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DETERMINATION OF PHYSICOCHEMICAL PARAMETERS, HEAVY METALS AND ESSENTIAL ELEMENT CONCENTRATION IN SOME ENERGY DRINKS MARKED IN JEMITA MODERN MARKET, NIGERIA

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Abstract: This study was carried out to determine the contribution of eight commonly consumed energy drinks to energy intake of youths in Yola and the associated health risk factors. Eight brands of non-alcoholic energy drinks were analyzed for some physicochemical properties (pH, turbidity, conductivity and total dissolved Solids), essential and heavy metals contents. The results of physicochemical properties ranged between 2.89±0.00 to 3.14±0.00, 3.12±1.44 to 1024±2.82, 156±0.70 to 834.75±8.83 and 0.14±110 for pH, conductivity, total dissolve solid, and turbidity, respectively. pH of the energy drinks were within the acidic range but conductivity, total dissolved solid and turbidity were within the recommended limit set by world health organization for energy drinks. Heavy metals determine in energy drinks were copper, iron, manganese, lead and zinc. The result reveals that the concentration of zinc, iron, copper, manganese and lead were within the recommended permissible limit set by world health organization, food and agricultural organization, standard organization of Nigeria etc. The essential elements determined in energy drinks were calcium and potassium. The result reveal that the calcium concentration was low compared to the standard set by food and agricultural organization while the concentration of potassium in sample last shoot was high, about 937.00 mg/L which are higher than the recommended limit.

Keywords: Chemical composition, minerals, energy drinks, physicochemical parameters

Introduction

Energy drinks are beverage that contain energy enhancing ingredient such as caffeine, taurine, herbal extracts and vitamin B which are meant to give consumers short term boost in energy and increase in mental alertness. Energy drinks are mostly patronized by youth in Nigeria but little is known about the consumption pattern and possible health risks to consumers. Recently, the consumption of readily available energy drinks has increased significantly with youths forming the largest part of the consumers (Akinmolusun*et al*., 2012). Energy drinks refer to beverages that contain, besides calories, caffeine in combination with other presumed energy-enhancing ingredients such as taurine, herbal extracts, and B vitamins (Reissig and Griffiths, 2008). The history of energy drinks dates back to 1987 when Red Bull was introduced in Austria (Red Bbull, 2002). It became more popular in the 1990s following its introduction to the United States (Heckman *et al*., 2010). Since then, the sale of this drink has increased exponentially (Attila and Cakir, 2011). In 2006, the energy drink market grew by 80% (Foran*et al*., 2011). This is because manufactures claimed that the drinks can boost energy levels as well as physical endurance, improve concentration and reaction speed (Van den Eyndeand, 2008). Recently a number of different energy drinks have been introduced in the Nigerian market to provide an energy boost or as dietary supplements. These drinks are marketed specifically to youth and young adults. These products have been used for various reasons for example in a survey conducted among college students, 67% admitted using it to coping with insufficient sleep, 65% mentioned increasing energy and 54% use it to increase fun at parties. 50% for studying or completing a major course project, 45% used it while driving a car for a long period of time and 17% for treating hangover (Malinauskas and Aeby, 2007). These products have also been used to reduce the depressor effect of alcohol or even to gain social status (Ferreira and Hartmann, 2004; Kaminer, 2010).

