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

Uwague, A.
Department of Science Laboratory Technology, Delta State Polytechnic. P.M.B. 5.
Ozoro. Delta State. Nigeria.

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: A_1, A_2, A_3, A_4 & A_5 (alcoholic) and B_1, B_2, B_3, B_4 & B_5 (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: $A_4 < A_3 < B_1 < A_1 < A_5 < B_2 < A_2 < B_3 < B_4 < B_5$. It was highest (0.056%) in B_5 among the non-alcoholic and lowest (0.003%) in A_4 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 A_2 and least (0.04mg/l) in B_5. The level of Mn ranged from 0.05mg/l in B_1 to 0.22mg/l in A_3. 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 A_4 and A_5 to 0.06mg/l in B_4, and its mean concentratin was 0.03±001 in the achic 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 B_1 to 0.10mg/l in A_2 and A_3. Cu was not detected in samples B_3 and B_5. Zn content in the beverages ranged from 0.02 in B_3 to 0.06mg/l in B_4., The mean concentration of Zn was 0.03±000 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 alcohols and 0.05±0.03 in the non-alcohols. Its concentration ranged from 0.02 in A_4 and A_5 to 0.06mg/l in B_4. Tin content ranged from 0.02 in samples A_1, A_4 and B_3 to 0.07mg/l in B_4. 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 A_1, A_4 and A_5 to 0.02mg/l in samples A_2, A_3 and B_4. 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.*

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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 com 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 rise 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 organs 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 tremendiously improved on the economic activities of the area. Ozoro lies within latitude $5^0 32^1 18$”N and longitude $6^0 12^1 58$”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: A_1, A_2, A_3, A_4, & A_5 and five (5) non-alcoholic beverages, labeled as: B_1, B_2, B_3, B_4 & B_5 respectively were purchased from retail outlets in Ozoro town. The samples were taken to the laboratory and stored at 4 ^{0}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 H_2SO_4 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 filterate 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 (%).

Sample Codes	Sugar content (%)
A_1	0.013
A_2	0.022
A_3	0.004
A_4	0.003
A_5	0.015
B_1	0.011
B_2	0.018
B_3	0.038
B_4	0.046
B_5	0.056

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

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

IV. Discussion

From table 1 above, the value of sugar content ranged from 0.003% in sample A_4 to 0.022% in sample A_2 among the alcoholic beverages, while it ranged from 0.011% in sample B_1 to 0.056% in sample B_5 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 of these sugar-based beverages can increase the risk of type2 diabetes, heart disease, and other chronic diseases. More so, higher consumption of 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 A_2 and least (0.04mg/l) in B_5. 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. Maduabuci *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 extimated 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 A_2) and the lowest was 0.03mg/l across all other samples (A_1, A_3, A_4, and A_5) 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 inbalance, nausea, anaemia and lethargy while its deficiency can lead to dwarfism, hypognalism and dermatitis (Ma and Betts, 2003).

The result of Nickel concentration in table 3 was 0.06mg/l in sample B_4 and was not detected (<0.001mg/l) among the other samples (B_1, B_2, B_3 and B_5) 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 - 0.063mg/l levels 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 5.0ug/kg bw/day (EVM, 2003; Biurrum *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, malaice, 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 carcinogenic 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 - 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: $A_4 < A_3 < B_1 < A_1 < A_5 < B_2 < A_2 < B_3 < B_4 < B_5$. It was highest (0.056%) in B_5 among the non-alcoholic and lowest (0.003%) in A_4 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.

References

[1]. Abdulrahman,,F.I., Akan, J.C., Chellube, Z.M. and Waziri, M. (2012). Level of Heavy Metals in Human Hair and Nail Samples from Maiduguri Metropolis, Borno State, Nigeria. World Environment. 2(4):81-89. DOI:10.5923/;.env.2012024.05.

[2]. Adepoju-Bello, A.A., Oguntibeju, O.O., Onuegbu, M.T., Ayoola, G.A.A. and Coker, H.A.B. (2012). Analysis of selected metallic impurities in soft drinks marketed in Lagos,

[3]. Nigeria. African Journal of Biotechnology. Vol. 11(20), pp. 4676-4680. Available online at http://www.academicjournals.org/AJB. DOI: 10.5897/AJB11.3851.

[4]. Al-Mayaly, I.K.A. (2013). Determination of some Heavy Metals in some Artificial Fruit Juices in Iraqi Local Markets. Int. J. Research and Development in Pharmacy and Life Sciences. Available online at http//www.ijrdpl.com. Vol.2, No.4, pp. 507-510.

