Analysis of Sugar and Heavy Metal Contents in Bottled Alcoholic and Non-Alcoholic Beverages Consumed in Ozoro, Delta State, Nigeria.

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Abstract
This study investigates the sugar and heavy metal content of some commonly consumed bottled alcoholic and non-alcoholic beverages in Ozoro town. Ten brands of beverages which comprised of five (5) alcoholic and five (5) non-alcoholic beverages were purchased from retail outlets and analysed for their sugar and heavy metal concentration using UV-spectrophotometer. The samples were labeled as: A1, A2, A3, A4 & A5 (alcoholic) and B1, B2, B3, B4 & B5 (non-alcoholic) beverages respectively. In this study, the result showed that the sugar content in percentage of the beverages analysed are in the ascending order of magnitude: A4 < A3 < A1 < A5 < B2, < A2 < B1 < B3 < B4 < B5. It was highest (0.056%) in B5 among the non-alcoholic and lowest (0.003%) in A4 among the alcoholic beverages. The concentration of heavy metals in mg/l of the analysed beverages are in the order of magnitude: Pb > Mn > Cu > Sn > Ni > Zn > Cd > As. The mean concentration of Pb was 0.22 ±0.01 among the alcohols and 0.14±0.07 among the non-alcohols. Pb was highest (0.24mg/l) in A3 and least (0.04mg/l) in B5. The level of Mn ranged from 0.05mg/l in B1 to 0.22mg/l in A3. The mean concentration of Mn was 0.13±0.05 in the alcoholic beverages and 0.07±0.03 in the non-alcoholic. Ni content ranged from 0.02mg/l in A3 and A5 to 0.06mg/l in B4, and its mean concentration was 0.03±0.01 in the alcoholic beverages while it was 0.06±0.00 in the non-alcoholic beverages respectively. The mean concentration of Cu was 0.09±0.01 in the alcohols and 0.02±0.02 in the non-alcohols. Cu content ranged from 0.01 in B1 to 0.10mg/l in A2 and A1. Cu was not detected in samples B3 and B5. Zn content in the beverages ranged from 0.02 in B3 to 0.06mg/l in B4. The mean concentration of Zn was 0.03±0.00 in the alcoholic beverages while it was 0.04±0.02 in the non-alcoholic beverages respectively. The mean concentration of Cd was 0.03±0.01 in the alcoholic and 0.05±0.03 in the non-alcoholic. Its concentration ranged from 0.02 in A4 and A5 to 0.06mg/l in B4. Tin content ranged from 0.02 in samples A1, A2 and B1 to 0.07mg/l in B4. The mean concentration of Sn was 0.03±0.01 in the alcoholic beverages while it was 0.04±0.02 in the non-alcoholic beverages respectively.The mean concentration of As was 0.01±0.01 in the alcohols and 0.02±0.00 in the non-alcohols. Arsenic concentration ranged from 0.01 in A3, A4 and A5 to 0.02mg/l in samples A2, A3 and B5. The results showed that the concentrations of sugar in % and heavy metals (Mn, Ni, Cu, Zn, Sn and As) in mg/l of the bottled beverages are within the recommended limits of WHO, SON, and USEPA. The concentrations of Pb and Cd were found in both alcoholic and non-alcoholic beverages to be higher than the recommended safe limits by world standard agencies. This can cause health risk to consumers. The need to improve on the quality control and quality assurance by the manufacturers in the processing of these beverages cannot be glossed over, because heavy metals in beverages are present due to different raw material sources including water, equipment and brewing process (WHO, 1989).

Keywords: alcohols, beverages, contamination, heavy metals, investigation.

