British Journal of Applied Science & Technology
12(6): 1-8, 2016, Article no.BJAST.19163
ISSN: 2231-0843, NLM ID: 101664541

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Determination of Metals Content of Alcohol and Non-alcoholic Canned Drinks Consumed at Idiroko Border Town Ogun State Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author SGS designed the study, author OOA performed the statistical analysis, author AAA wrote the protocol, author SGS wrote the first draft of the manuscript and Hammed managed the literature searches. Authors SGS, OOA, AAA and TBH managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2016/19163
Editor(s):
(1) Rui Xiao, School of Energy and Environment, Southeast University, China.
Reviewers:
(1) Taratisio Ndwiga, Moi University, Kenya.
(2) Jeremiah Odhek Masime, The Technical University of Kenya, Kenya.
(3) Jorge Isaac Castro Bedriñana, National University of the Center of Peru, Peru.
(4) Chen-Chin Chang, University of Kang Ning, Taiwan.
Complete Peer review History: http://sciencedomain.org/review-history/12074

Original Research Article

Received 28th May 2015
Accepted 27th August 2015
Published 3rd November 2015

ABSTRACT

Aims: The study was carried at the Idiroko Border Town in Ogun Southwestern Nigeria, a popular border known for movement of goods and service, an international border town a gateway for many ECOWAS countries is chosen known for movement of smuggled goods and services. The study was aimed at the proliferation of canned alcoholic and non alcoholic drinks and their qualities were determined for public health concern. Therefore, a total of 28 canned alcoholic (Harp, 33, Star,

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Gulder, Guinness, Heinken, Turbo, Smirnoff and Red Bull) and 31 canned non-alcoholic (Farouz, Snappes, Cocacola, Sprite, Amstel Malta, Fanta, Malta Guinness and Maltina) samples were collected from Idiroko border area of Ogun State, Nigeria to determine levels of essential and toxic metals detected in these consumed products.

Methods: The numbers of samples as shown in the methodology were prepared with standard wet digestion procedure, while the metals were analysed using the Atomic Absorption Spectrophotometer (Buck 210) techniques and the results were then compared with WHO standards.

Results: The metal concentrations ranges from 0-3.25 mg/l, 20.08-133.20 mg/l, 0.97-2.45 mg/l, 0-0.44 mg/l, 0-0.26 mg/l, 0-0.30 mg/l, 0-0.14 mg/l, 0.11-7.38 mg/l, 0-0.02 mg/l for Cu, Mg, Fe, Pb, Cd, Ni, As, Zn, and Cr respectively. High concentration of toxic metals such as Pb, Cd, and Ni above WHO recommended limit were recorded from some non alcoholic samples but all the alcoholic samples revealed low concentration of Cd. The samples were rich in essential metals such as Zn, Mg and Fe. It is essential that proliferation of alcoholic and non alcoholic drinks through the border should be controlled to prevent incidences of health risk due to ingestion of toxic metals and the study recommended that the port health services and security personnel should be strict in maintaining in-flow of standard and non-expiry goods.

Keywords: Alcohol; beverages; border town; health risk; heavy metals; non-alcohol.

