Journal of Anatomical Sciences

info@journalofanatomicalsciences.com
submissions@journalofanatomicalsciences.com

J Anat Sci 10 (1)

Effects of Energy Drinks on the Heart and Blood Vessels

Eze GI[1], Akonoafua KA[1] and Afimoni EE[1]
Department of Anatomy, University of Benin, Benin-city, Edo State

Corresponding author: Akonoafua Kevin Aiwanfoh
Email: kevinakonoafua@gmail.com; +23408034030148

ABSTRACT
There are a myriad of energy drink brands and this depicts both their popularity and the size of the available market. However, numerous adverse effects have come to be associated with their consumption. This study was carried out to investigate the effects of the consumption of energy drinks on the heart and blood vessels of adult Wistar rats. The experiment involved the use of twenty-five (25) Wistar rats of either sexes and they were randomly assigned into five (5) groups (A, B, C, D and E) of five (5) adult wistar rats each. Lucozade Boost and Red Bull energy drinks were the agents of study. Group A was the control group. Group B was treated with high dose of Lucozade Boost, Group C was treated with low dose Red Bull, Group D was treated with a moderate dose of Red Bull while Group E was treated with high dose of Red Bull energy drink. At the completion of the experiment, Group A showed no pathology, while the other experimental groups showed a number of pathological changes. In conclusion, energy drinks scarcely have therapeutic benefits. The consumption of these energy drinks will seriously harm the body. Those planning to consume energy drinks should be warned.

Keywords: Energy drink, hypertrophy, congestion, cholesterol, heart, blood vessels.

INTRODUCTION
Energy drinks allude to beverages that contain, in addition to calories, caffeine, intermixed with other presumed energy-boosting ingredients such as taurine, herbal extracts, and B vitamins. They first surfaced in Europe and Asia in the 1960s in response to consumer demand for a dietary supplement that would result in increased energy, stamina, athletic performance and concentration [1,2].

Ab initio, energy drinks were not marketed as they currently are. In 1929, in the United Kingdom, Lucozade Energy was originally introduced as a hospital drink for "aiding the recovery" of convalescing patients, and by the 1980s, it was advertised as an energy drink for "replenishing lost energy" [3]. Energy drinks became popular in Asia long before they reached the United States. In 1962, the Japanese pharmaceutical company, Taisho, released its Lipovitan D drink. They were sold in small brown glass medicine bottles, or cans styled to resemble such containers. These "eiyō dorinku" (literally, "nutritional drinks") are marketed primarily to "salarymen". Salarymen are known for working many hours and having very busy work schedule [4, 5]. Currently, there are a lot of forceful, rigorous and extreme advertising of energy drinks. From "unleash the beast", "party like a rockstar" to one brand even tagging their product as "the legal alternative" to cocaine [6,7].

More than 500 new energy drinks were launched worldwide in 2006 and in 2016, a total of 6,062 billion cans of Red Bull drink were sold worldwide [8, 9]. The wide availability of the beverages, from grocery stores, convenience stores and school bookstores makes them readily accessible for purchase by adolescents, even though the products often retail for more than twice the price of "traditional" soft drinks [10].

The reemergence of energy drinks initially targeted athletes as its primary consumers. However, as the energy drink market grew and expanded into various niche markets, athletes are no longer the primary target [2]. Adolescents and young adults are now being targeted as the primary energy drink consumers, with such products appearing to perform a distinct social function in the construction and maintenance of a desirable social image within their peer group [11]. In the UK alone, the annual consumption of energy drinks increased from 4.4 litres per person in 2007 to 9.4 litres per person in 2014 [12]. The global energy drink market was worth $39 billion in 2013, and is forecast to reach $61 billion by 2021 [13].

Despite the fact that there are hundreds of energy drinks in the market, many share ingredient profiles that cut across brands. Most of these energy drink blends consist mainly of caffeine and taurine at varying concentrations. In addition, sugar is typically present; however, many brands have sugar-free options available as well. Sugar is widely used in energy drinks because it is a source of rapid energy. Other ingredients that are commonly incorporated into these products are ginseng, guarana, yerba mate, and green tea extracts [2].