I. Introduction
Non-alcoholic drinks, otherwise known as soft drinks are sweetened water-based beverages, often with a balanced acidity (Eyon et al., 2010; Adepoju-Bello, 2012). They exist in various forms and brands and are marketed by different brewery industries across the country Nigeria (Ambler, 2011). The non-alcoholic drinks usually contain several health qualities to human consumptions. It provides pleasant flavor, antioxidants, vitamins, fibers, phosphates and minerals which are an essential vehicle for hydration. They rapidly replace lost salt and energy as well as quenches thirst instantly (Jasmine, 2012; Pofahl et al., 2005). These are responsible for its high consumption rate across the globe (Phillip et al., 2013), where they are served during sports, leisures, relaxation outings, and to the general public in celebrations such as traditional marriages, weddings, funerals etc (Dharmasena, 2010).

The sweetener used in the manufacture of non-alcoholic drinks may be sugar, high fructose corn syrup, fruit juice, or any sugar substitute (Vaux and Golder, 2003). These sweeteners (sugar) can be of high...
consequences to the consumers of non-alcoholic drinks, the health benefits notwithstanding. Research has shown that excess sugar consumption can lead to diabetes, obesity, heart related diseases, and other complications (France, 2000). Sucrose (a disaccharide of fructose and glucose) is mostly popular and used among the sugars for flavouring, sweetening, preservation and texture in food and beverages. Sugar to a very large extent has been assumed to raise blood glucose level. The role of excessive sugar intake on health and diseases is currently an active area of scientific and policy debate with respect to guidelines by World Health Organization (WHO, 2015). Alcoholic drinks on the other hand, are such which contain a substantial amount of ethanol, a depressant which even in low doses causes euphoria, reduced anxiety, and sociability and in higher doses causes intoxication, stupor and unconsciousness. Alcohol is one of the most widely used recreational drugs across the globe (Ambler, 2011), and it plays an important role in many cultures. The long term use of alcohol is capable of damaging nearly every organ and system in the body (Caan and Belleroche, 2002).

Heavy metals are substances that have shown to be very harmful and poisonous to the human body (http://www.lef.org/ 2003; Duffus, 2002), and constitute a major public health concern (Bingol et al., 2010; Cabrera et al., 1995). They have the potentials of causing acute and chronic toxicity by various modes of action in both adults and children (Ibrahim et al., 2006; Berry and Wallace, 1981). Arising from the high level of consumption and demand for both alcoholic and non-alcoholic drinks, quality control and quality assurance within the process of production particularly during fermentation, sterilization and purification may be compromised and their qualities can be challenging. As a result, alcoholic and non-alcoholic drinks have been found to contain traces of heavy metals. It has been reported that environmental pollution from surface and underground water, food and fruits used during production can introduce heavy metals such as lead, cadmium, zinc, tin, manganese, nickel, copper, arsenic etc.

Arsenic level was reported by Ashraf et al., 2000 as 0.837mg/l in 34 non-alcoholic drinks in Pakistan, while Onianwa et al. (1999), reported Cd, Cu, Pb, and Zn levels in non-alcoholic drinks in Nigeria. In either ways, the excess or deficiency of trace elements present in the human body can cause a lot of harmful effects (Zahir et al., 2009).

The objective of this study therefore, is to determine the percentage of sugar and heavy metal content (mg/l) in some selected bottled samples of alcoholic and non-alcoholic beverages consumed by the populace of Ozoro, Delta State, Nigeria. The ever increasing rate of consumption of both beverages deserves much attention to verifying the level of their sugar and heavy metal content with a view to protecting the consumers from exposures and harmful effects.

II. Materials And Method

DESCRIPTION OF STUDY AREA

The study was conducted in Ozoro which is the Headquarter of Isoko North Local Government Area of Delta State. Ozoro is one of the two administrative units in the Isoko region of Delta State, Southern Nigeria. The main economic activity of the people is food crop farming on cassava and yams, accompanied by some hunting. They also engage in trade of food crops for cash to meet other basic household needs. The presence of a Polytechnic has tremendously improved on the economic activities of the area. Ozoro lies within latitude 5°32′18″N and longitude 6°12′58″E (www.wikipedia.org).