1. INTRODUCTION

Alcoholic beverage is a drink containing ethanol and are divided into the general classes; bears, wines and spirits [1] while a non-alcoholic beverage is a beverage that contains less than 0.5% alcohol by volume [2]. These definitions varied from countries based on food regulation and definition. It is agreed that non-alcoholic drink are admittedly vital vehicles of a balance diet. Non alcoholic drinks have turned out to be a drink preferred in most social gathering, for health and or religious belief [3]. They are quickly absorbed than water, providing to human body hydration and energy while replenishing all the key vitamins and mineral that the body losses during exercises. The technology of canning implies the storing of drink in air tight containers [4]. This process involved the Tinplating in light gauge, cold reduced, low carbon steel sheet or strip, coated on both sides with commercially pure tin [4]. This is extensively used for the production of beverages (beers, carbonated soft drinks, wine, and water), of which half are made of tinplate and all are internally lacquered. However, it is obvious that some metals may dissolve into the food content, particularly when plain uncoated internal surfaces are used or when the cans containing the foods are subjected to adverse environmental conditions [4]. Heavy metal in canned drinks has it source traced to the untreated water, chemical residue in process drink, bio accumulation in aquatic animals and industrial emission into drink before packaging or canning [5]. Other sources of these metals are natural occurrences and man activities doing process handling of raw materials, processing operation, packaging and distribution [6]. The neurological aspect of metal poisoning indicated nervous system as target organ. Other target organ include respiratory tract, blood, kidney, bone, gastrointestinal tract, endocrine [7]. Heavy metal composition of foods is of interest because of their essential or toxic nature. For example, Fe, Zn, Cu, Cr, Co, and Mn are essential though very high level levels are intolerable, while Pb, Cd, Ni, As, and Hg are toxic at very low concentration [8,9]. They have potential hazardous effect not only on compound but human health. Therefore, consistent auditing and monitoring of metals in beverages is very essential especially at the border areas where proliferation of sub-standard goods is common to prevent food poisoning as a result heavy metal contamination. [10] and Diet is the major source of heavy metal exposure; therefore it is important to note the dietary intake of these heavy metals and to quantify them. The aforementioned was the drive for the study, with the main objective to determine some heavy metal concentration of alcoholic and non alcoholic beverages at Idiroko border area of Ogun State Nigeria where cheap beverages were common among the inhabitants.

2. MATERIALS AND METHODS

The study was carried out to investigate the contents of the selected drinks that are alcoholic and non-alcoholic hat are heavily consumed largely in Southwetern part of Nigeria that pass through the Idiroko Border to determine the qualities of these drinks either they constitute health risks.

2.1 Sample Collections Procedure

Ninety five (95) samples of alcoholic and non alcoholic drinks which comprised five samples each of nine brands of alcoholic drinks (45 samples) and five sample unit each of eight brands of non alcoholic drinks (40 samples) were purchased at Idiroko border of Ogun state Southwest Nigeria.

2.2 Samples Preparation Procedure

Wet digestion method was used in the preparation of the beverages for mineral analysis. 5 ml of analytical unit was weighed into digestive tube and 10 ml of concentrated H_2SO_4 and $HClO_4$ at ratio 1:1 was added. This was latter digested using FOSS TECATOR Digestor Model 210 at 250_C for 1 hour at the first instance and continued until a clear solution was obtained in a fume cupboard. The clear solution was filtered into a 100 ml volumetric flask and completed to the mark with de-ionised water.

2.3 The Determination of Mineral Analysis

Metal analysis Fe, Mg, Cu, Zn, Pb, Cd, and As were determined using Atomic Absorption Spectrophotometer (Buck 210). Standards for each element under investigation was prepared in part per million (ppm) and the limit standard concentration for each element was adhered to according to the BUCK Scientific instruction and the results obtained by compared with World Health Organisation standards for the metals limits for human consumption, with the chemicals sourced from Central Laboratory of the Bells University, Ota and Environmental Health Laboratory of Ogun State College of Health Technology, Ilese-Ijebu both in Ogun State Nigeria. The standard solutions were aspirated and the graph obtained. The samples concentrations of various metals were read and calculated using equation 1.

$$\text{Specific mineral (i.e Zn, Fe) ppm} = \frac{\text{Machine reading(ppm)}}{\text{Weight of sample}} \text{ x dilution factor}(100) \qquad (1)$$

3. RESULTS AND DISCUSSION

3.1 Copper (Cu)

The results of metal concentrations Cu, Mg, Fe, Pb, Cd, Ni, As, Zn and Ar for alcoholic and non alcoholic drinks were present in Table 1 and 2 respectively. The maximum concentrations for copper in alcoholic and non alcoholic drinks were 0.67 mg/l and 3.25 mg/l respectively. [11] reported, 0.10 mg/l in carbonated soft drink in Nigeria while a similar work by [12] in Turkey reported 0.126 mg/l for Cu in soft drink. Although, there is no recommended limit for Cu in alcoholic and non alcoholic drinks, it could be advisable to use the recommended daily limit as benchmark (1.3 mg/l) [13]. The concentration of copper in alcoholic drinks is below the World Health Organisation (WHO) standard 1984 [14]. Copper is an essential trace mineral that cannot be formed by the human body but it must be ingested from dietary sources. It is very essential for the proper functioning of organs and metabolic processes. However, like all essential element and nutrients, too much or little of copper ingestion can result in a corresponding condition of copper excess or efficiency in the body, each of which has its own unique set of adverse health effects. Copper greater than 5.0 mg/kg body weight is toxic and can be gastrointestinal metal.

