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Assessment of Levels of Heavy Metals in Selected Canned Lager and Native Beer (*Burukutu*) Sold in Kugiya Market, Jos – Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SYG and JDD conceptualised and designed the work. Authors SAO and BHA mobilised and processed the samples. All authors partook in the analysis, interpretation of data obtained. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To determine the levels of Cd, Zn, Pb and Fe in some branded canned lager beers and *burukutu* (native beer) samples. To compare the prevalence of these metals in the two types of beers in order to proffer recommendations about the contamination of liquor with the metals.
Study Design: The work was descriptive.
Place and Duration of Study: Department of Biochemistry, University of Jos; National Research Institute for Chemical Technology, Zaria (Nigeria) from 10th March-10th April, 2017.
Methodology: 10 samples of *burukutu* were obtained from different sellers within Kugiya market Jos South Local Government Area, Nigeria. 10 samples each, of branded canned lager beers were purchased from the market and they included A®, B®, C®, and D®. To analyse the samples for the metals, atomic absorption spectrophotometry was applied.
Results: Mean concentrations (mg/litre), of Cd, Fe, Pb (in branded beers) and Zn ranged from: 0.011 to 0.037±.54; 0.404 to 1.645±.24; 0.120 to 0.215±.75 and 0.017 to 0.088±.76 respectively.

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Compared to the respective standard reference values for drinking water for each metal, the levels in the branded canned lager beers samples were all higher (p=.05). In the case of *burukutu*, mean levels of Cd, Fe and Zn were also higher (P=.05) relative standard reference value. Contamination with the metals was higher in branded canned lager beers (pH 5.3) than in *burukutu* (pH 3.2) which should be contaminated more because it is more acidic. Cd and Pb are implicated in cancers, brain damage, Fe predisposes to haemochromatosis; alcohol causes hepatitis, liver cirrhosis.

Conclusion: Based on these findings, drinkers of branded canned lager beers are more at risk of exposure to the combined toxicities of alcohol and the metals than drinkers of *burukutu*. Since both types of drinks are routinely consumed, better quality vessels, especially cans, should be used to check leaching of metals from wall of containers into the liquor. This will guarantee safer alcoholic beverages and hence the health of drinkers. *P*=.05 was considered significant.

Keywords: Branded; burukutu; canned; iron; zinc; cadmium; lead; beers.

1. INTRODUCTION

Alcohols are of various types; some are home-made (locally produced) whereas others are prepared in breweries. The most conventionally consumed are the branded factory-based lager beers including A®, B®, C® and D®. African traditional native beers such as *burukutu and pito* are popularly consumed. They are made using *Sorghum bicolor* as substrate; other cereals such as *Panicum species* (millet) or *Zea mays* (corn) are also used. Leftovers of previous brews are used to drive fermentation.

Foods become hazardous when contaminated by biological agents such as bacteria, fungi and their toxins or by metals from the walls of vessels used for brewing. Contaminants have been reported in foods including native beers [1]. Heavy and trace metals such as lead (Pb) and cadmium (Cd) are another group of toxicants that are deleterious to health. So also the overload of some mineral elements such as iron (Fe), copper (Cu) and zinc (Zn). Haemochromatosis is a disease condition that results as a consequence of iron overload in the body and has a lethal effect on the body if not taken care of at the early stage [2]. The toxicity of zinc leads to impairment of gastrointestinal absorption of copper, calcium, magnesium and iron and promotes folate deficiency [3].

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Apparatus/Reagents

Crucibles, plastic sample containers, glass rod stirrer, 10 ml pipette, filter paper, spatula, and beaker, distill water.

2.1.2 Equipment

Analytical balance; name-Adventurer ohaus (item no. ARC 120, max cap: 3100 g, readability: 01 g, power requirement: 8-14.5V 50/60 $H_2$6VA)., Atomic absorption spectrophotometer (AAS PG 940).