SAMPLES COLLECTION AND TREATMENT

A total of ten (10) different brands of samples comprising of five (5) alcoholic beverages -labeled as: A₁, A₂, A₃, A₄, & A₅ and five (5) non-alcoholic beverages, labeled as: B₁, B₂, B₃, B₄ & B₅ respectively were purchased from retail outlets in Ozoro town. The samples were taken to the laboratory and stored at 4 °C until the completion of analysis for the sugar and heavy metal contents. Before analysis in the laboratory, all the samples were degassed using an ultrasonic bath for 30min (Donadini et al., 2008).

A. Quantitative determination of sugar content:

The percentage sugar content in the various beverage samples was determined using standard methods of AOAC, 1990. 10ml of ethanol was added to 5ml of the different samples in a test tube and weighed. The mixture was heated on a heating mantle until the solution attained a boiling point and the ethanol was evaporated and allowed to cool to room temperature. 5ml of distilled water was added to all the ten samples. 1ml aliquot of each was pipette into ten different test tubes. 1ml of distilled water as blank was pipette into another test tube with the aid of an automated pipette. 0.5ml of phenol and 2ml of H₂SO₄ was added to the ten different test tubes containing 1ml aliquot. The absorbance of the golden yellow solution of each sample was read on a UV spectrophotometer at wavelength 490nm against the blank.
B. Quantitative determination of heavy metal content:

The heavy metal content in the various alcoholic and non-alcoholic beverage samples were determined using standard methods of AOAC, (1990); WHO, (1989) and as described by (Emmanuel, 2013).

15ml of nitric acid and hydrochloric acid mixture was added to 20ml of each of the degassed sample in a digestion tube. The mixture was heated for 1hr until complete clarification and allowed to cool, filtered and diluted to 25ml with distilled water. 5ml aliquot of each filtrate was placed in the ten different test tubes. 2ml of ammonium molybdate was then added to the sample in the ten different test tubes. The absorbance at 279.5, 232.0, 324.7, 213.9, 228.9, 217.0, 357.9 and 240.0 of the following metals; Mn, Ni, Cu, Zn, Cd, Pd, Sn, and As was read and recorded respectively with UV spectrophotometer. Analytical blanks were prepared in a similar manner. Appropriate quality assurance procedures and precautions were carried out to ensure reliability of the results. Samples were equally handled carefully to avoid contamination. All the reagents used were of analytical grades.

III. Results

Table 1: Showing result of sugar concentration in alcoholic and non-alcoholic beverage samples (%)

<table>
<thead>
<tr>
<th>Sample Codes</th>
<th>Sugar content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.013</td>
</tr>
<tr>
<td>A2</td>
<td>0.022</td>
</tr>
<tr>
<td>A3</td>
<td>0.004</td>
</tr>
<tr>
<td>A4</td>
<td>0.003</td>
</tr>
<tr>
<td>A5</td>
<td>0.015</td>
</tr>
<tr>
<td>B1</td>
<td>0.014</td>
</tr>
<tr>
<td>B2</td>
<td>0.018</td>
</tr>
<tr>
<td>B3</td>
<td>0.038</td>
</tr>
<tr>
<td>B4</td>
<td>0.046</td>
</tr>
<tr>
<td>B5</td>
<td>0.056</td>
</tr>
</tbody>
</table>

Table 2: Showing the concentration (mg/l), mean, standard deviation and ranged of heavy metals in alcoholic and non-alcoholic beverages.