The scientific community, media, governments, athletic

departments, and the general public have expressed distress over energy drinks, due to harmful occurrences that have emanated from their consumption [14]. The health risks associated with energy drink consumption are primarily related to their caffeine content [15]. A caffeine overdose can cause palpitations, hypertension, diuresis, central nervous system stimulation, nausea, vomiting, pronounced hypocalcaemia, metabolic acidosis, convulsions [16], and, in rare cases, even death [17, 18]. In adults, there is also an increased risk of arterial hypertension [19] and type 2 diabetes [20], as high intake of caffeine has been associated with insulin sensitivity [21]. High-caffeine consumption has also been reported to increase the risk of late miscarriages and stillbirths amongst pregnant women [22]. Also, as a result of the high-sugar content of energy drinks, there is an increased risk of obesity [23], dental cavities [24] and cervical dentin hypersensitivity [25]. After caffeine toxicity has been established, sinus tachycardia is almost always present, and supraventricular tachycardia has been commonly observed. Supraventricular tachycardia may however result from adenosine antagonism [26]. Excessive caffeine use has also been associated with one case of myocardial infarction in a young woman with no cardiac risk factors [27].

Caffeine has a dehydrating effect, which is why an energy drink should not be recommended after strenuous physical effort [12]. Higgins et al [28] carried out a study on exploring the effects on endothelial function following consumption of energy drinks in healthy young adults at rest and it was revealed that the consumption of energy drinks may lead to an acute attenuation of endothelial function.

Energy drinks also likely increase myocardial oxygen demand, and this may be increased under stress. A study by Grasser, Dulloo and Montani [29] reported that the combination of Red Bull and mental stress results in greater increases in heart rate and blood pressure (greater cardiovascular load).

MATERIALS AND METHODS

Experiment

The experiment involved the use of twenty-five (25) Wistar rats of either sexes, which were obtained from the Animal House of the Department of Anatomy, School of Basic Medical Sciences, University of Benin, Benin-city, Edo-state, Nigeria, and accommodated in the same location. The mean weight was 203 g and it lasted two (2) weeks. During this period, all the observations were written in a protocol book. Before the beginning of the experimental phase, the animals were given two (2) weeks to acclimatize to their new environment. The rats were divided into five (5) groups of five (5) animals each: Group A (Control), Group B (Lucozade Boost: 1.4ml), Group C (low dose of Red Bull: 0.35ml), Group D (moderate dose of Red Bull: 0.7ml), Group E (high dose of Red Bull: 1.4ml). All groups had an equal, unlimited access to food and water. The energy drinks were administered orally by gavage. The Wistar rats were marked individually to avoid erroneous administration.

Blood samples and histopathology

After two (2) weeks of administration of energy drinks, the animals of all groups were anesthetized and sacrificed. Their hearts and blood vessels were collected for histological analysis. Blood samples were obtained by cardiac puncture and collected in plain bottles, using disposable syringes, and were immediately sent to the Chemical Pathology Laboratory of the University of Benin Teaching Hospital (UBTH) for biochemical assays. The organs removed were fixed in 10% buffered formalin. Fixed tissues were completely dehydrated in ascending concentrations of alcohol (70%, 90%, 96% and 100%). The tissues were placed in xylene to remove the alcohol, impregnated and embedded with molten paraffin wax. They were allowed to solidify before sectioning into 4 µm using a microtome (Leica RM 2235, UK) the 4 µm sections were placed on slides and stained with hematoxylin-eosin dye (Bancroft and Gamble, 2006). Stained slides were viewed using an optical photomicroscope (Leica MC170 HD, Leica Biosystems, Germany) at x100 and x400 magnifications. Photomicrographs were made using a standard photomicrography setup.

Statistical analysis

All values were presented as mean ± standard deviation (SD). The significance of difference in the means of all parameters will be determined using one way analysis of variance (ANOVA; 95% confidence interval). All statistical analysis were carried out using Statistical package for Social Sciences (SPSS) (version 20).

