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Risk assessment of the intake of heavy metals in locally and foreign packaged non-alcoholic beverages consumed by adults living within Emene in Enugu State, Nigeria

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Abstract

Studies were carried out to assess the risk associated with the intake of heavy metals in locally and foreign packaged non-alcoholic beverages consumed by adults living within Emene in Enugu State, Nigeria, using standard analytical procedures and instrumentation. The samples (Zobo drink, soya milk, tiger nut drink, maltina peps and spirite) after wet digestion were analyzed for the presence of Pb, Cd, Cu and Zn using atomic absorption spectrophotometer. The mean Pb range in the locally packaged non-alcoholic beverage (soya milk, zobo drink and tiger nut drink) samples was 0.035 - 0.053 $\mu\text{g/g}$ and 0.014-0.017 $\mu\text{g/g}$ in the foreign packaged non-alcoholic beverage (Pepsi, maltina and spirite) samples. Zn had a mean range of 1.371 - 5.622 $\mu\text{g/g}$ in the locally packaged beverage samples and 1.114-2.677 $\mu\text{g/g}$ in the foreign packaged beverage samples. Cd had a mean range of 0.033 - 0.060 $\mu\text{g/g}$ in the locally packaged beverage samples and 0 - 0.018 $\mu\text{g/g}$ in the foreign packaged beverage samples. In the same vein, the mean Cu range in the locally packaged non-alcoholic samples was 1.672-2.182 $\mu\text{g/g}$ and 0.462 - 1.873 $\mu\text{g/g}$ in the foreign packaged non-alcoholic beverage samples. There was no risk associated with the dietary intake of the studied metals by the adult consumers of the investigated non-alcoholic beverage samples in Emene, Enugu State.

Keywords: Heavy metals, locally packaged non-alcoholic beverage samples, foreign packaged non-alcoholic beverage samples and estimated daily intake

Introduction

Fluid intake in all forms in the diet is very important for maintaining maximum level of body hydration and general body well-being. Non-alcoholic beverages such as carbonated drinks, juices, energy drinks, coffee, tea, bottled water and probiotic drinks among others are consumed daily by people across all human society to quench taste, improve hydration and meet sundry health needs [16]. Stated that non-alcoholic beverages account for between 87 – 90% of the body's water supply. According to [4, 12, 25], water is critical for food digestion, absorption of ingredients, excretion of metabolic products and toxins, maintaining ion balance and acid-based body balance. Non-alcoholic beverages are consumed based on preference and specific individuals body needs and therefore its consumption is generally expected to improve body's wellness apart from enhancing hydration. In Nigeria, non-alcoholic beverages are easily the greatest source of water supply to the body and, both the locally produced or packaged and foreign packaged non-alcoholic beverages are ideal companion of people as they unwind or while at work and impacts positively on their sensory and health needs. For instance, [11] stated that zobo (*Hibiscus jarbdariffa*) drink, a locally produced non-alcoholic beverage from dried red calycas and sepals of roselle plant, which can be served both hot or cold; apart from its refreshing taste, lowers blood pressure, cholesterol level, clears the liver, relieves menstrual cramps and weight loss and are very rich in anti-oxidants, which are critical body requirements in fighting oxidative stress caused by the presence of free-radicals [13]. Observed that the increasing awareness of people in maintaining a healthy diet and body well-being, has increased the popularity of locally produced non-alcoholic beverages such as zobo drink etc. Other non-alcoholic beverages such as soya bean (*Glycine max*) milk (popular called soya milk) and tiger nut (*Cyperus esculentus*) drink because of their low sugar values are very popular among the Nigerian populace. According to [3], both soya milk and tiger nut drink are rich in minerals, high unsaturated fatty acids, which helps to enhance heart health and has abundant vitamin B₆ and vitamin B complex, which are good anti-depressants.