<table>
<thead>
<tr>
<th>Heavy metals</th>
<th>Alcoholic Beverages</th>
<th>Non-Alcoholic Beverages</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WHO, 2006</td>
<td>USEPA, 2011</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.13 ± 0.05</td>
<td>0.07 ± 0.03</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(0.1 – 0.22)</td>
<td>(0.05 – 0.10)</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>0.03 ± 0.01</td>
<td>0.06 ± 0.00</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(0.02 – 0.04)</td>
<td>(0.00 – 0.06)</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>0.09 ± 0.01</td>
<td>0.02 ± 0.02</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>(0.08 – 0.10)</td>
<td>(0.01 – 0.04)</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.03 ± 0.00</td>
<td>0.04 ± 0.02</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(0.03 – 0.04)</td>
<td>(0.02 – 0.06)</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.03 ± 0.01</td>
<td>0.05 ± 0.03</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.02 – 0.04)</td>
<td>(0.04 – 0.06)</td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.22 ± 0.01</td>
<td>0.14 ± 0.07</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.21 – 0.24)</td>
<td>(0.04 – 0.21)</td>
<td></td>
</tr>
<tr>
<td>Sn</td>
<td>0.03 ± 0.01</td>
<td>0.04 ± 0.02</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(0.02 – 0.05)</td>
<td>(0.02 – 0.07)</td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>0.01 ± 0.01</td>
<td>0.02 ± 0.00</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(0.01 – 0.02)</td>
<td>(0.00 – 0.02)</td>
<td></td>
</tr>
</tbody>
</table>

IV. Discussion

From table 1 above, the value of sugar content ranged from 0.003% in sample A1 to 0.022% in sample A2 among the alcoholic beverages, while it ranged from 0.011% in sample B1 to 0.056% in sample B5 among the non-alcoholic beverages. Though all the samples (both alcoholic and non-alcoholic beverages) contained sugar in varying amounts, the result showed that the sugar levels are virtually within the range specified for beverages (7-14g/100ml). The danger of sugar level in beverages may not necessary be the concern but the rate of consumption or daily intake that could lead to excess in the body. Usually, the side effects of sugar manifest after prolong accumulation in the body (Sodamade, 2014). In developing countries like Nigeria in particular, the consumption of sugary drinks is rising drastically due to widespread urbanization and beverage marketing (Malik et al., 2013). Beyond weight gain, routinely drinking sugary beverages has been linked with an increased risk of premature death (Malik et al., 2019).

The results in table 2 show the mean concentration of lead was 0.22 ± 0.01mg/l among the alcohols and 0.14 ± 0.07mg/l in the non-alcohols respectively. Pb was highest (0.24mg/l) in A3 and least (0.04mg/l) in B5. The level of Pb ranged from 0.21-0.24mg/l in the alcoholic beverages while 0.04-0.21mg/l in the non-alcoholic
beverages. In this study, the value of Pb exceeded the WHO limit of 0.01mg/l. Maduabuchi et al., (2006) and Krajpcio et al., (2005), reported lead levels ranging from 0.020 – 0.46mg/l, which exceeds WHO limit of 0.01mg/l. Adepoju-Bello et al., (2012), reported lead levels in soft drinks ranging from not detectable – 0.002mg/l in Lagos, which is below the WHO limit of 0.01mg/l. Lead levels in soft drinks have equally been reported by other researchers reaching 2.78mg/l which is by far above the safe limit of 0.01mg/l recommended by World Health Organization (WHO), (Ofori, 2013). The toxicity of Pb has been recognized the world over as a major environmental health risk (Bingol et al., 2010; Krejpcio et al., 2005). Lead affects humans and animals of all ages, though its effects are more pronounced amongst children (Adepoju-Bello, 2012).

The mean concentration of Mn was 013 ± 0.05mg/l among the alcoholic beverages while 0.07 ± 0.03mg/l in the non-alcoholic beverages as shown in table 2. Among the alcoholic beverages, Mn content ranged from 0.10 - 0.22mg/l, while it ranged from 0.05 - 0.10mg/l in the non-alcoholic beverages. In this study, all the values obtained for Mn in both alcoholic and non-alcoholic beverages are within the WHO recommended limits of 0.4mg/l in foods and drinks. Mn is an essential micronutrient and does not occur naturally (Emmanuel, 2013). The recommended daily intake for children is 1.2 - 1.5mg/day; for men 2.3mg/day; and for women 1.8 - 2.0mg/day (FNB, 2001).