RESULTS

The results of the biochemical assays in table 1 shows a significant difference ($P<0.05$) in the levels of triglyceride across the experimental groups. There were also difference in the levels of cholesterol, high density lipoproteins and low density lipoproteins, but they were rather insignificant ($P>0.05$).

The histopathologic results showed that control group's blood vessels (Figure 1) and the heart (Figure 6) had no pathology. The lumen, tunica intima, tunica media and tunica adventitia were clearly visible. Bundles of myocardiac fibres, interstitial space, and coronary vessels were also present. The other experimental groups showed many pathological changes. Group B's blood vessels (Figure 2) showed mild active congestion, while the heart (Figure 7) showed mild coronary active vascular congestion. In Group C *(Figure 3), the blood vessels showed mild hypertrophy,* intimal ulceration and obstruction, and narrowing of the lumen; the heart (Figure 8) showed mild vascular congestion and mild oedema. The blood vessels of the experimental animals in Group D (Figure 4) showed mild hypertrophy, severe intimal ulceration and perivascular infiltrates of inflammatory cells while the heart (Figure 9) showed mild vascular hypertrophy, congestion, intimal ulceration and oedema of Purkinje fibres. Group E (Figure 5) showed moderate hypertrophy and patchy intimal ulceration in the blood vessels, and the heart (Figure 10) showed moderate vascular congestion, severe media hypertrophy and complete luminal

obstruction, mild intima erosion and a mild infiltrate of inflammatory cells.

Table 1: comparison of mean values of blood lipid profile parameters between groups

		A	B	C	D	E	P-Value
CHOL	**Mean**	63.33	67.67	59.00	53.67	61.67	0.745
	S.D	3.055	1.528	1.000	1.528	1.528	
TG	**Mean**	47.33	61.67	63.33	66.33	62.67	**0.006****
	S.D	1.528	2.082	1.528	2.082	1.528	
HDL	**Mean**	22.67	23.67	22.33	16.33	22.00	0.881
	S.D	2.517	1.528	1.528	1.528	2.000	
LDL	**Mean**	22.67	32.67	21.33	27.33	27.67	0.891
	S.D	2.517	1.528	1.528	1.528	1.528	

***significant at P<0.05*

Photomicrographs

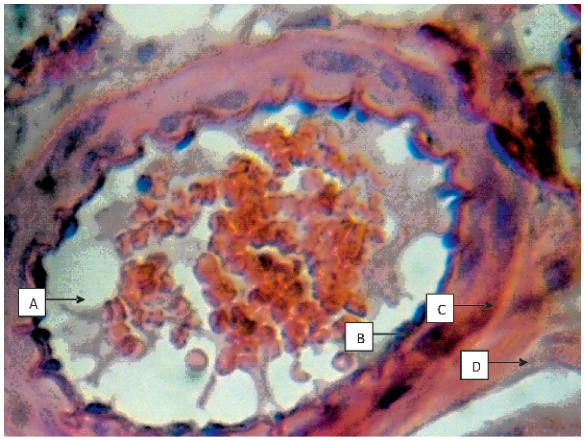

Figure 1: Control: Rat blood vessel composed of the lumen A, tunica intima B, tunica media C and tunica adventitia D (H&E x 40)

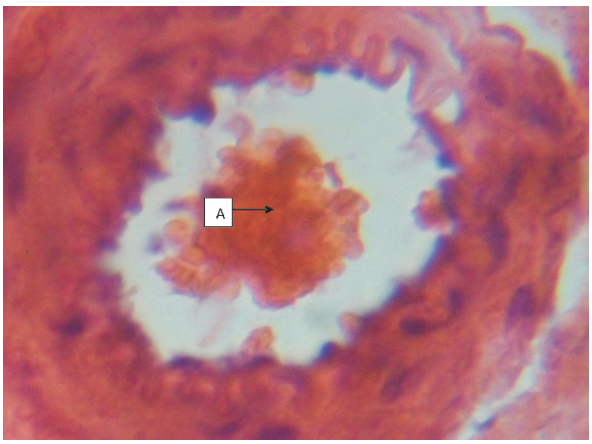

Figure 2: *Rat blood vessel given 1.4ml Lucozade boost for 2 weeks showing mild active congestion A (H&E x 40)*