Furthermore [30], observed that soya milk and tiger nut drink are rich in calcium and magnesium, which promotes bone health and contains phyto-chemicals capable of lowering cancer risks. Apart from reducing glucose levels in the body, improving digestive health and boosting immune system [14], stated that soya milk contains isoflavones that helps to reduce symptoms of menopause such as hot flashes. According to [16], carbonated drinks such as malts, spirite, coke, pepsu etc., are ideal energy drinks for mental and physical activity and helps to keep the body hydrated because of high water content [19]. Stated that foreign packaged non-alcoholic beverages improve food digestion and helps to reduce heart problems due to the presence of potassium, folate and vitamin B₆. However, these non-alcoholic beverages, whether locally or foreign packaged apart from containing essential chemicals required for body's well-being, are not completely free from food contaminants such as heavy metals [14]. Heavy metals, being highly non-biodegradable, bio accumulative and persistent, are food toxicants that disrupt body's biochemical activities, causing malfunctioning of vital organs of the body and triggering life threatening illnesses [5, 7, 9, 10, 23, 24, 26]. Heavy metals being ubiquitous in our environment and are magnified in the food chain through undesirable anthropogenic activities of man, could easily contaminate the critical ingredients required for preparing both the locally and foreign packaged non-alcoholic beverages if the sources of the raw materials are heavy metal burdened. These ingredients such as water, flavouring agents, and plant materials (Soya beans, calycas and sepals of roselle and tiger nuts) may be contaminated with heavy metals from industrial discharges and fertilizer application, especially those raw materials that are soil derived [6, 10, 14, 20, 21, 27]. Non-alcoholic beverages, whether locally or foreign packaged form the daily drinking choice of the people as they recreate, refresh and quench their taste before, during or after meals. People, especially adults, consume non-alcoholic beverages almost daily to improve vitality and body functionality and therefore, their economic status, social status and occupational responsibility places them at a great disadvantage of being unduely exposed to food toxicants such as heavy metals. Emene is an economic thriving area, inhabited by people from all works of life, with a significant adult population, who consumes either locally or foreign packaged non-alcoholic beverages (Especially zobo drink, tiger nut drink, soya milk, pepsu, maltina and spirite) daily as part of their food diets and therefore, assessing the heavy metal levels in these non-alcoholic beverages and the possible exposure risk to these adult consumers necessitated this research.

Materials and Methods

Sample collection

The non-alcoholic beverage samples were purchased from open stores and supermarkets within Emene municipality in Enugu State. Five (5) plastic cans of each of the selected locally packaged non-alcoholic beverage (tiger nut drink, zobo drink and soya milk) samples and foreign packaged non-alcoholic beverage (spirite, maltina and pepsu) samples were gotten for the research. The samples were properly labeled and kept under laboratory condition prior to analysis.

Heavy metal determination

The samples were analyzed for the presence of Cd, Pb, Cu and Zn in accordance with the procedures described by [2]. Few drops of Conc. HNO₃ was added to about 0.5ml of the sample in a beaker and heated until a light-coloured clear solution was obtained. The digest was then filtered into a 100 ml beaker, cooled and made-up to mark with de-ionized water. The solution digest was thereafter analyzed for the presence of Pb, Cd, Zn and Cu using UNICAM 969, atomic absorption spectrophotometer. The samples were prepared in triplicates and adequate quality control measures were employed to ensure the reliability of the data obtained.

Statistical Analysis

The data obtained were expressed in mean and standard deviation and subjected to one way analysis of variance (ANOVA) at 5% confidence level using IBM SPSS 23.0.

Human Risk Assessment

The risk assessment of the studied heavy metals to the adult population, who consumes the non-alcoholic beverage samples daily was done using the following equation;

$$EDI = \frac{C \times Ac}{bw}$$

where EDI connotes the estimated daily intake of the metals (µg/ kg bw/day), C represents the concentration (µg/g) of the selected studied metals in the non-alcoholic beverage drink samples, Ac connotes the average weight (360g) of the selected non-alcoholic beverage drink samples consumed daily by the investigated population and this was gotten using questionnaire while, bw represents the average bodyweight (60 kg) of the adult population.