The mean concentration of Cu in this study was 0.09 ± 0.01mg/l among the alcoholic drinks while 0.02 ± 0.02mg/l among the non-alcoholic beverages as shown in table 2. Copper content ranged from 0.08 - 0.10mg/l in the alcoholic beverages while it ranged from 0.01 - 0.04mg/l in the non-alcoholic beverages. All the values of Cu obtained across the beverages are within the safe limit of 3.0mg/l set by World Health Organization, (2006). The permissible limit of Cu in drinking water in Nigeria is 1.0mg/l (SON, 2003). The Cu content of the beverage samples are in agreement with the reports of (Amelia and Marana, 2011). Cu is an essential substance to human life, however, in high concentration, it can be very toxic and cause anaemia, liver and kidney damage, stomach and intestinal irritation, allergies, hair loss, arthritis, cancer, depression, failure to thrive, fatigue, fears, heart attacks, strokes, tooth decay (Sonofonte et al., 2000). The estimated provisional tolerable daily intake of Cu from the consumption of these beverages ranged from 0.005 - 0.05mg/l bw/day, which is within the safe daily intake limits (Emmanuel, 2013).

The mean concentration of Zinc among the alcoholic beverages was 0.03 ± 0.00mg/l while it was 0.04 ± 0.02mg/l among the non-alcoholic beverages as shown in table 2 respectively. Among the alcoholic beverages, the highest value of Zn was 0.04mg/l (sample A3) and the lowest was 0.03mg/l across all other samples (A1, A2, A4, and A5) respectively. Zinc ranged from 0.02 - 0.06mg/l in the non-alcoholic beverages. All the values of Zn obtained from this study are below the safe limit of 0.20mg/l set by World Health Organization, (2006). In this study, the values of Zn are far below the range of 0.42 – 2.06mg/l for Zn reported in the study of Zinc in soft drinks in Ghana (Ofori et al., 2013). Adepoju-Bello et al., (2012), reported no detectable levels of Zn in soft drinks in Lagos. The results obtained in this study are in close agreement of 0.009 – 0.90ppm Zn levels reported in the study of Bingol et al., (2010). Zinc is a necessary element for embryo development and it is important to reproductive organs (Carpene et al., 1994). Zn usually constitute about 33ppm of adult body weight and is essential as a constituent elements of many enzymes involved in a number of physiological activities, such as protein synthesis and energy metabolism (Adepoju-Bello et al., 2012). Excessive intake of Zn can cause electrolyte imbalance, nausea, anaemia and lethargy while its deficiency can lead to dwarfism, hypogonialism and dermatitis (Ma and Betts, 2003).

The result of Nickel concentration in table 3 was 0.06mg/l in sample B4 and was not detected (<0.001mg/l) among the other samples (B1, B2, B3, and B5) of the non-alcoholic beverages. According to the result in table 2, the concentration of Ni ranged from 0.02 - 0.04mg/l among the alcoholic beverages while it ranged from 0.00 - 0.06mg/l among the non-alcoholic beverages. The mean concentration of Ni as presented in table 2 among the alcoholic beverages was 0.03 ± 0.01mg/l, while it was 0.06 ± 0.00mg/l among the non-alcoholic beverages respectively. Adepoju-Bello (2012), reported in Lagos a range of 0.016 - 0.06mg/l concentrations of Ni in soft drinks. In this study, the values of Ni obtained in both alcoholic and non-alcoholic beverages falls within the WHO limits of 0.10mg/l. The tolerable daily intake of Ni is 5.0µg/kg bw/day (EVM, 2003; Biurrrm et al., 1991). The presence of metallic impurities in alcoholic and non-alcoholic beverages can constitute severe health hazards to the populace (Onianwa et al., 1999; Krepcio et al., 2005). Ni is known to be responsible for cancer, depression, heart attacks, haemorrhages, kidney dysfunction, low blood pressure, malaria, muscle tremors, paralysis, nausea, skin problems and vomiting (Kasprzak et al, 2003).