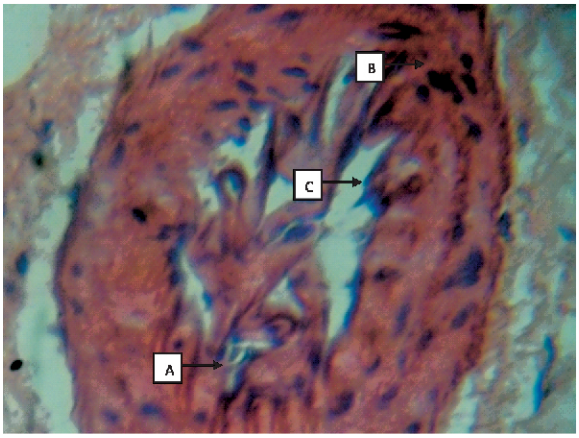

Figure 3: Rat blood vessel given 0.35ml (low dose) Red Bull for 2 weeks showing mild hypertrophy A, intimal ulceration B and obstruction and narrowing of the lumen C (H&E x 40)

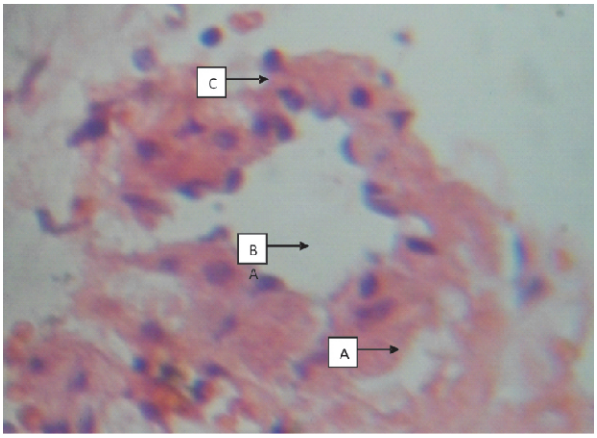

Figure 4: Rat blood vessel given 0.7ml (moderate dose) Red Bull for 2 weeks showing mild hypertrophy A, severe intimal ulceration B and perivascular infiltrates of inflammatory cells C (H&E x 40)

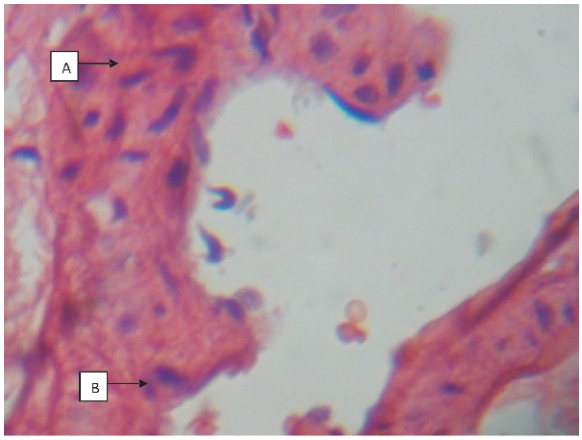

Figure 5: Rat blood vessel given 1.4ml (high dose) Red Bull for 2 weeks showing moderate hypertrophy A, and patchy intimal ulceration B (H&E x 40)

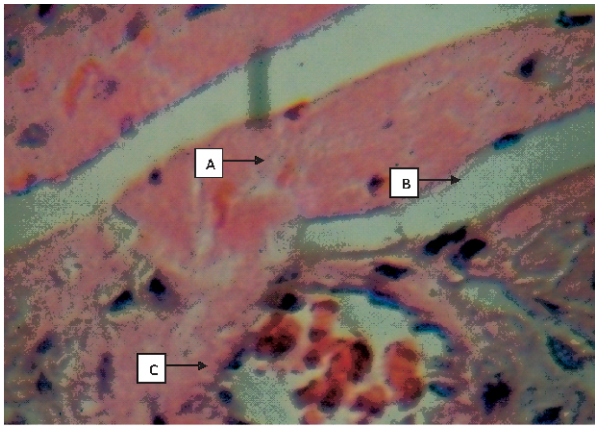

Figure 6: Control rat heart composed of bundles of myocardiac fibres A, interstitial space B, coronary vessel C (H&E x 40)

