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Levels of Selected Heavy Metals in Some Imported Canned Energy Drinks in Lagos Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OOJ designed the study and wrote the protocol. Author OTO collected all data, performed the statistical analysis, and wrote the first draft of the manuscript. Authors OO, ABS and OOO did the literature search and also wrote part of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Background: Energy Drink are drugs or beverage which is purported to boost mental or physical energy. The energy in these drinks is derived through a choice of stimulants, vitamins and herbal supplements the manufacturer has combined. Different brands of energy drinks are currently in high demands in this part of the country.
Aim: Trace metals (iron, zinc, manganese, cadmium and lead) were evaluated from ten brands of energy drinks *using Atomic Absorptive Spectrophotometer (AAS).*

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Methodology: Ten brands of imported energy drinks which reflect the most popular brands consumed were sampled in triplicate from Yaba, Ojuelegba and Oyingbo markets in Lagos-Nigeria. The drinks were digested by weighing 20ml of the energy drinks into an evaporating dish and 10ml of Conc.HNO_3 was added. Each metal was measured using the Atomic Absorption Spectrophotometer which was set up according to the wavelength corresponding to that of the element under investigation. Reagent blank determination was used to correct the instrument reading.
Results: All metals, except lead and cadmium, were present at varying concentrations in the drinks. The concentration of cadmium and lead were below detectable value while. by and large, the mean value of the metals found in the energy drinks ranges from 0.040 – 0.010ppm. Zinc has the highest individual concentration of metals and it is closely followed by iron and then manganese. The Order of abundance of these heavy metals in the samples is presented as follows: zinc > iron > manganese > cadmium = lead.
Discussion and Conclusion: These results showed that there is no risk in energy drink with respect to the concentrations of zinc, iron and manganese as they were within the permissible limits set by health authorities. The trace metals in canned drinks must be monitored comprehensively and periodically with respect to the consumer health as the safety of drinks and any other edible material cannot be compromised.

Keywords: Heavy metals; energy drinks; health; atomic absorption spectrometer; permissible limit; Lagos.

1. INTRODUCTION

Heavy metals contamination in recent time is receiving increasing awareness globally due to their activity in human body [1]. They are an important component of plants and animal tissues but have also been found in food and some drug preparations as a result of contamination or deliberate addition. The ingestion of food, environmental contamination and contamination during processing are obvious means of exposure of metals to the human body [2]. Although certain heavy metals are essential for animal tissue metabolism, the ranges between beneficial and toxic levels are usually small. There is an increasing concern about the health burden in humans due to continuous consumption of food contaminated with heavy metals. The extent of this contamination depends on several complex factors. One of them being specific metabolic and homeostatic mechanism operating in the type of food and tissue considered.

Health problems associated with heavy metal poisoning include disability in learning, impaired protein and hemoglobin synthesis and the shortening of lifespan of red blood cells leading to severe anemia (hypochromic microcytic anemia) in children [3].

Energy drink is a type of beverage which is purported to boost mental or physical energy. They are drinks and drugs that build up muscle and give more energy through a choice of stimulants, vitamins, and herbal supplements as combined by the manufacturer. They are often packaged in cans and have been marketed globally with different brand names. They are on high sale in Nigeria and are consumed in many parts of the world such as US and Canada and many European countries such as Latvia [4,5,6].

This study aimed at ascertaining the levels of Iron (Fe^{3+}), Zinc (Zn^{2+}), Manganese (Mn^{2+}), Cadmium (Cd^{2+}) and Lead (Pb^{2+}) in ten brands of energy drinks marketed in different part of Lagos City. They are all transition metals with partially filled d-orbitals. Their standard atomic weight are 55.845, 65.38, 54.94, 112.41 and 207.2 respectively. They all exhibit different physiological on the body system. While manganese, iron and zinc are beneficial to the human and animal body system in their right concentrations, lead and cadmium are toxic to the body system. Because manganese, iron, zinc and other beneficial heavy metals are required in small quantities essential for a healthy life, they are sometimes referred to as the trace elements [7].