[5]. Ambler, T. and Styles, C.(1997). Brand development versus new product development: toward a process model of extension decisions. J. Prod. Brand Manage., 6(4). Pp222-234.

[6]. Amelia, B and Mariana, I. (2011). "A study of metal migration from packaging in beer during Storage". J. Agroalimentary. 17(3): 270-274.

[7]. Association of Official Analytical Chemists. (AOAC) (1990). International, Methods of Analysis, Arlington, VA, 1990.

[8]. Ashraf, W., Jaffar, M., and Masud, K. (2000). Heavy trace metal and macronutrient levels in various soft drinks and juices. Journal of the Chemical Society of Pakistan, 22: 119-124.

[9]. Berry, W.L. and Wallace, A. (1981). Toxicity – The Concept and Relationship to the Dose-Response Curve.

[10]. Bingol, M., Yentur, G., Buket, E.R., Bayhan, A. and Oktem, A.B. (2010). Determination of Some Heavy Metal Levels in Soft Drinks from Turkey using ICP-OES Method. Czech. J. Food Sci. Vol. 28, No. 3: 213-216.

[11]. Biurrum, M.C.Y., Dopazo, M.C.G., Barrera, M.P.B., Barrera, A.B. (1991). Determination de ploma en cerveza por espectometria de absorption atomic con atomizacion electrtermica. Alimentaria, 223: 59-62.

[12]. Caan, Woody; Belleroche, Jackie de. (2002). Drink, Drugs and Dependence: From Science to Clinical Practice (1st ed). Routledge. Pp. 19-20. ISBN 978-0-415-27891-1.

[13]. Cabrera, C., Lorenzo, and Lopaz, M.C. (1995). Lead and Cadmium contamination in dairy product and its repercurssion on total dietary intake. J. Agric. Food Chem., 43, pp. 1605-1609.

[14]. Dharmasena, K.A. (2010). The Non-Alcoholic Beverage Market in the United States: Demand Interrelationships, Dynamics, Nutrition Issues and Probability Forecast Evaluation. (PhD thesis). Texas A and M University.

[15]. Donadini, G., Spalla, S. and Beone, G.M. (2008). Arsenic, Cadmium and lead in beers from the Italian market. J.Inst. Brew. 114: 283-288.

[16]. Duffus, J.H. (2002). "Heavy Metal" – a meaningless term? Pure Appl. Chem., 74, pp. 793-807.

[17]. Emmanuel, A.U. (2013). Analysis of metal concentrations in selected canned beers consumed in Owerri Urban, Imo State, Nigeria. Int. Jour. Of Chem. and Material Sci., Vol.1(5): pp 090-095

[18]. Eyong, E.A., Eteng, M.U. and Eyong, U.O. (2010). Comparative chemical analysis of some brands of soft drinks consumed in Southern Nigeria. Nig. J. Biochem. Mol. Biol. 25:36-39.

[19]. Expert Group on Vitamins and Minerals (EVM)(2003). Safe upper levels for vitamins and mineral. Report of the Expert Group on Vitamins and Minerals. Food Standards Agency.

[20]. Food and Nutrition Board (FNB) (2005). Dietary reference intakes for Arsenic, Iron, Chromium, Copper. Institute of Medicinal Plants, Washington, DC. National Academy Press. Pp442

[21]. France, K.I. (2000). "Public Attitudes towards the healthiness of Fruit Juices". Journal of Human Nutrition and Dietetics, Vol. 13, No. 5, pp. 139.

[22]. Ibrahim, D., Froberg, B., Wolf, A. and Rusyniak, D.E. (2006). Heavy metal poisoning: clinical presentations and pathophysiology. Clin. Lab. Med., 26, pp. 67-97.

[23]. Jasmine, Y.S. (2012). Comparison of sugar content in Bottled 100% Fruit Juice Versus Extracted Juice of Fresh Fruit. Journal of food and Nutrition Science, 3. Pp1509-1513.

[24]. JECFA, (2005). Joint FAO/WHO Expert Committee on Food additives. World Health Organization. Geneva, 2005.

[25]. Kasprzak, K.S., Sunderman, F.W. Jr., and Salnikow, K. (2003). Nickel carcinogenesis. Mutat. Res. 533: 67-97.

[26]. Krejpcio, Z., Sionkowski, S. and Bartela, J. (2005). Safety of fresh fruits and juices available on the Polish market as determined by heavy metalresidues. Polish Journal of Environmetal Studies, 14: 877-881.