2.2 Methods

2.2.1 Collection of samples

10 samples of *burukutu* were obtained from different sellers within Kugiya, market Jos South Local Government Area, Nigeria. The 10 *burukutu* samples were mixed into four (4) composites. 10 samples each of branded canned lager beers were purchased from the market and they included A®, B®, C®, and D®.

2.2.2 Preparation of samples

Samples were poured into properly labeled crucibles and placed in an oven set at 42℃ initially and later increased to 60° to dry completely. The samples were then weighed using analytical weighing balance. Thereafter, the samples were transferred into appropriately labeled set of crucibles and placed in furnace set at 130℃ for one hour thereby burning off all organic components in all the samples. Samples were digested using concentrated trioxonitrate (v) acid and concentrated tetraoxochlorate (vii) acid in the ratio 6:1 v/v respectively. 5 ml of distilled water was added to each crucible and the contents stirred using glass rod. The resulting mixture was then transferred into labeled set of plastic containers. Thereafter, 5 ml of distilled water was again added to each of the plastic sample containers giving a final volume of 10 ml. The samples were then mixed by shaking vigorously to allow the solute dissolve. The samples were then analyzed using atomic absorption spectrophotometer (AAS).

2.3 Statistical Analysis

Results obtained were analysed using One Way ANOVA (Turkey-Kramer multiple comparisons test). *P* = 0.05 was considered significant.

3. RESULTS AND DISCUSSION

3.1 Results

From Table 1, levels of Fe and Zn appear higher compared to Cd and Pb in all the samples. Comparing iron and zinc, concentration of iron was higher than zinc in the beers. Iron level was highest in C®, followed by D®, B® and then A®. As for zinc, the trend in descending order was: A®, B®, C® and D®. The level of Pb in C® lager beer was not detected but was quantified in the other brands. D® had the highest level of lead, followed by A®, B®. In the case of cadmium, all the brands contained it over a range of values in descending order thus: A®, C® B®, and D®.

Concentration of cadmium in canned A® was statistically significant (p=.05) compared with its levels in B®, C® and D®. Level of cadmium in all brands of canned beers was higher than zinc. Generally, cadmium levels in all the canned beer brands were above the safe limits (p=.05). Comparing level of Cd in A® with all other metals, there was significant (p=.05) relationship except Cd in B® versus D®, Cd in B® versus Zn in D®, Cd in B® versus Pb in D®, Cd in D® and Pb in A®, Zn in D® and Pb in A®, Fe in A® and Fe in C® (p>.05). Similar trends were obtained with iron, zinc and lead in all the brands of the canned beers and with the reference values.

Table 2 bears the results of *burukutu* samples where the level of Fe was highest in all the samples thus: Fe>Zn>Cd. Pb was not detected by the AAS machine. Mean level of cadmium in *burukutu* is lower than in canned beers. Similarly, mean concentration of zinc in canned beers is above that in *burukutu*; this trend includes the level of iron as well.

3.2 Discussion

This work sought to determine the levels of Cd, Pb, Fe, and Zn in canned branded lager beers and in *burukutu* (native beer) from Kugiya area of Bukuru town, Nigeria. Generally, metals (mineral elements) are harmful to health when ingested at amount higher than required by the body. Heavy metals such as cadmium and lead do not serve any biological functions in living systems. The metals exert their toxicity by forming adducts/and ligands with organic compounds thereby losing their biological functions which lead to tissue and cellular necrosis. Metals could inhibit the catalytic role of certain enzyme families.

The presence of metals in alcoholic beverages results from the containers, materials or ingredients used in its production [4,1,5]. [6] reported that sources of potential toxic chemicals in human foods and drinks include food utensils and packaging materials, food spoilage

Table 1. Levels of Pb, Cd, Fe, and Zn (mg/L, ppm) in branded canned factory- based lager beer samples

Brand	Cd	Zn	Pb	Fe
A®	0.866±0.24	3.527±.12	0.254±.63	2.037±.56
B®	0.441±.32	1.885±.11	0.073±.14	2.143±.26
C®	0.804±.51	1.421±.41	ND	5.035±.16
D®	0.311±0.12	0.355±.31	0.350±.43	4.266±.34
Safe levels	0.003	2.800	0.010	0.300