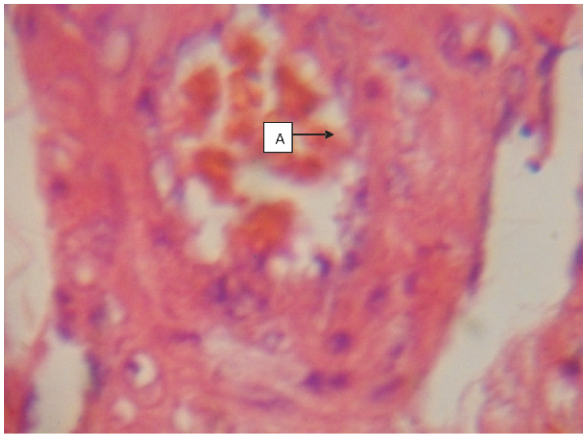

Figure 7: Rat heart given 1.4ml Lucozade boost for 2 weeks showing mild coronary active vascular congestion A (H&E x 40)

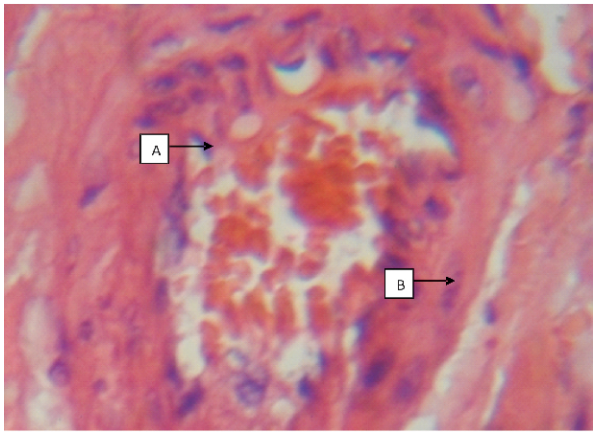

Figure 8: Rat Heart given 0.35ml (low dose) Red Bull for 2 weeks showing mild vascular congestion A, and mild oedema B (H&E x 40)

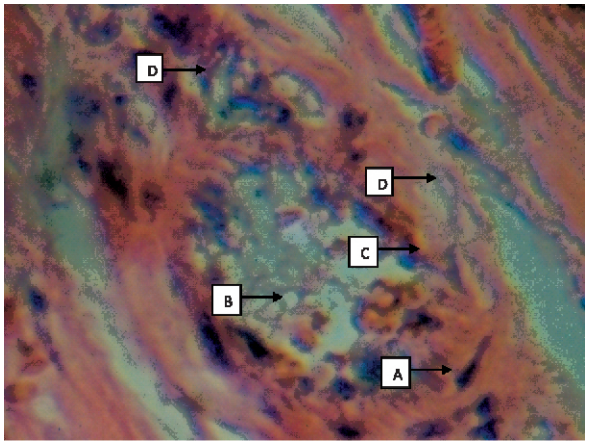

Figure 9: Rat Heart given 0.7ml (moderate dose) Red Bull for 2 weeks showing mild vascular hypertrophy A, congestion B, intimal ulceration C and vacuolation D (H&E x 40

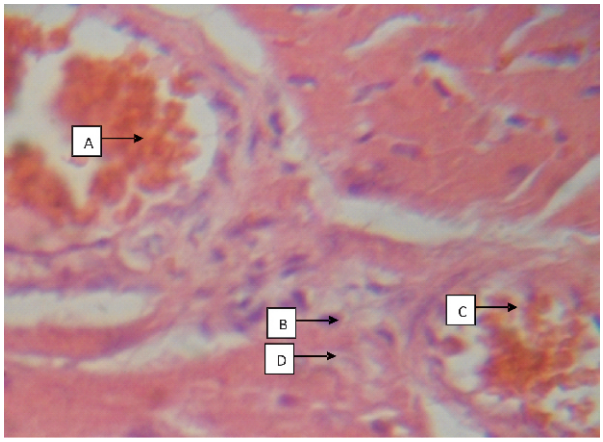

Figure 10: Rat heart given 1.4ml (high dose) Red Bull for 2 weeks showing moderate vascular congestion A, severe media hypertrophy and complete luminal obstruction B, mild intima erosion C, a mild infiltrates of inflammatory cells D (H&E x 40)