Although many energy drinks are promoted as being nut foods, boosting health, energy, or otherwise having sought-after benefits, there is some concern among health professionals that these beverages, and the drinking behaviors of the targeted consumers, may in fact have adverse health consequences. The most commonly reported adverse effects include insomnia, nervousness, headache, and tachycardia (Clauson and Mcqueen, 2008). In a recent study, heavy consumption of energy drinks was attributed to new onset seizures in four patients (Iyadurai and Chung, 2007) and hospitalization of individuals with pre-existing mental illness (Chelben*et al.*, 2008). They first appeared in Europe and Asia in the 1960s in response to consumer demand for a dietary supplement that would result in increased energy (Reissig and Griffiths, 2008). In 1962, a Japanese company, Taisho Pharmaceuticals, launched Lipovitan D, one of the very 1st energy drinks, which is still dominating the Japanese market. (Taisho Pharmaceutical Co. Ltd. TSE: 4535. 2009) Since the 1960s, the energy drink market has grown into a multibillion dollar business which has been reported as being the fastest growing segment in the beverage industry since bottled water (AAFC, 2008). Energy drinks have established a viable position in the beverage market as evidenced by their commonplace consumption in the morning, afternoon, and night, not only by the general consumer, but those of age 18 to 34 in particular (Lal, 2007).

The popularity of energy drinks and the growth in their consumption among adolescents/adults have brought worries regarding general health and well-being of these consumers. Adolescents and adults are often uninformed about the content of energy drink (Rath, 2012). Although, there are hundreds of energy drinks in the market, many share very similar ingredient profiles. Most of these energy drinks consist mainly of caffeine, taurine, guarana, ginseng, B vitamins, ginko, biloba, L-carntine, sugars, antioxidants, glucuronolactone, yerba mate, creatine, acai berry, milk thistle, L-theanine, Inositol and artificial sweeetners (Babu*et al.*, 2008).

The presence of heavy metals in beverages is also widely speculated. Lead toxicity causes many sign and symptoms such as abdominal pains, anaemia, anoxia, bone pair, brain damage, convulsion, dizziness, and inability to concentrate (Satarug and Moore, 2004). Excessive exposure to lead may also cause microcytic anemia, glycosuria, cognitive dysfunction, anorexia, metallic taste, insomnia, reticulocytosis. Target organs include the brain, bone, blood, kidneys, and thyroid gland (Satarug and Moore, 2004).

Health education research published an article titled "consumption of nutritional supplements among youths: Usage and perceived benefits" in which Jennifer O'dea (2003) defined different categories of nutritional supplements, their usage and perceive benefits among youths. Some of these nutritional supplement use are sport drinks, vitamin and mineral tablets, energy drinks herbal supplement, guarana, creatine, high protein milk supplements and coenzyme Q_{10}. Depending on the choice of supplement used, youths purported a variety of reason for usage: to promote better health, prevent illnesses, and do something positive for themselves. In addition, youths admitted using supplements for taste, to quench thirst, to improve sports performance as substitution for soft drinks and for stimulant and ergogenic effects (O'Dea, 2003).

Materials and Methods

Sample collection

The commonly consumed samples of non-alcoholic energy drinks after interacting with some youth/adults within the ModibboAdama University of Technology Yola was purchased from Jimeta modern market, Yola. Eight brand (three per product) of different cans and plastics energy drinks (LS, CL, XR , LB, SE, BT, PH and FG with NAFDAC REG. number C1-3667, A1-6830, A1-8473, A1-9754, 01-4203, C1-3620, 01-6204 and C1-1915) were randomly purchased from the market and evaluated. The samples were refrigerated at temperature of 4°C prior to analysis.

Physicochemical parameters

Determination of pH

The pH was determined using a digital pH meter (JENWAY 3505). The probe was rinsed thoroughly with distilled water before use on sample. For each energy drink samples (liquid), 50 mL was placed in a beaker, the probe of the pH meter was inserted and the pH values were recorded (Gimba*et al*., 2014).

Determination of conductivity

The electrical conductivity measurement was determined using a digital TDS/conductivity meter (HACH) Sension 5. The probe was rinsed thoroughly with distilled water before use on sample. Each energy drink samples (liquid) (50 mL was placed in a beaker, the probe of the TDS/conductivity meter was inserted and the conductivity values were recorded (Gimba*et al*., 2014).

Determination of turbidity

The turbidity measurement was determined using a digital turbidity meter (HACHDR/890 Colorimeter) the probe was rinsed thoroughly with distilled water before use on sample. For each energy drink samples (liquid), 50 mL was placed in a beaker, the probe of the digital turbidity meter was inserted and the turbidity values were recorded (Gimba*et al*., 2014).