3.2 Magnesium (Mg)

The concentrations of magnesium in both alcoholic and non alcoholic drinks ranged between 20.08- 36.92 mg/l and 22.562-133.206 mg/l respectively. The recommended daily allowance (RDA) of magnesium is between 310-320 mg, Mg per day [15]. The results of Mg in alcoholic drinks were low compared to most findings. [15] reported 97 µg/ml, Mg in alcoholic beverages from Spain. However, it is interesting that the consumption of alcoholic and non alcoholic drinks can also contribute to the recommended required daily intake of magnesium. Recently, the physicians have identified Mg for treating acute heart attacks, chronic cardiovascular disease, diabetes, asthma, chronic fatigue syndrome and many other disorders. According to the United States, the department of Agriculture National Nutrient Database, one 12 ounce serving regular beer supplies 21 mg source of folate, niacin, magnesium, potassium and niacin. Drinking one bottle of beer per day may improve health [16].

3.3 Iron (Fe)

The concentrations of the iron content in alcoholic and non alcoholic drinks ranged between 1.093 - 2.455 mg/l and 0.572-1.734 mg/l respectively. Although there is no recommended standard for iron, the average daily intake of iron in man between ages 20-34 yrs is estimated to be 17 mg per day and for females 9 – 12 mg/day [17]. Human body needs iron to carry oxygen to red blood cells, Low level or iron can cause fatigue, shortness of breath and difficult thinking. High iron levels can also cause health problems, including liver damage. The level of metal in drinks is highly affected by the sources of their ingredients such as the type of water, the components of the pipes, barrels and other materials involved in the process [18]. Excess iron is found to produce ferric but the content detected within the alcoholic and non alcoholic drinks are considered to be very low to form ferric cases [18].

3.4 Lead (Pb)

The lead concentration in the alcoholic drinks are within the standard limit set by World Health Organisation [14] aside from the concentration of lead in C (Guilder). 65.5 percent of the non alcoholic drinks analysed were above the maximum standard limit of 0.001 mg/l of lead set by [13]. These results revealed that non alcoholic drinks could prove more risk of lead toxicity to the public more than alcoholic drinks.

Heavy metals in beer may have different sources. Its presence in beer may be related to the uptake from contaminated soil and such contamination may occur during technological processes [19]. High concentration of lead indicates that the control of contamination was of low quality or as a result of adulteration or ill practices of processing or proliferation of low quality of product at the border. Lead plays no biological role in living organisms. According to the Royal commissions of Environmental Pollution (UK), the consumption of wine and beer raises blood lead concentrations [20]. Canned drinks have been figured to have the highest levels, probably because of low quality of the canned used. The results obtained for alcoholic drinks is related to the levels of lead in alcoholic drinks in Bulgaria and Poland as documented by [19] while the result for non alcoholic drinks varied with investigation conducted by [21] on soft drinks in Lagos Nigeria which the leads were within the limits.

3.5 Cadmium (Cd)

The cadmium concentrations in the alcoholic and non alcoholic drinks ranged between 0.001-0.104 and 0-031 mg/l respectively. About 66% of the cadmium was not in conformance with standard limit of WHO (0.1 ppm). The result obtained for the non-alcoholic drinks were totally in conformance with the standard maximum limit (0.055 ppm). The incidences of cadmium contaminations are mostly from the sources of raw materials for the production, Food contamination is the most important pathway of Cd and it is more readily taken up by plants than other metals, such as lead, [22]. Factors contributing to the presence of cadmium in the soil are fallout from the air, cadmium containing water used for irrigation and cadmium in fertilizers. This metal is later absorbed by plant [22]. Basic cereal such as rice, wheat can accumulate relatively high amounts of Cd when grown in contaminated soil. Another major source is related to the use of cadmium in several industrial processes such as protective coating (Often applied by electroplating for some metals such as iron [23]. Thereby, the rusting process of canned drinks can serve as source of cadmium contaminations.