Manganese plays a role in fat & carbohydrate metabolism, calcium absorption, and blood sugar regulation. Low levels of manganese in the body can contribute to infertility, bone malformation, weakness and seizures. It is fairly easy to get enough manganese in your diet. Manganese helps in the prevention and treatment of osteoporosis [8]. Iron is a very important part of the daily diet. Without enough of it, individuals can suffer a condition called iron deficiency (anemia) which symptoms include feeling dizzy, tired and apathetic. The immune system can become compromised as well [9]. Zinc finds therapeutic use for their local actions as mild astringents, emetics and antiseptics. Zinc is a constituent of insulin preparations for diabetes mellitus e.g insulin zinc suspension [10]. Lead is a cumulative poison and the target organs are the bones, brain, blood, kidneys, and thyroid gland [10,11].

Lagos city where the samples are collected is often referred to as the commercial nerve center of Nigeria and is located in the southwestern part of the country. It lies between latitude $6^{0}2^{'}$N to $6^{0}2^{'}$N and from longitude $2^{0}45^{'}$E to $4^{0}20^{'}$E. It occupies a total geographical area of about 3,475.1km^2. In the koppen climate classification system, Lagos has a tropical wet and dry climate that borders on a tropical monsoon climate and has temperature ranging from 13.90c to 37.30c[7]. It is the second fastest-growing city in Africa and the seventh in the world. With over 21million inhabitant, it is referred to as the largest-city in Africa [12,13].

The present study was carried out in view of the scarcity of information about heavy metals in canned foreign energy drinks imported into Nigerian Markets. It is hoped that our results will help in generating data needed for the assessment of toxic metal intake from this source.

2. MATERIALS AND METHODS

Ten brands of imported energy drinks were sampled in triplicate from Yaba, Ojuelegba and Oyingbo markets in Lagos-Nigeria. The triplicate samples were tagged batch 1, 2 and 3 respectively. The selection was specially made to reflect the most popular brands consumed. The sampled brands were also influenced by availability at the time of sampling. Samples were stored at almost identical conditions similar to those of retail shop.

To digest the sample, 20ml of energy drink were measured into an evaporating dish and 10ml of Conc.HNO_3 was added. The dish was gently heated on a regulated hot plate to dissociate the solvent into its component atoms. Heating was then continued until the brown fumes turned white (colorless). It was allowed to cool to room temperature. The concentrated sample mixture was rinsed with 10ml of de-ionized water and filtered into a 25ml standard volumetric flask and made up to mark with distilled water [14]. The digested sample was stored in a special container ready for analysis. This same process was repeated for all the energy drink samples. The Atomic Absorption Spectrophotometer was set up according to the wavelength corresponding to that of the element under investigation. This Spectrophotometer (PERKIN ELMER A. Analyst 200; Germany) consist of a hollow cathode lamp, slit width of 0.7 nm and an air-acetylene flame.

Acceptable quality assurance procedures and precautions were carried out to ensure reliability of the results. All samples were cautiously handled to avoid contamination. Glassware were soaked in 1M nitric acid for 48hours and rinsed with ultra pure water. The reagents (HNO_3 and distilled water) were of analytical grades. Reagent blank determination was used to correct the instrument reading [11]. Calibration standards were made by dilution of high purity commercial BDH metal standards ($CdSO_4.8H_2O$, $Pb(NO_3)_2$, $Fe(NO_3)_3.9H_20$, $MnSO_4.4H_20$and $ZnSO_4.7H_20$) for atomic absorption analysis. Concentrations for calibration are 2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm.

3. RESULTS AND DISCUSSION

Table 1 represents the Mean ± SD of heavy metals (ppm) characteristics of canned energy drink while Table 2 shows the range of these heavy metals in the samples. Iron, zinc and manganese were present in all the brands analyzed but cadmium and lead were absent or beyond detection level.