DISCUSSION

Energy drinks increase blood pressure, heart rate or alter glycemic levels; these can often prevent normal sleep cycles and may have more serious effect on dehydrated athlete by increasing the heart rate [30]. Energy drinks are able to provide an additional burst of energy in a short-time period [31]. However, they are a current public health threat.

In this study, we investigated the effects of energy drinks on the heart and blood vessels of wistar rats, evaluating both microscopic analysis and biochemical assays. This study showed that there was significant increase in triglyceride levels in the energy drinks treated rats. Ingestion of a high-fat meal increases blood triglyceride levels resulting in endothelial dysfunction for several hours after the meal [32]. Since ingestion of a fructose drink enhances the postprandial increase in plasma triglycerides seen after an oral fat load [33] a meal or drink that is high in fat and sugar has the potential to diminish postprandial endothelial function, eventually leading to increased cardiovascular risk.

In the heart, coronary atherosclerosis (which eventually leads to ischaemia in the myocardium), myocardial oedema and infiltrates of inflammatory cells (necrosis) were present, while in the blood vessels, media hypertrophy, vascular ulceration, stenosis and congestion were observed. As have been reported by earlier studies, acute exposure to caffeine and other components in energy drinks (typically consumed in less than 5 minutes) impairs arterial endothelial function (within the next few hours) in healthy young adults at rest [34]. Endothelial function is a barometer of vascular health, and abnormal endothelial cell function termed "endothelial dysfunction" acutely is associated with vasoconstriction, poor vascular reactivity, pro-thrombosis, pro-adhesion, pro-inflammation, and growth promotion [34,35].

It has been well established that the presence of oedema is related to cell death [36]. This is in agreement with a study carried out by Salih, Abdul-Sadaand and Abdulrahman [37].

Inflammatory cell infiltration occurs when inflammatory cells such as neutrophils, eosinophils, lymphocytes, plasmacytes, macrophages and mast cells infiltrate around the blood vessels, as a result of unusual growth (perivascular infiltration). Cardiac hypertrophy occurs when the heart experiences elevated workload or injury. Although it is an adaptive response to reduce ventricular wall stress and initially maintain output, sustained hypertrophy leads to ventricular dysfunction and, ultimately, heart failure [38]. Research has shown that caffeine can induce cardiac hypertrophy [39]. The cardiac hypertrophy observed is therefore invariably due to the caffeine contents present in energy drinks.

Taurine, a very common component of energy drinks is not essential for humans, and it should only be recommended under supervision of a physician. Glucuronolactone is a precursor to taurine and the body manufactures glucuronolactone naturally [40,41].

CONCLUSION

At the conclusion of this experiment to explore the effect of energy drinks on the heart and blood vessels, the researchers concluded that energy drinks have dose–response relationship, with adverse effect. Evidently, the consumption of these energy drinks will seriously harm the body. Those planning to consume energy drinks should be warned.