Results and Discussion

Table 1: Mean heavy metal levels in the investigated non-alcoholic beverage samples

Sample Metal (µg/g)	Soya milk	Zobo drink	Tiger nut drink	Maltina	Spirite	Pepsu	F test P value	[29] std.
Pb	0.041±0.003	0.035±0.012	0.053±0.007	0.017±0.005	0.014±0.003	—	0.01	0.05
Zn	1.735±0.047	2.403±0.320	5.622±0.873	2.677±0.212	1.371±0.033	1.114±0.513	0.01	10
Cd	0.060±0.026	0.044±0.011	0.033±0.024	—	—	0.018±0.001	0.02	0.05
Cu	2.182±0.403	1.672±0.342	2.097±0.272	0.873±0.484	0.583±0.176	0.462±0.310	0.01	2

Lead: The result of Table 1 shows that the mean Pb values in the soya milk, zobo drink, tiger nut drink, maltina and spirite samples were, 0.041 ± 0.003, 0.035 ± 0.012, 0.053 ± 0.007 and 0.017 ± 0.005µg/g respectively. The non-alcoholic beverage samples had mean Pb values in the

following decreasing order; tiger nut drink > soya milk > zobo drink > maltina > spirite as shown in Fig. 1. Lead was not detected in the pepsu samples. The mean Pb values in the studied non-alcoholic beverage samples was statistically significant.

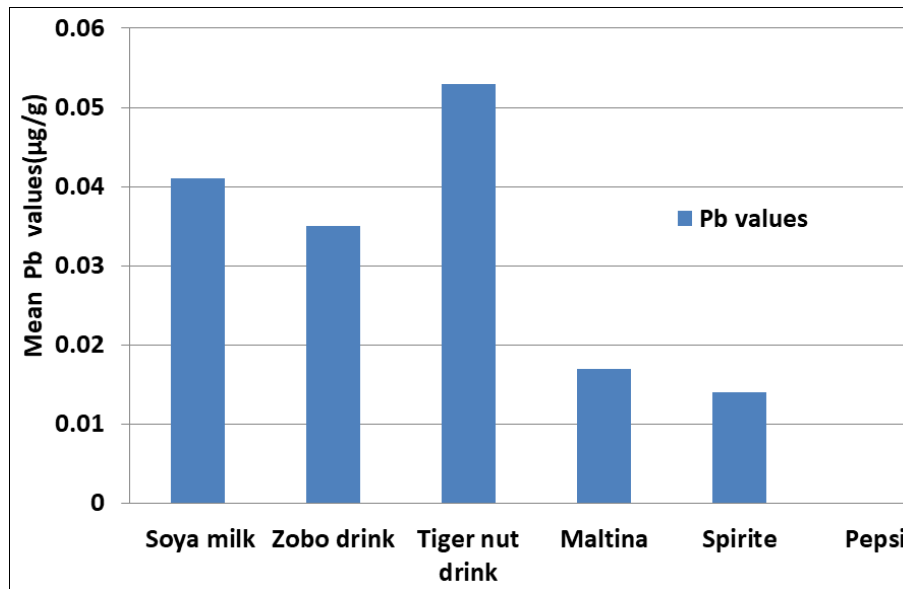


Fig 1: Mean Pb values in the non-alcoholic beverage samples sold at Emene in Enugu State, represented in a bar chart.

The different sources of raw materials and processing conditions adopted in producing the samples, some of which could have followed anthropogenic heavy metal contamination could have given rise to their varying Pb values. The mean Pb values in the tiger nut drink samples was above the recommended threshold limits as established by [29], however, the mean values of the metal in the other studied samples were within the permissible limits. It was also observed that the mean Pb values in the locally packaged non-alcoholic beverages were higher than it was obtained for the metal in the foreign packaged non-alcoholic beverage samples. According to [5, 9, 11, 31, 24, 25], agricultural practices such as undue inorganic fertilizer application, discharge of untreated industrial effluents in water bodies and the topography of soil areas greatly impacts on the heavy metal load in such environment and agricultural produce harvested within such soil areas are usually heavily burdened with heavy metals. This submission could have been the reason for the higher mean Pb presence in the locally produced and packaged non-alcoholic beverage samples, whose main sources of raw materials are usually

from the soil [15]. Reported a lower mean Pb value of 0.13 µg/g in three popular local non-alcoholic drinks consumed in Benue State, than what was gotten for the metal in the locally packaged beverage samples sold at Emene in Enugu State. The toxicity associated with undue exposure to Pb, especially to the bone, kidney, liver, central nervous system and intelligence quotient (Especially for kids) have been well described as reported by [4, 5, 7, 9, 12, 21, 24].