3.6 Nickel (Ni)

The range of Nickel is from 0.184 - 0.278 ppm for alcoholic drinks while result for non alcohol ranged between 0 - 0.301 ppm. 65% of non alcoholic drinks are not in compliance with the maximum standard limit of Nickel put at 0.02 ppm. The major use of Nickel is in the preparation of alloys because of its strength, ductility and resistance to corrosion and heat. The use Nickel in cans preparation can result to a means of contamination. Nickel can accumulate in the kidneys, bones, and thyroid glands and cause toxicity. In small quantities nickel is essential, but when uptake is too high it can be a danger to human health. An uptake of two large quantities of nickel causes lung embolism, lung cancer, sickness and dizziness after exposure to nickel gas, asthma and chronic bronchitis, heart disorders, and allergic reactions such as skin rashes, mainly from jewellery [24].

3.7 Arsenic (As)

There was no significant presence of Arsenic in the samples of alcoholic and non alcoholic drinks except in sample Q (Maltina). The maximum limits by World Health Organisation for arsenic in alcoholic and non alcoholic are 0.2 and 0.1 mg/l respectively. Arsenic is usually found in the environment combined with other elements as inorganic and organic forms. The most common inorganic arsenic in air is

Table 1. Metal concentrations of alcoholic drinks collected from Idiroko border of Ogun State

S/N	Product	N	Cu	Mg	Fe	Pb	Cd	Ni	As	Zn	Cr
A	HARP	3	<0.001	34.84±0.023	2.136±0.047	0.001±0.001	0.007 ±0.001	0.258±0.004	ND	0.135±0.012	ND
B	33	4	<0.001	26.08±0.031	1.924±0.003	0.024±0.001	0.001±0.001	0.196±0.008	0.003±0.001	0.114±0.004	0.001
C	STAR	3	<0.001	25.86±0.031	1.927±0.004	0.010±0.004	0.104±0.005	0.184±0.026	ND	0.227±0.011	0.001
D	GULDER	3	<0.001	36.92±0.314	2.021±0.008	0.211±0.016	0.079±0.002	0.254±0.063	0.002±0.001	0.125±0.002	ND
E	HEINEKEN	3	<0.001	25.96±0.561	1.894±0.017	ND	0.089±0.001	0.273±0.013	0.003±0.001	0.111±0.005	ND
F	GUINNESS	4	0.671±0.081	28.6±0.242	2.455±0.121	0.081±0.002	0.099±0.006	0.248±0.006	0.001±0.001	0.123±0.015	ND
G	SMIRNOFF	3	<0.001	29.74±0.018	2.116±0.001	ND	0.088±0.014	0.211±0.009	ND	0. 0.007	ND
H	RED BULL	2	0.0222±0.001	21.82±0.090	1.093±0.003	0.003±0.001	0.006±0.002	0.246±0.016	0.120±0.002	0.203±0.004	ND
I	TURBO	3	0.013± 0.001	20.08±0.121	2.054±0.007	0.006±0.001	0.019±0.001	0.188±0.003	0.004±0.001	0.270±0.001	0.002±0.001
	WHO		1.0	0.2	0.3	0.01	0.05	0.002	00.1	3	0.005

Table 2. Showing the metal concentrations of non-alcoholic drinks collected from Idiroko border of Ogun State