REFERENCES

1. Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks—a growing problem. Drug and alcohol dependence. 2009, 99(1-3):1.
2. Heckman MA, Sherry K, De Mejia EG. Energy drinks: an assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the United States. Comprehensive Reviews in food science and food safety. 2010, 9(3):303-17.
3. Sauceman FW. The place setting: Timeless tastes of the Mountain South, from bright hope to frog level. Mercer University Press; 2009.
4. Taisho Pharmaceutical Co., Ltd. Available from: http://www.taisho.co.jp/en/company/profile/history/index.html Accessed July 13, 2018.
5. Wingate K. Japanese Salarymen: On the Way to Extinction?. Undergraduate Journal of Global Citizenship. 2011, 1(1):2.
6. Capps Jr O, Hanselman RD. A Pilot Study of the Market for Energy Drinks. Journal of Food Distribution Research. 2012, 43(3).
7. Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K. A survey of energy drink consumption patterns among college students. Nutrition journal. 2007, 6(1):35.
8. Valle MC, Couto-Pereira NS, Lampert C, Arcego DM, Toniazzo AP, Limberger RP, Dallegrave E, Dalmaz C, Arbo MD, Leal MB. Energy drinks and their component modulate attention, memory, and antioxidant defences in rats. European journal of nutrition. 2018, 57(7):2501-11.
9. Red Bull Website. Available online: http://energydrink-pl.redbull.com/firma-red-bull (accessed on 15 July, 2018).
10. Babu KM, Church RJ, Lewander W. Energy drinks: the new eye-opener for adolescents. Clinical Pediatric Emergency Medicine. 2008, 9(1):35-42.
11. Bunting H, Baggett A, Grigor J. Adolescent and young adult perceptions of caffeinated energy drinks. A qualitative approach. Appetite. 2013, 1(65):132-8.
12. Nowak D, Jasionowski A. Analysis of the consumption of caffeinated energy drinks among