Zinc: Zinc is an important trace element, required by the body for optimum biochemical and enzymatic activities. Its deficiency in the body can result to nausea, vomiting, constipation, bone defects and vision impairment as reported by [7, 10, 11, 25]. The result of Table 1 shows that the mean Zn values in the studied soya milk, zobo drink, tiger nut drink, matina, spirite and pepsi samples were, 1.735 ± 0.047 , 2.403 ± 0.320 , 5.622 ± 0.873 , 2.677 ± 0.212 , 1.371 ± 0.033 and 1.114 ± 0.513 µg/g respectively. The mean Zn values in the samples decreased in the following order; tiger nut drink > maltina > zobo drink > spirite > pepsi as shown in Fig. 2.

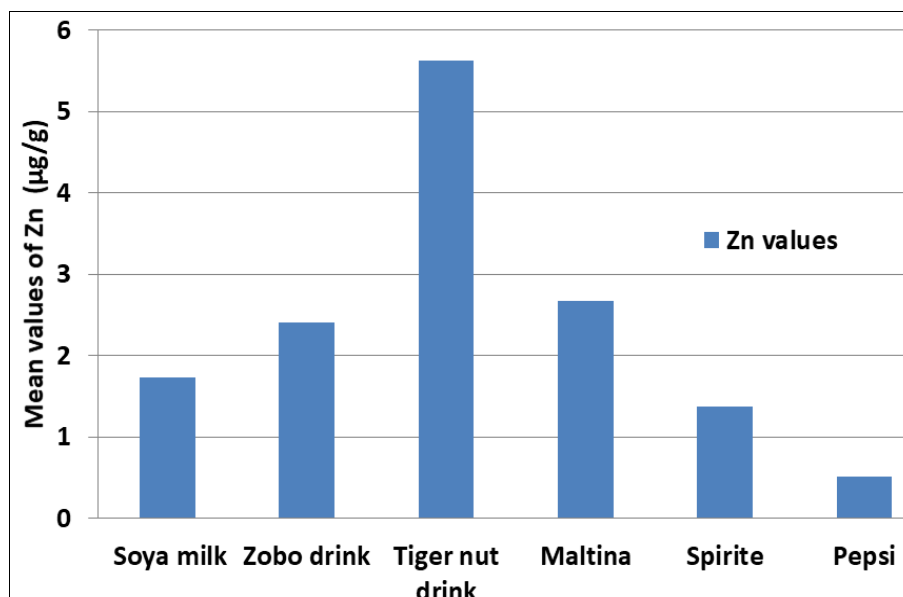


Fig 2: Mean Zn values in the non-alcoholic beverage samples sold at Emene in Enugu State, represented in a bar chart.

The mean Zn values in the studied non-alcoholic beverage samples were within the permissible limits but were however, statistically significant. Higher mean Zn values were recorded for the locally produced and packaged samples, which underscores their rich mineral composition and could serve as potential chief suppliers of essential trace elements to the body from fluid intakes by the people. Undue exposure to Zn to humans could trigger acute to severe health challenges as reported by [4, 6, 7, 27, 19]. Reported a lower mean Zn value of 0.10 µg/g in the malt samples sold at supermarkets in Port Harcourt, Rivers State, than what

was gotten for the metal in the studied maltina samples sold at Emene in Enugu State.