**Values are means of triple determinations (±SEM); n = 10 (10 samples of each branded lager beer). ND = not detected by AAS machine*

Table 2. Levels of Pb, Cd, Fe, and Zn (mg/L, ppm) in samples *burukutu*

BKT	Cd	Zn	Pb	Fe
1	0.363±0.002	0.814±0.001	ND	3.829±0.001
2	0.417±0.003	0.826±0.001	ND	3.843±0.001
3	0.385±0.002	0.818±0.001	ND	3.963±0.002
4	0.402±0.003	0.834±0.001	ND	3.832±0.001

ND = Not detected by AAS machine

microbes, agrochemicals, industrial chemical wastes and domestic water. *Burukutu* is a fermented native drink prepared using clay or metallic (iron, aluminum or galvanised) containers as fermentation vessels while branded lager beers are made from malted cereal grains, hops and water at breweries.

Although metallic vessels are used in breweries, they are generally of higher quality than the ones used in making *burukutu.*

Cadmium accumulates in the human kidney for a relatively long time, 20 to 30 years, and at high doses, produces health effects on the respiratory system and bone disease. It has no known necessary function in the body. It acts as a catalyst in forming Reactive Oxygen Species [7,8]. It increases lipid peroxidation just as it depletes glutathione and protein-bound sulfhydryl groups and promotes the production of inflammatory cytokines. [9] reported that the most important metabolic parameter for cadmium uptake is a person's possible lack of iron; people with low iron supplies showed a 6% higher uptake of cadmium than those with a balanced iron stock.

Cadmium accumulates in biologic systems and has a long half-life. [10] reported that cadmium content in factory based lager beers was low; however, when the consumption of large amounts of certain beverages causes the dietary intake of cadmium to reach the maximum allowable levels, it may be physiologically significant. Consumption of both lager beers and *burukutu* is common in the study area. Cadmium is known to be better absorbed in presence of alcohol albeit the concentration or quantity of the alcohol is not defined [11].

Drinkers stand the risk of cadmium toxicity more so that it is used as coating for copper, iron and steel vessels which are used in breweries and homes in preparing alcoholic beverages. Mean levels (ppm) of cadmium in canned A®, B®, C® and D® were 0.866±0.84, 0.441±0.79, 0.804±0.64, and 0.311±0.93 respectively. These values are above safe limits of the 0.003 ppm [12] and 0.01 ppm [13]. The level of cadmium in *burukutu* samples ranged from 0.363 to 0.417 which is lower than that in canned lager beers. [1] have reported the pH of *burukutu* at 3.2.

The pH of some selected branded lager beers was reported to be 5.3 [9]. Therefore, *burukutu* is a 'stronger acid' relative branded canned beers. Acidic pH will favour leaching of walls of containers thereby dissolving metals into the drink. Hence, branded canned beers should be less contaminated with metals from the walls than *burukutu.* But that is not the case in this work.

Alcoholic beverage prepared in galvanised metallic containers coated and plated with cadmium caused gastric upset traced tp cadmium toxicity [13]. Compared to their levels in **bottled** A®, B®, and C® as reported by [9], levels of Cd, Fe, and Zn in **canned** containers were higher. However, level of Pb in bottled A® [9] was highest relative all other brands of bottled beers as well as reference safe limits for drinking water (p=0.001). Lead is a component of glass as lead trioxosilicate (iv), [$PbSiO_3$] and its reduction by hydrogen peroxide has been reported to cause formation of metallic lead granules [14]. It might be that Pb was leached from the wall of the container (glass) into the brew. Lager beers and fermented drinks have been reported to contribute to Pb burden in foods [15]. Daily exposure (µg/kg bw/day) to Cd, Pb and Zn through beers in Ethiopia was 0.0006, 0.0024, and 0.676 respectively [16]. The levels may be low but Cd and Pb are particularly toxic even at very low concentrations more so that they are not easily excreted and could accumulate over time and exert their deleterious effects.