Total dissolved solid

The total dissolved solids measurement was determined using a digital TDS/conductivity meter (HACH) Sension 5. The probe was rinsed thoroughly with distilled water before use on sample. For each energy drink samples (liquid), 50 mL was placed in a beaker, the probe of the TDS/conductivity meter was inserted and the TDS values were recorded.

The physicochemical parameters were done according to the method of Gimba*et al*. (2014).

Elemental analysis

Acid digestion of samples

Sample was digested in a clean 250 mL dry Pyrex digestion flask. 25 mL of the sample energy drink was measure into the digestion flask. Then 20 ml concentrated aqua regia was added. The digestion flask was heated gently until frothing subsided; then heated to dryness. It was dissolved in 30 mL distilled water and filter with filter paper. The solution will be made up to volume in a 100 mL flask. This was used for the determination of the following elements: Cu, Zn, Pb, Mn, Ca, K and Fe by direct aspiration via atomic absorption spectrophotometer. This procedure was repeated for all the samples collected (Anna *et al.*, 2013).

Results and Discussion

Physicochemical parameters

pH

Table 1 shows the physico-chemical parameters of eight selected energy drinks. It present the mean ± SD of the pH of the sampled energy drinks at the temperature of 26^0C. The value of pH ranged from 2.89± 0.04 to 3.50±0.04. The sample LB has the least concentration of pH while sample LS has the highest concentration of pH. The result obtained were in line with the pH <3.0 and <4.0 of beverages carried out in United states by Avanija*et al*. (2016), 2.75 to 366 Reported by Mohammed *et al.* (2012), Oladejo and Victoria (2014). But less than 4.47±0.01 to 5.27±0.01 recorded by Gimba*et al.* (2014). All the value of pH of the energy drinks was measured to be less than 7, and hence, acidic. The low pH value of these drinks may be attributed to the CO_2 gas used as preservative in these drinks or could be due to presence of acid such as citric, phosphoric, ascorbic, malic and tartaric acids used as preservative (Bassiouny and Yang, 2005; Ahurst, 2005).

Turbidity

The mean ±SD of the turbidity of the sampled energy drinks is shown on Table 1. The turbidity of the energy drinks ranged from 110.2±0.14 to 112.6±0.28 NTU. This result were within the range of the result obtained by Gimba*et al*. (2014) who reported a ranged of 53±1.73. Sample FG is less turbid, while sample pH has the highest turbidity (112.6±0.28 NUT). Turbidity is the measure of the degree to which water loses its transparency due to presence of suspended particles. The more total suspended solids in the water, the murkier it seems and the higher the turbidity (Maurice, 2010). Turbidity is considered as a good measure of the quality of water. The suspended particles help the attachment of heavy metals and other toxic organic compounds which may pose negative health effects to the consumers by Gimba*et al.* (2014).

Total dissolved solids (TDS)

The total dissolved solids (TDS) ranged from 156 ± 0.70 to 834.75 ± 8.83 mg/L as shown in Table 1. These values were within the range of 243±0.577 to 940 mg/L reported by Gimba*et al.* (2014)and 327.37 to 1480 mg/L reported by Obuzor and Ajaezi (2010) for malt drinks. Sample LS had the highest TDS while sample LB had the least TDS. Beverages with high values of TDS are likely to contain metals (essential and toxic) at high concentrations which may cause adverse health effects when consumed (Gimba*et al.*, 2014). All TDS of sample energy drinks were significantly different from each other.