S/N	Product	n	Cu	Mg	Fe	Pb	Cd	Ni	As	Zn	Cr
J	FERROUS	4	0.470±0.016	51.211±0.075	1.257±0.042	0.447±0.001	ND	0.272	ND	0.001	ND
K	SCNAPPES	3	2.261±0.320	22.562±0.159	0.991±0.0036	0.069±0.008	0.010±0.001	0.271± 0.106	0.003±0.001	7.38± 0.203	0.001±0.001
L	SPRITE	3	ND	48.283±0.030	0.572±0.325	0.413±0.126	ND	0.173± 0.004	0.001±0.001	3.624±0.079	0.004±0.002
M	COCACOLA	5	ND	133.206±0.098	0.978±0.007	0.192±0.003	0.031±0.002	0.020± 0.0021	ND	1.414±0.227	ND
N	AMSTEL MALTA	4	1.413±0.002	81.412±0.002	1.483±0.004	0.281±0.024	ND	0.301± 0.009	0.006±0.001	0.993±0.003	0.001±0.001
O	FANTA	5	0.714±0.205	53.804±0.137	1.552±1.301	ND	ND	0.267± 0.006	0.013±0.004	1.88±0.062	ND
P	MALTA GUINESS	3	3.256±0.008	120.026±1.030	1.734±0.051	ND	ND	0.001± 0.1	ND	2.12±0.118	ND
Q	MALTINA	4	0.817±0.004	56.039±0.004	1.547±0.006	0.010±0.001	0.26±0.013	ND	0.141±0.120	1.144±0.004	0.026±0.004
	WHO (2007)		1	0.2	0.3	0.01	0.05	0.02	0.1	3	0.05

arsenic trioxide (As_2O_3), while arsenates AsO_4^{-3} or Arsenites (AsO_2) are the form usually occur in water, soil, or food [23]. Organic arsenic can cause neither cancer, nor DNA damage, but exposure to high doses may cause certain effects to human health, such as nerve injury and stomach aches. Exposure to inorganic arsenic can cause various health effects, such as irritation of the stomach and intestines; it decreases the production of red and white blood cells, skin changes and high irritation. Many sources of Arsenic contamination are usually from water [25,26] reported high arsenic concentrations in whisky more than 0.1 mg/l and some illicitly produced whisky with more than 0.4 mg/l.

3.8 Zinc (Zn)

The concentrations of Zinc obtained indicate low presence far below the maximum limit of 5 mg/l in alcoholic drinks. The results range between 0.111 - 0.270 and 0.993 - 7.38 mg/l in alcoholic and non alcoholic drinks respectively. Zinc contents in beer from various countries revealed an average of 0.083 μg^{-1} for Denmark [27], 0.293 μgg^{-1} [29] (Canada Ministry of Health, 2005), 0.113 $\mu g\ g^{-1}$ [28,30]. Zinc is an essential trace element because very small amount of Zinc is very essential for human health. It is required for the proper growth and maintenance of the human body needed for immune function, wound healing, blood clothing, thyroid function and maintaining vision. [29] reported that zinc deficiency is prevalent in developing world which usually leads to growth retardation and immune dysfunction; hence, high dose of Zinc in drinks could be toxic and must be avoided.

3.9 Chromium (Cr)

Chromium concentration results were not significant and fall bellow maximum limit of [31] (WHO, 1984), for the alcoholic and non alcoholic drinks respectively. The two major prevalent forms of chromium are Cr 214 (III) and Cr (VI) however it is only Cr (VI) that is deleterious to health when amount above limit is consumed [30]. The consistent finding of lung cancer in workers exposed during 216 chromate and chromate pigment production and chromium plating has led to the identification of Cr (VI) compounds as a known human carcinogen by number of authoritative institutions [30]. The use of chromium as alloy in the preparation of cans and electroplating process might 219 contribute to the status of their presence in the drinks. However, chromium at low concentration performs many functions such as catabolism of fats and carbohydrates; it maintains the blood glucose in the body this helping the diabetic.

4. CONCLUSION

The investigated products in this work revealed that canned alcoholic and non alcoholic drinks can contribute to health hazard with the consumption of high dosage of heavy metals. However this may be as a result of corrosion of the packaging material (Can) if the products are smuggled goods that are usually exposed to unfriendly environmental condition which can affect the stability of the product and its packaging materials. Therefore, proliferation of goods at the border should be dealt with by the government. Manufacturing industries should ensure that the source of water use in the alcoholic and non alcoholic industries, thus not constitute hazard in term of metal contamination. It is essential that proliferation of alcoholic and non alcoholic drinks through the border should be controlled to prevent incidences of health risk due to ingestion of toxic metals and the study recommended that the port health services and security personnel should be strict in maintaining in-flow of standard and non-expiry goods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/12074