The mean concentration of Cd in the alcoholic drinks was 0.03 ± 0.01mg/l, while it was 0.05 ± 0.03mg/l in the non-alcoholic beverages as presented in table 2. The value of Cd in the alcoholic beverages ranged from 0.02 - 0.04mg/l while it ranged from 0.04 - 0.06mg/l in the non-alcoholic beverages. The concentration of Cd in this study was found to be higher than WHO limit of 0.005mg/l. Maduabuchi et al., (2006) reported Cd levels ranging from 0.003 – 0.081mg/l in canned drinks which are within the range of results obtained in this study, Onianwa et al., (2001), reported Cd levels as 0.002 ± 0.005ppm, in carbonated soft drinks in Nigeria. In 2007, the average content of Cd in alcoholic beverages from the Italian market was reported as
0.16 – 0.15µg/l. The levels of Cd reported in this present study are similar to levels reported in different alcoholic beverages in other parts of the world (WHO, 2001). Cadmium is highly toxic non-essential and carcinogetic element, which does not have any role in biological process in living organisms (Tsui and Wang, 2004). Cd intake in relatively high amounts can be very detrimental to human health. Its long-term exposure to lower concentration leads to a build up in the kidneys and possible kidney disease, liver damage, fragile bones. Other forms of ailment arising from a long-term exposure to Cd are cancer, anaemia, diabetes, cardiovascular disease, strokes (Ofori, 2013). Itai-itai disease was the name given to the mass Cd poisoning of Toyama prefecture, Japan, which started around 1912 (Nwagei, 2018)

Arsenic (As) has well been established as a human carcinogen even at extremely low levels of exposure, and it has no possible beneficial metabolic functions in humans. The mean concentration of Cd in the alcoholic drinks was 0.01 ± 0.01mg/l, while it was 0.02 ± 0.00mg/l in the non-alcoholic beverages as presented in table 2 respectively. The As levels in this study are within the reference values of England (0.02mg/kg). This notwithstanding, one cannot rule out the long-term health complications of As in the continuous consumption of these beverages. Arsenic at low level exposure causes nausea and vomiting, while its long-term exposure causes abnormal ECG, anorexia, fever, goiter, hair loss, headache, jaundice, kidney and liver damage (Abdulrahman et al., 2012).

The mean concentrations of Sn in the alcoholic and non-alcoholic beverages were 0.03 ± 0.01mg/l and 0.04 ± 0.02mg/l as shown in table 2 respectively. The value of Sn ranged from 0.02 - 0.05mg/l among the alcoholic beverages. Among the non-alcoholic beverages, the value of Sn ranged from 0.02 - 0.007mg/l. In this study, levels of Sn obtained are well below the permissible limit of 150mg/l set by WHO in foods and drinks (JECFA, 2005). Vomiting, diarrhea, fatigue and headache are often observed following the consumption of canned products containing Sn concentration as low as 150mg/kg in canned beverages and 250mg/kg in other canned foods (JECFA, 2005).

V. Conclusion And Recommendations

The level of sugar content in the beverage samples are within the acceptable limits set by the relevant agencies. The result shows that the sugar content of the beverages analysed are in the ascending order of magnitude: A1 < A3 < B1 < A2 < B3 < B2 < B4. It was highest (0.056%) in B3 among the non-alcoholic and lowest (0.003%) in A1 among the alcoholic beverages. The danger of sugar level in beverages may not necessarily be the concern but the consumption rate or daily intake that could lead to excess in the body. Alcoholic and non-alcoholic beverages should be taken moderately to avoid the health risk associated with excess sugar in the body.

The results in this study showed different amounts of heavy metals among the beverage samples because heavy metals in beverages are present due to different raw material sources including water, equipment and brewing process (WHO, 1989). Few heavy metals analysed were present in some of the bottled non-alcoholic beverages, but were virtually present in all the bottled alcoholic beverages. Whereas the concentrations of Mn, Ni, Cu, Zn, Sn and As in this study falls within the local and international regulatory limits in drinking water, the level of Pb and Cd is observed to be above permissible limit in drinking water set by WHO, and USEPA. The increased rate of consumption of these beverages may constitute a major public health concerns for excess sugar and heavy metal contamination in Nigeria. The need to improve on the quality control and quality assurance by the manufacturers in the processing of these beverages cannot be glossed over.

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