Conductivity

Conductivity of energy drinks ranged from 166.95±1.44 to 1024±2.828 µS/cm as shown in Table 1. These values were within the range of 497 ± 0.00 to 1935 ± 1.55 µS/cm reported by Gimba*et al.* (2014)and 2.93 to 1999 µS/cm reported by Obuzor and Ajaezi (2010) for malt drinks. Sample LS is least conductive while sample BT has the highest conductivity. The mean conductivity of all sampled energy drinks was within the permissible limit for conductivity in beverages. Conductivity is the ability of electricity to pass through water using the impurities contained in the water as conductors. When water has a lot of impurities, it is more conductive; however, if water is pure, it is less conductive unless it is polarized (Maurice, 2010; Gimba*et al.*, 2014). Hence, energy drinks conduct electricity because it contains ions and it follows that energy drink with the highest concentration of ions will conduct the most.

Table 1: Physicochemical parameters of the eight selected energy drinks

Sample	pH	Conductivity	Total Dissolved Solid	Turbidity
LS	3.50 ± 0.004	166.95 ± 1.768	834.75 ± 8.839	111.30 ± 0.141
PH	3.23 ± 0.004	839 ± 2.828	419.50 ± 1.414	112.60 ± 0.283
SE	3.14± 0.006	531 ± 0.000	265.50 ± 0.000	110.65 ± 0.495
BT	3.66± 0.004	1024 ± 2.828	512 ± 1.414	112.05 ± 0.707
XR	2.93 ± 0.002	415.50 ± 3.535	207.75 ± 1.768	111.00 ± 0.000
LB	2.89 ± 0.004	312 ± 1.414	156 ± 0.707	110.80 ± 1.131
CL	3.25 ± 0.006	675 ± 5.657	337.50 ± 2.828	110.45 ± 0.071
FG	3.42 ± 0.028	881 ± 4.243	440.50 ± 2.121	110.20 ± 0.141

Table 2: Elemental analysis of the eight selected energy drinks (mg/L)

Sample	Ca	Cu	Fe	K	Mn	Pb	Zn
LS	100.00 ± 0.014	0,161 ± 0.001	2.692 ± 0.001	750 ± 0.001	0.545 ± 0.001	0.163 ± 0.001	5.345 ± 0.001
PH	125.00 ± 0.283	0.323 ± 0.001	2.308 ± 0.001	155 ± 0.003	0.727 ± 0.000	0.217 ± 0.001	1.897 ± 0.001
SE	110. 00 ± 0.014	0.161 ± 0.000	1.154 ± 0.001	937.5 ± 0.001	0.455 ± 0.008	0.054 ± 0.001	2.586 ± 0.001
BT	125.00 ± 0.014	0.323 ± 0.001	1.538 ± 0.001	31.28 ± 0.001	0.273 ± 0.001	0.109 ± 0.001	3.966 ± 0.001
XR	110.00 ± 0.000	0.323 ± 0.000	2.308 ± 0.003	191.25 ± 0.001	0.182 ± 0.001	0.163 ± 0.003	3.448 ± 0.001
LB	100.00 ± 0.283	0.161 ± 0.001	0.385 ± 0.001	17.5 ± 0.001	0.636 ± 0.001	0.435 ± 0.283	7.241 ± 0.001
CL	140.00 ± 0.014	0.323 ± 0.003	1.538 ± 0.001	20 ± 0.001	0.273 ± 0.003	0.217 ± 0.001	3.793 ± 0.001
FG	155.04 ± 0.707	0.323 ± 0.001	0.769 ± 0.001	21.25 ± 0.001	0.909 ± 0.000	0.380 ± 0.001	5.690 ± 0.001