Lead is also a toxic heavy metal widely distributed in the environment. The entry of lead into the food chain is a major concern, because of its toxicity. Lead has strong effects on haem biosynthesis and erythropoiesis [17]. It can injure the kidney and cause symptoms of chronic toxicity, including hepatic dysfunction, reduced intelligence quotient [18], slow growth, behavioral abnormalities, hearing difficulties and cognitive functions in human. Lead interferes with the activity of three enzymes; indirectly stimulates the mitochondrial enzyme δ-aminolevulinic acid synthetases; directly inhibits the activity of the cytoplasmic δ-aminolevulinic acid dehydratase and interferes with the normal functioning of intra- mitochondrial ferrochelatase, which is responsible for the insertion of iron (II) into the protoporphyrin ring. Anaemia is a frequent outcome of chronic Pb intoxication [19].

Zinc is an essential component of several enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acid as well as in the metabolism of other nutrients. Furthermore, zinc has an essential role in polynucleotide transcription and thus in the process of genetic expression. Its involvement in such fundamental activities probably accounts for all life forms [20].

[5] have reported that zinc and manganese were contaminants of local alcoholic beverages (*burukutu* and *pito*). These metals were reported to emanate from either the substrates or water used or from the walls of the brewing vessels used. Levels of Zn obtained in this work were higher than levels in drinking water (p=0.05); this is similar to the report of [21]. Zinc levels observed in beers produced in Ethiopia are higher than the values found in beers from other origins [22].

Iron is a component of haemoglobin, the oxygen-carrying component of the blood; it is also a component of myoglobin, which helps muscle cells store oxygen. Without iron, ATP cannot be properly synthesized. Although iron is a component of the antioxidant enzyme, catalase, it is not generally considered an antioxidant because too much iron causes oxidative damage [23].

Drinkers of native beers are at risk of iron accumulation although that would be dependent on absorption of iron from the gastrointestinal tract, gastric emptying, and level of fibre in both the native beers drank and the foods consumed (bioavailability). Excess intracellular iron results in formation and deposition of haemosiderin which can lead to cellular dysfunction and damage [24]. Iron solubility gradually increases during beer making process of germination and fermentation [25]. Iron toxicity can be classified as corrosive or cellular. Ingested iron can have an extremely corrosive effect on the gastrointestinal (GI) mucosa which can manifest as nausea, vomiting, abdominal pain, hematemesis, and diarrhea; patients may become hypovolemic because of significant fluid and blood loss. Haemochromatosis, a disorder of iron metabolism is characterised by excessive iron absorption, saturation of iron-binding proteins and deposition of haemosiderin in the tissues is of the numerous problems associated with iron metabolism; the primary tissues affected are liver, skin and pancreas. Iron deposition in liver leads to cirrhosis, incapacitating liver's numerous biochemical functions, and in the pancreas causes diabetes. The biochemical significance of iron in alcohol toxicity in drinkers of *burukutu* remains a matter worthy of consideration.

Both branded lager beers and *burukutu* samples analysed contained metals whose levels are above the safe limits for drinking water except Pb in *burukutu* samples that was not detected. Although branded beers are brewed by different brewing industries, it would be reasonable to assume that the quality of water and substrate used are of better grade relative the ones used in preparing *burukutu*. Also, regulatory agencies such as the Standards Organisation of Nigeria (SON) and National Agency for Food and Drug Administration and Control, NAFDAC, (in Nigeria) do monitor the quality of products produced and sold to drinkers. However, except for Fe whose level is similar in both branded and *burukutu* beer samples, the mean levels of Zn and Cd in the branded beers are higher than in *burukutu* samples.

4. CONCLUSION

It is therefore concluded that branded canned beers and *burukutu* were contaminated with respect to Fe, Zn, Cd leached from the wall of the containers. Contamination with the metals is greater in branded canned lager beers than in *burukutu* implying cans used in packaging of lager beers are potential sources of metal contaminations. Quality of cans to be used in storing lager beers should be of high standards to check metal contamination of lager beers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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