foundation. (2007). Caffeine & Health: Clarifying The Controversies. IFIC Review: International Food Information Council Foundation, P 16.

Kaplan GB, Greenblatt DJ, Ehrenberg BL, Goddard JE, Cotreau MM, Harmatz JS, Shader RI (1997). Dose-dependent pharmacokinetics and psychomotor effects of caffeine in humans. Journal of Clinical Pharmacology, 37(8):693-703.

Lodato F, Araújo J, Barros H, Lopes C, Agodi A, Barchitta M, Ramos E (2013). Caffeine intake reduces sleep duration in adolescents. Nutrition Research, 33(9): 726-732.

Meredith SE, Juliano LM, Hughes JR, Griffiths RR (2013). Caffeine Use Disorder: A Comprehensive Review and Research Agenda. Journal of Caffeine Research, 3(3):114-130.

Mohammed S, Nour I, Shabaan AE, Shouman B, Abdel-Hady H, Nasef N (2015). High versus low-dose caffeine for apnea of prematurity: a randomized controlled trial. European Journal of Pediatrics, 174(7):949-956.

Nonthakaew A, Matan N, Aewsiri T, Matan N (2015). Caffeine in foods and its antimicrobial activity. International Food Research Journal, 22(1):9-14.

Olaniyi AA, Ogungbamila FO (1998). Experimental Pharmaceutical Chemistry (Second). Ibadan, Nigeria: Shaneson C.I. Ltd. pp. 23- 24.

Pohler H (2010). Caffeine Intoxication and Addiction. Journal for Nurse Practitioners, 6(1):49-52.

Reissig CJ, Strain EC, Griffiths RR (2009). Caffeinated Energy Drinks - A growing problem. Drug Alcohol Depend, 99(410):1-10.

Smith A (2002). Effects of caffeine on human behavior. Food and Chemical Toxicology : An International Journal Published for the British Industrial Biological Research Association, 40(9):1243-1255.

Telford RM, Telford RD, Olive LS, Cochrane T, Davey R (2016). Why Are Girls Less Physically Active than Boys? Findings from the LOOK Longitudinal Study. PLOS ONE, 11(3):1-11.

Temple JL, Bernard C, Lipshultz SE, Czachor JD, Westphal JA, Mestre MA (2017). The Safety of Ingested Caffeine: A Comprehensive Review. Frontiers in Psychiatry, 8:1-19.