Polish adolescents. International journal of environmental research and public health. 2015, 12(7):7910-21.
13. PRNewswire. Global Energy Drinks Market 2015–2021: Insights, Market Size, Share, Growth, Trends Analysis and Forecasts for the $61 Billion Industry. Available from: http://www.prnewswire.com/news-releases/global-energy-drinks-market-2015-2021-insights-market-size-share-growth-trends-analysis-and-forecasts-for-the-61-billion-industry-300137637.html. Accessed on 16 July, 2018.
14. Higgins JP, Babu K, Deuster PA, Shearer J. Energy Drinks: A Contemporary Issues Paper. Current sports medicine reports. 2018, 17(2):65-72.
15. Breda JJ, Whiting SH, Encarnação R, Norberg S, Jones R, Reinap M, Jewell J. Energy drink consumption in Europe: a review of the risks, adverse health effects, and policy options to respond. Frontiers in public health. 2014, 14(2):134.
16. Flanagan RJ, Braithwaite RA, Brown SS, Widdop B, De Wolff FA, World Health Organization. Basic analytical toxicology.
17. Kerrigan S, Lindsey T. Fatal caffeine overdose: two case reports. Forensic Science International. 2005, 153(1):67-9.
18. Berger AJ, Alford K. Cardiac arrest in a young man following excess consumption of caffeinated "energy drinks". The Medical Journal of Australia. 2009, 190(1):41-3.
19. Brown IJ, Stamler J, Van Horn L, Robertson CE, Chan Q, Dyer AR, Huang CC, Rodriguez BL, Zhao L, Daviglus ML, Ueshima H. Sugar-sweetened beverage, sugar intake of individuals, and their blood pressure: international study of macro/micronutrients and blood pressure. Hypertension. 2011, 1:HYPERTENSIONAHA-110.
20. Seifert SM, Schaechter JL, Hershorin ER, Lipshultz SE. Health effects of energy drinks on children, adolescents, and young adults. Pediatrics. 2011, 14:peds-2009.
21. Lee S, Hudson R, Kilpatrick K, Graham TE, Ross R. Caffeine ingestion is associated with reductions in glucose uptake independent of obesity and type 2 diabetes before and after exercise training. Diabetes Care. 2005, 28(3):566-72.
22. Greenwood DC, Alwan N, Boylan S, Cade JE, Charvill J, Chipps KC, Cooke MS, Dolby VA, Hay AW, Kassam S, Kirk SF. Caffeine intake during pregnancy, late miscarriage and stillbirth. European journal of epidemiology. 2010, 25(4):275-80.
23. Davis MM, Gance-Cleveland B, Hassink S, Johnson R, Paradis G, Resnicow K. Recommendations for prevention of childhood obesity. Pediatrics. 2007, 120(Supplement 4):S229-53.
24. Marshall TA, Levy SM, Broffitt B, Warren JJ, Eichenberger-Gilmore JM, Burns TL, Stumbo PJ. Dental caries and beverage consumption in young children. Pediatrics. 2003, 112(3):e184-91.
25. Pinto SC, Bandeca MC, Silva CN, Cavassim R, Borges AH, Sampaio JE. Erosive potential of energy drinks on the dentine surface. BMC research notes. 2013, 6(1):67.
26. Hoffman R. Methylxanthines. Goldfrank's toxicologic emergencies. 8th ed. New York (NY): McGraw-Hill. 2006.
27. Forman J, Aizer A, Young CR. Myocardial infarction resulting from caffeine overdose in an anorectic woman. Annals of emergency medicine. 1997, 29(1):178-80.
28. Higgins JP, Yang B, Herrin NE, Yarlagadda S, Le GT, Ortiz BL, Ali A, Infanger SC. Consumption of energy beverage is associated with attenuation of arterial endothelial flow-mediated dilatation. World journal of cardiology. 2017, 9(2):162.
29. Grasser EK, Dulloo AG, Montani JP. Cardiovascular and cerebrovascular effects in response to red bull consumption combined with mental stress. The American journal of cardiology. 2015, 115(2):183-9.
30. Lieberman HR. The effects of ginseng, ephedrine, and caffeine on cognitive performance, mood and energy. Nutrition reviews. 2001, 59(4):91-102.
31. Petrelli F, Grappasonni I, Evangelista D, Pompei P, Broglia G, Cioffi P, Kracmarova L, Scuri S. Mental and physical effects of energy drinks consumption in an Italian young people group: a pilot study. Journal of Preventive Medicine and Hygiene. 2018, 59(1):E80.
32. Vogel RA, Corretti MC, Plotnick GD. Effect of a single high-fat meal on endothelial function in healthy subjects. The American journal of cardiology. 1997, 79(3):350-4.
33. Jeppesen J, Chen YI, Zhou MY, Schaaf P, Coulston A, Reaven GM. Postprandial triglyceride and retinyl ester responses to oral fat: effects of fructose. The American journal of clinical nutrition. 1995, 61(4):787-91.
34. Higgins JP, Yarlagadda S, Yang B. Cardiovascular complications of energy drinks. Beverages. 2015, 1(2):104-26.
35. Veerasamy M, Bagnall A, Neely D, Allen J, Sinclair H, Kunadian V. Endothelial Dysfunction and Coronary Artery Disease. Cardiology in review. 2015, 23(3):119-29.
36. Garcia-Dorado D, Oliveras J, Gili J, Sanz E, Pérez-Villa F, Barrabés J, Carreras MJ, Solares J, Soler-Soler J. Analysis of myocardial oedema by magnetic resonance imaging early after coronary artery occlusion with or without reperfusion. Cardiovascular research. 1993, 27(8):1462-9.
37. Salih NA, Abdul-Sadaand IH, Abdulrahman NR. Histopathological effect of energy drinks (Red Bull) on Brain, Liver, Kidney, and Heart in Rabbits. Medical Journal of Babylon. 2018, 15(1):16.
38. Zhou H, Bian ZY, Zong J, Deng W, Yan L, Shen

DF, Guo H, Dai J, Yuan Y, Zhang R, Lin YF. Stem cell antigen 1 protects against cardiac hypertrophy and fibrosis after pressure overload. Hypertension. 2012, 1:HYPERTENSIONAHA-112.
39. Xu H, Zhang Y, Sun J, Wei J, Sun L, Zhang J. Effect of distinct sources of Ca2+ on cardiac hypertrophy in cardiomyocytes. Experimental Biology and Medicine. 2012, 237(3):271-8.
40. Kennedy DO, Scholey AB. A glucose-caffeine 'energy drink' ameliorates subjective and performance deficits during prolonged cognitive demand. Appetite. 2004, 42(3):331-3.
41. Lee WM. Drug-induced hepatotoxicity. New England Journal of Medicine. 2003, 349(5):474-85.