Cadmium: Cadmium is a food toxicant of special concern to environmentalists and health scientists. Its presence in any food portends great concern to man. The result of Table 1 shows that the mean Cd values in the soya milk, zobo drink, tiger nut drink and pepsi samples were, 0.060 ± 0.026 , 0.041 ± 0.011 , 0.033 ± 0.024 and 0.018 ± 0.001 µg/g respectively. The metal was not detected in both the maltina and spirite samples. The beverage samples had mean Cd values in the following decreasing order; soya milk > zobo drink > tiger nut drink > pepsi as shown in Fig.3.

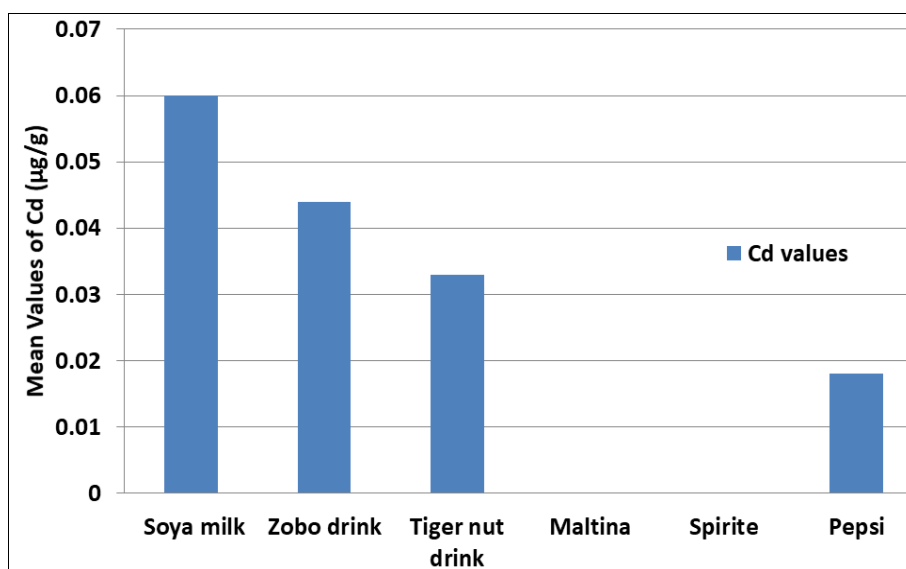


Fig 3: Mean Cd values in the non-alcoholic beverage samples sold at Emene in Enugu State, represented in a bar chart.

Of the six studied samples, only soya milk samples had mean Cd value above the recommended permissible limits. The indiscriminate and unchecked anthropogenic activities going on in our environment, which proliferates heavy metals that are easily translocate through plant roots, increases the concern about the safety of agricultural produce from heavy metals [4, 6, 7, 12, 20, 24, 26]. This indeed could be the reason for the higher presence of Cd in the locally packaged non-alcoholic beverage samples than it was in the foreign packaged non-alcoholic beverage samples. The mean Cd values in the studied beverage samples were statistically significant. Although [19] reported a mean Cd value of 0.010 ± 0.003 µg/g in popular malt drinks sold at supermarkets in Port-Harcourt, Rivers State, the metal was undetected in the investigated maltina samples sold at Emene in Enugu State. The debilitating effects of undue exposure to Cd to man’s health either dermally, orally or inhalation have been well reported [5, 9, 10, 31].

Copper: Copper is an essential trace element required by the body for both enzymatic and non-enzymatic functions, along with other essential trace elements such as zinc and iron. It is an essential trace element required for the well-being of both plants and animals.

The result of Table 1 shows that the mean Cu values in the soya milk, zobo drink, tiger nut drink, maltina, spirite and pepsi samples were, 2.182 ± 0.403 , 1.672 ± 0.342 , 2.097 ± 0.272 , 0.873 ± 0.484 , 0.583 ± 0.176 and 0.462 ± 0.310 µg/g respectively. The metal was present in the investigated samples in the following decreasing order; soya milk > tiger

nut drink > zobo drink > maltina > spirite > pepsi as shown in Fig. 4.