Elemental analysis

Lead

Lead concentration of energy drinks ranged from 0.054±0.001 to 0.435±0.283 mg/L. sample LB had the highest and sample SE had the lowest as shown in Table 2. The lead concentration are within the ranged of 0.447 mg/L as reported by Sylvester *et al.* (2016) in beverage drinks. But is higher than the value of 0.028 ± 0.0006 to 0.139 ± 0.0004 mg/L reported by Casimir*et al.* (2014), 0.001 mg/L reported by Orisakwe (2014) and 0.010±0.00 to 0.020±0.00 mg/L reported by Ogulana*et al.* (2015). Maduabuchi *et al.* (2006) also reported lead levels of 0.002 to 0.0073 mg/L in canned drinks and 0.092 mg/l in non-canned drinks. These were lower compared to the values determined in energy drinks. The maximum contaminant level of lead is 0.01 mg/L (WHO 1993). Lead is a non-essential element for living organism and it is highly toxic to man and animal (FiField, 1997). Lead toxicity influences brain, heart, kidney, liver nervous system and pancreas. It may cause many signs and symptoms such as abdominal pain, anemia anorexia, anxiety, bone pain, brain damage, confusion, Fatigue, headaches and hypertension. Lead is found in the Earth’s crust and has been reported to emit from anthropogenic activities, such as combustion of fossil fuels, mining, paint, batteries production, etc. Lead detected in samples were within the recommended limit. Therefore, the contents of lead lie below the safety limit and can be consumed without any risk regarding the concentration of lead.

Copper

The concentration of Copper in energy drinks are ranged from 0.161±0.001-0.323 ±0,003 mg/L samples LS, SE and XR had the least concentration while samples PH,BT,LH and CL had the highest concentration, the value were high compared to the value 0.002 ± 0.0002 - 0.070 ± 0.0006 mg/L. reported by Gimba*et al.* (2014) in energy drink. But are with the result of 0.04-0.79 reported by Sylvester *et al.* (2016) and 0.040±0.01-0.590±0.01 reported by Ogulana*et al.* (2015). In soft drinks. Copper is one of the essential heavy metals found in the environment, including water and Soil. The biological functions of copper include cell metabolism, normal iron metabolism, and red blood cell (hemoglobin) synthesis, connective tissue metabolism, and bone development (Izah*et al.*, 2016). In this present study, the concentration of Copper in energy drinks are within the recommended permissible limit of 1.0-2.0 mg/L set by SON and WHO (Izah*et al.*, 2016).

Zinc

Table 2 shows the concentration of zinc ranged from 1.897±0.001 to 7.241±0.001 mg/L sample PH had the least concentration while sample LB had the highest concentration. These results are higher than the value of 0.45 to 0.83 obtained by Gizaw. (2013) in Mango juice and 0.016±0.00 to 1.620±0.04 reported by institute of medicine (2015). In soft drink but lower than the result of 0.011 to 228 reported by Sylvester *et al.* (2016) in non-carbonated soft drinks 0.045±0.0001 to 13.887±0.00037 reported by Gimba*et al.* (2014) in energy drinks. Sample FG, LS and LB had reached the acceptable limit while the rest are below. The recommended dietary allowance of zinc is 15 mg per day for men and 12 mg per day for women (ATSDR, 1994). The acceptable limit for human consumption of zinc is 5 mg/L (Pearson, 1976; FAO, 1980). Zinc is an essential trace element, performs important biochemical functions and is necessary for maintaining health throughout life. Zinc constitutes about 33 ppm of adult body weight and is essential as constituent of many enzymes involved in a number of physiological functions, such as protein synthesis and energy metabolism. In recent years, zinc has been identified as a mineral that plays important role in the genes and progression of several diseases related in certain manner to oxidative stress (Hossieni, 2011). Zinc deficiency resulting from poor diet alcoholism and mal-absorption, causes dwarfism, hypogonadism and dermatitis (Ensminger, 1995). Its presence in environment and consequent up take by humans causes pulmonary manifestation, fever, chills and gastroenteritis (Hossieni, 2011).