[27]. Life Extention (2003). Heavy Metal Toxicity, http://www.lef.org/ (updated 06.12.2003)

[28]. Ma, J. and Betts, N.M. (2000). Zinc and Copper intakes and their major food sources for older adults in the 1994-96 continuing survey of food intakes by individuals (CSF-II). Journal of Nutrition. 130: 2838-2843.

[29]. Maduabuchi, J.M.U., Nzegwu, C.N., Adigba, E.O., Aloke, R.U., Ezomike, C.N., Okocha, C.E., Obi, E. and Orisakwe, O.E. (2006). Lead and Cadmium exposures from canned and non-canned beverages in Nigeria. A Public health concern. Science of Total Environment, 366: 621-626.

[30]. Malik, V.S., Willett, W.C and Hu, F.B. (201). Global obesity: trends, risk factors and policy implications. *Nature Reviews Endocrinology*. **(3)**

[31]. Malik, V., Li, Y., Pan, A., De Koning, L., Schernhammer, E., Willett, W. and Hu, F. (2019). Long-Term Consumption of Sugar-Sweetened and Artificially Sweetened Beverages and Risk of Mortality in US Adults. *Circulation* ***(36)***

[32]. Nwagei, G.E.. (2018). Living With Chemical Time Bomb. 68th in the series of Inaugural Lectures of Delta State University, Abraka. Nigeria. pp32.

[33]. Ofori, H., Owusu, M. and Anyebuno, G. (2013). Heavy Metal Analysis of fruit Juice and Soft Drinks Bought From Retail Market in Accra, Ghana. Journal of Scientific Research and Reports 2(1): pp 423-428.

[34]. Onianwa, P.C., Adeyemo, A.O., Idowu, O.E. and Ogabiela, E.E. (2001). Copper and zinc contents of Nigerian foods and estimates of the adult dietary intakes. Food Chemistry. 72: 89-95.

[35]. Onianwa, P.C., Adetola, I.G., Iwegbue, C.M.A., Ojo, M.F. and Tella, O.O. (1999). "Trace heavy metals composition of some Nigerian beverages and food drinks". Food Chem. 66:275-279.

[36]. Phillip, B.B., Shittu, A.M. and Ashaolu, O.F. (2013). Demand for non-alcoholic beverages among urban households in South West, Nigeria. Afr. J. Food Agric. Nutr. Dev., 13(3): pp7853-7869.

[37]. Pofahl, G.M., Capps Jr, O. and Clauson, A. (2005). Demand for non-alcoholic beverages: evidence from the AC-Nelson Home scan panel. Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, 24-27th July, 2005.

[38]. Popkin, B.M. and Hawkes, C. (2016). Sweetening of the global diet, particularly beverages: patterns, trends and policy response. Lancet Diabetes Endocrinol 2016..

[39]. Sodamade, A. (2014). Assessment of Sugar Levels in Different Soft Drinks: A Measure to Check National Food Security. Int. J. Sci. Resch. Vol.3, No.12, pp567-569.

[40]. Sonofonte, O., Violante, N. and Caroli, S. (2000). Assess of reference valves for element in human hair of urban schoolboys. J. Trace Elements Med. Bio. 14:6-13.

[41]. Standard Organization of Nigeria (SON)(2003). Safe drinking regulation. Standard Organization of Nigeria: Abuja, Nigeria.

[42]. Vaux, B. and Scott, G. (2003) "105. What is your generic term for a sweetened carbonated beverages?".

[43]. USEPA, (2011). Edition of the Drinking Water Standards and Health Advisories Office of Water. U.S. Environmental Protection Agency, Washington, DC. pp. 8, 719-726, 731-732.

[44]. World Health Organization. (WHO). (2006). Guidelines for drinking water quality. Health criteria and other supporting information. Vol. 1:130. 2nd Ed. Geneva.

[45]. World Health Organization. (WHO). (1989). Evaluation of certain food additives and contaminants: Thirty-third Report of the Joint FAO/WHO Expert committee on Food Additives. WHO Technical Report Series No. 776. World Health Organization.. Geneva.

[46]. World Health Organization. (WHO). (2001). Safety evaluation of certain food additives and contaminants: Cadmium: WHO food additives series 46 of the Joint FAO/WHO Expert committee on Food Additives. World Health Organization.. Geneva.

[47]. WHO (2015) sugars intake for adult and children Guidelines. 2015. Available from http://www.who.int/nutrition/publication/guidelines/sugars intake/en/. accessed April 2016.

[48]. Zahir, E., Naqvi, I.I., and Uddin, S.M. (2009). Market Basket Survey of Selected Metals in Fruits from Karachi City (Pakistan). Journal of Basic and Applied Sciences. Vol.5, No. 2, pp47-52.