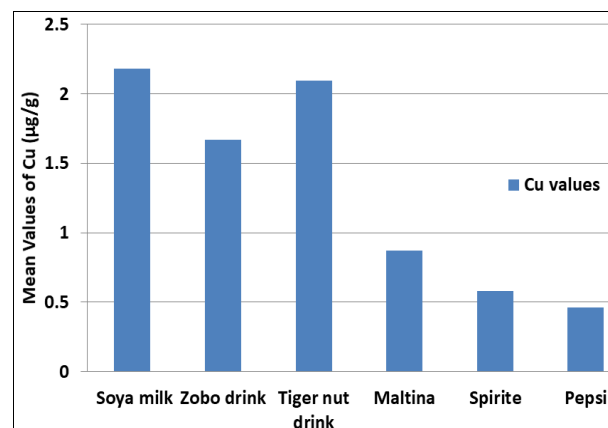


Fig 4: Mean Cu values in the non-alcoholic beverage samples sold at Emene in Enugu State, represented in a bar chart

The mean Cu values in the investigated locally and foreign packaged non-alcoholic beverage samples were statistically significant. The mean Cu values in both the soya milk and tiger nut drink samples was above the threshold limits. Unwholesome practices by farmers [27], may have contributed to the increased levels of Cu in the locally produced and packaged non-alcoholic beverage samples since the main sources of raw materials for their production are soil derived. Another likely source of increased Cu in the beverage samples could be the use of water from heavy

metal contaminated environment by the processors. Increased exposure to Cu by man can result to an excessive retention of it in the liver, which can cause damage to the liver [4, 20, 21, 31, 24, 28]. Reported a lower mean Cu value of $0.511 \pm 0.168 \mu\text{g/g}$ in the tiger nut residues within Kaduna metropolis than what it was in the investigated tiger nut drink samples sold at Emene in Enugu State. Varying topography, soil chemistry and anthropogenic activities in this two compared areas could have been responsible for the wide variation of Cu levels in the compared samples.

Human Health Risk Assessment

Table 2: The adult population's estimated daily intake ($\mu\text{g/kg}$ bw/day) of the investigated metals (Pb, Cd, Cu and Zn) from the daily consumption of the non-alcoholic beverage samples sold at Emene in Enugu State

Sample	Pb	Cu	Cd	Zn
Soya milk	0.25	13.09	0.36	10.41
Zobo drink	0.21	10.03	0.25	14.42
Tiger nut drink	0.32	12.58	0.20	33.73
Maltina	0.10	11.23	—	16.06
Sprite	0.08	3.50	—	8.22
Pepsi	—	2.77	0.11	6.68
PMTDI, [8, 29]	3.6	70	0.83	1000

As shown in Table 2, the average daily intake of the studied metals from the consumption of the non-alcoholic beverage samples by the adult population living in Emene, Enugu State, were within the provisional tolerable maximum daily intake of the metals as established by [8, 29]. Although the adult population are at a daily risk of increased dietary exposure to the metals from the consumption of the locally packaged non-alcoholic beverage samples, careful sourcing of raw materials from less heavy metal contaminated environment and moderate application of inorganic fertilizer to the soil, would help reduce this risk.

Conclusion

The locally packaged non-alcoholic beverage (zobo drink, tiger nut and soya milk) samples showed higher burden with the studied metals than the foreign packaged non-alcoholic beverage (Maltina, pepsi and sprite) samples, although the only exception was the considerable high mean Zn values in the maltina samples. Lead in the tiger nut samples, cadmium in the soya milk samples and copper, in both the soya milk and tiger nut samples, were at mean toxic levels when compared with their established permissible limits. The average daily intake of the studied metals by the adult population, who consumes the non-alcoholic beverage samples daily, were within the metals' provisional maximum tolerable daily intakes. Because these non-alcoholic beverages are common fixture accompanying the daily meals of people of all ages in our society, periodic assessment of their heavy metal burden by health authorities is very important, in order to safeguard the health of the people from this food toxicant.

Conflicts of Interests

The authors' declare that there are no conflict of interests in carrying out this research and its publication.

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