Generally, the mean value of the metals ranges from 0.040ppm – 0.010ppm. Zinc has highest average value of 0.040ppm in sample D while Manganese records the lowest average value of 0.010pm in sample B. Zinc has the highest individual concentration of metals and it is closely followed by iron and then manganese. The Order of abundance of these heavy metals in the samples is presented as follows: zinc > iron > manganese > cadmium = lead.

The absence of lead and cadmium in these samples devoid the drinks of toxicity potentials. This is because the presence of lead alone can cause both acute and chronic symptoms of poisoning depending on the level and duration of exposure. They could lead to reduction of mental intelligence, growth disturbances, spasticity, severe kidney damage and their ability to possibly substitute for calcium in bone causing skeletal anomalies especially in children [15,16,17]. While cadmium on the other hand accumulates in the human body and cause some diseases[1].It is proven to be associated with renal dysfunction, obstructive lung disease which has been linked to lung cancer. It may also produce bone defects (osteomalacia), or can cause skin irritation and cause ulceration. In Japan, the Itai-itai sickness (associated with bone damage) is a result of the regular consumption of rice highly contaminated with cadmium [18].

When compared with the standard values (Table 3), the values of iron, zinc and manganese concentrations are within the consumption range as they are within the WHO permissible limit. Though inorganic metals have wide range of functions in the biological systems which include enzyme co-factors, co-transporters, electrolytes and ligands, they may be harmful when they are excessively higher than their permissible limits too [19,20].

The result of the metals distribution in the samples is further represented graphically in Fig. 1.

Table 1. Mean ± SD of heavy metals (ppm) characteristics of canned energy drink

Samples	Fe	Zn	Mn	Cd	Pb
A	0.019 ± 0.001	0.035 ± 0.056	0.013 ± 0.000	N.D	N.D
B	0.017 ± 0.000	0.033 ± 0.011	0.010 ± 0.001	N.D	N.D
C	0.015 ± 0.001	0.032 ± 0.002	0.011 ± 0.002	N.D	N.D
D	0.015 ± 0.000	0.040 ± 0.012	0.014 ± 0.003	N.D	N.D
E	0.018 ± 0.001	0.031 ± 0.010	0.016 ± 0.000	N.D	N.D
F	0.020 ± 0.000	0.033 ± 0.013	0.020 ± 0.001	N.D	N.D
G	0.017 ± 0.003	0.027 ± 0.007	0.018 ± 0.000	N.D	N.D
H	0.024 ± 0.001	0.034 ± 0.006	0.020 ± 0.000	N.D	N.D
I	0.024 ± 0.001	0.028 ± 0.003	0.021 ± 0.000	N.D	N.D
J	0.021 ± 0.001	0.029 ± 0.007	0.017 ± 0.000	N.D	N.D

ND= Not Detected or below detection limit. The detection limit = 0.001ppm

Table 2. Range of heavy metals (ppm) in the canned energy drinks

Samples	Fe	Zn	Mn	Cd	Pb
A	0.019-0.021	0.021-0041	0.012-0.015	N.D	N.D
B	0.016-0.019	0.017-0.042	0.009-0.012	N.D	N.D
C	0.013-0.017	0.026-0.036	0.010-0.014	N.D	N.D
D	0.015-0.017	0.023-0048	0.009-0.017	N.D	N.D
E	0.017-0.020	0.019-0.040	0.015-0.017	N.D	N.D
F	0.019-0.021	0.021-0.040	0.019-0.022	N.D	N.D
G	0.017-0.018	0.017-0.033	0.017-0.019	N.D	N.D
H	0.022-0.026	0.026-0.039	0.019-0.021	N.D	N.D
I	0.023-0.026	0.023-0.031	0.020-0.022	N.D	N.D
J	0.019-0.023	0.019-0.034	0.016-0.018	N.D	N.D