Iron

The concentration of iron ranged from 0.385±0.001-2.692±0.001 mg/L. Sample LB had the least concentration while sample LS had the highest concentration. This are with the result of 0.020-2.460 mg/L reported by Maduabuchi*et al.* (2006) in canned beverages and is lower than the result of 8.44-17.52 reported by Tesfaye (2013) in mango juice. Higher than the result of 0.08-0.55 reported by Sylvester *et al.* (2016). Iron is an essential element in the production of red blood cells. Low intake of iron cause anemia, tiredness and pallid physique, while high intake may result in to hepatic megaly, cardiac infraction and nephric malfunction. in soft drinks. The maximum contaminant level (MCL) of iron is 0.03 mg/L (WHO, 2011). All the sampled energy drinks had iron concentration higher than the MCL.

Manganese

The concentration of manganese energy drinks ranged from 0.182±0.001 to 0.909±0.000 mg/L. sample XR had the least concentration while sample FG had the highest concentration of energy drinks as show in Table 2. These correspond to the result of 0.021 to 0.43 reported by (Anna *et al.*, 2013) in energy drinks lower than the result of 12.90±1.12 to 51.74±2.44 mg/L. reported by Ameyaw*et al.* (2011). but higher than the result of 0.003 ± 0.0001 mg/L. reported by Gimba*et al.* (2014). Manganese help the body form connective tissue, bone, blood clothing factors and sex hormones. Deficiency in manganese leads to various health problems, which may include bone malformation, eye and hearing problems, high cholesterol levels, hypertension, infertility, weakness, heart disorders, memory loss, muscle contraction, tremors, seizures (Institute of Medicine, 2001). It could also result in decreased learning ability in school-aged children and increase the propensity for violence in adult (Finley, 2004).

Calcium

The calcium concentration of energy drinks ranges from 100.00±0.014 to 155.014±0.707 mg/L. samples LS and LB had the least while sample FG had the highest. This result is higher than the result of 3.14 to 5.3 mg/L reported by Lesniewicz*et al*. (2016) in energy drink, 11.41±1.11 to 27.74±2.70 mg/L reported by Ameyaw*et al*. (2011) in juices fruit and 2.763±0.0009 to 13.143±0.0011 mg/L reported by Gimba *et al*. (2014). This result was also less than the maximum level of 2.5 g/day reported by Ryan-Harshman and Aldoori (2005). The body needs calcium to maintain strong bones and to carry out many other important functions. The calcium is primarily sourced from the milk solids as well as added to the composition. Calcium is necessary for blood clotting, stabilizes many body functions and is thought to assist in preventing bowel cancer (Attieh, 1999). It has a natural calming and tranquilizing effect and is necessary for maintaining a regular heartbeat and the transmission of nerve impulses. The required amount include: 1,000 mg/day for people aged 19 to 50 years and 1,200 mg per day for people over the age of 51 years. The maximum level of calcium is 2.5 g/day (Ryan-Harshman and Aldoori, 2005). Rickets, tetany, and osteoporosis can result its deficiency. Hypertension and colon cancer may relate to chronic low intake.

Potassium

The concentration of potassium in energy drinks ranged from 7.50±0.001 to 937±0.001 mg/L. As shown in Table 2, they are in line with the result of 37.91±91 to 237.0±10.91 mg/L. Reported by Ameyaw*et al.* (2011) in fruit juices, higher than in carbonated beverages of 14.13±0.15 to 47.49±4.27 and 2.00 to 110 reported by Lesniewicz*et al*. (2016). Only sample LS recorded high level of potassium. The minimum limit of The RDI of potassium ranged between 1600 to 5000 mg/day.The remaining fall below the recommended daily intake set by the WHO (2012). Increase in potassium intake from food to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease in adult. Potassium is involved in nerve function, muscle control and blood pressure. It works with sodium to maintain the body's water balance.

Conclusion

Although the number of energy drink selected for analysis are only eight, the data presented in this Study gave a preliminary outline about some interesting result of the content frequently consumed in Nigeria. Based on these analytical data and other reports it seems that the content levels of lead, copper, manganese, iron and zinc are within the recommended limit. The essential element (calcium and sodium) concentration was low although potassium showed a high concentration of potassium above the recommended limit set by food and agricultural organization.

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