ND= Not Detected or below detection limit. The detection limit = 0.001ppm

Table 3. World Health Organization permissible limits

Metals	WHO permissible limit (ppm)
Iron	0.3
Manganese	0.03
Zinc	0.5/1.0
Cadmium	0.003
Lead	0.01

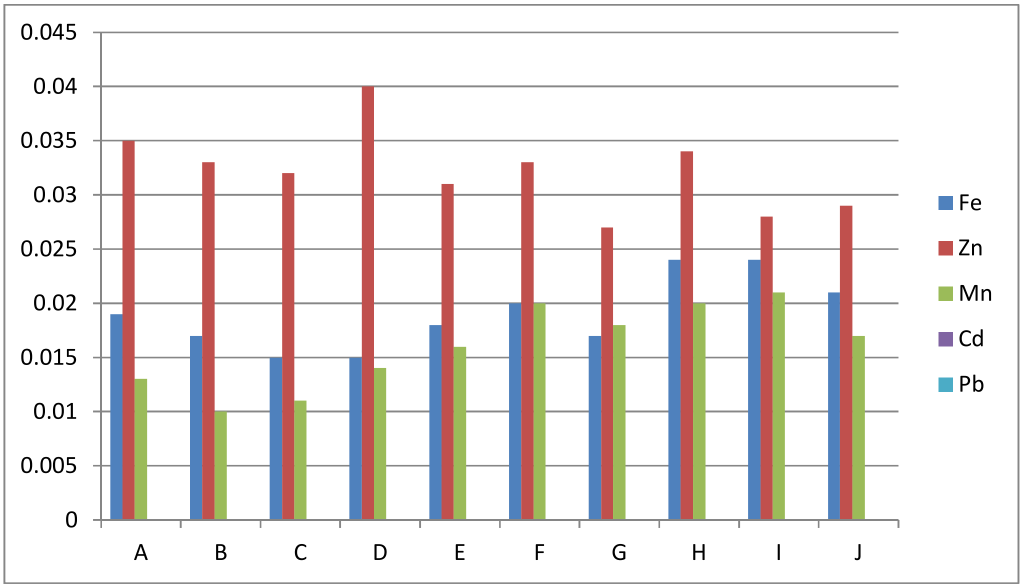

Fig. 1. Mean levels of heavy metals in each brand of drink

The sampled drinks can be said to be safe for consumption because none of the selected toxic heavy metals were present and the inorganic metals are within the permissible range.

The results from this study are contrary to a similar research conducted by Chukwujindu et al. [16] when they investigated the presence of various heavy metal such as lead, cadmium, iron, manganese, copper, nickel, chromium, zinc in canned fruits juice. Only manganese, zinc and iron had values that were within the statutory safe limits. Every other metals including the highly toxic lead (0.06-1.93ppm) and Cd (0.002-0.49ppm) had levels that were beyond the permissible limits. In another similar investigative analysis where the presence of selected heavy metals were determined in juice and carbonated drinks by Williams et al. [21], relatively high concentrations were recorded for lead and manganese while those of copper, iron, chromium, zinc, cadmium and cobalt were within the permissible limit. To avoid the presence of heavy metals in drinks, internationally accepted standard manufacturing ethics is hereby recommended prior to production. This is necessary for human safety.

4. CONCLUSION

In this study, the levels of iron, zinc, manganese, cadmium and lead in samples of canned energy drinks were reported. Contamination of these drinks by trace metals may occur from time to time during commercial handling and processing, depending on the conditions of the raw material. Therefore, monitoring of these products is important with respect to toxic elements affecting human health. Lead and cadmium were not detected in all the cans. It was also determined that there was no risk with respect to the concentrations of zinc, iron and manganese in the drinks. Our results may provide useful information for the assessment of toxic metal intake from this source.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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