Middle-East Journal of Scientific Research 22 (1): 39-44, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.22.01.21817

Dietary Exposure to Heavy Metals via Consumption of Some Fruit Juice and Carbohydrate Food by Adult in Awka, Nigeria

[1]*V.I. Onwukeme*, [2]*E.C. Obiuchendu and* [3]*M.U. Onuoha*

[1, 3]Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, PMB 5025, Awka, Nigeria
[2]Department of Chemistry, Federal College of Education Tech., Umunze, Anambra state, Nigeria

Abstract: Dietary exposure to toxic/heavy metals by adult population in Awka, Nigeria was carried out using analysis of some fruit juice/wine samples and some Carbohydrate food as well as food frequency questionnaire. The results showed that Lead (Pb), Cobalt (Co), Zinc (Zn) Arsenic (As) and Cadmium (Cd) are the risk factors from fruit juice/wine and carbohydrate food consumption to adult population in the areas, based on Provisional Tolerable Daily Intake (PTDI) for toxic metals and Acceptable Daily Intake (ADI) for metals. It was observed that the number of toxic/heavy metals in fruit juice /wine drink that exceeded the PTDI and ADI were in order of Co>Pb>As>Cd. Chromium and Copper intake in the fruit juice/wine samples were well below the ADI limits. For the carbohydrate samples, Co, Zn, As and Cd intake exceeded the PTDI and ADI limit for rice samples while only Co and Cd intake exceeded the PTDI and ADI limits for the yam sample. This calls for precautionary measures in the consumption of these sample due to the adverse health implication of these metals.

Key words: Toxic/heavy Metals · Fruit Juice/Wine · Risk Assessment

INTRODUCTION

The problem of heavy metal intake by human population through food chain is receiving serious attention from public, government agencies and particularly developing nations of the world [1]. This is because contamination by heavy metals knows no boundary and so sustainability of the Global ecosystem depends largely on the industrialized nations of the world. Food security does not end with provision of food for the citizens but assessment of risk associated with consumption of a particular food substance. Heavy metal contamination of food can take place during handling, processing of food from the farm to the place where they are consumed [1, 2]. Apart from growth of plants in contaminated soil, feeding of animals on feeds containing these metals storage and packaging containers, water used in cooking and preparation of beverage also contribute sufficient amount. The problem is that once these metals are present in food, their concentrations are rarely modified by traditional preparation and processing techniques [1, 2]. Heavy metal accumulation in the soil is of interest to agricultural food production because of its adverse effect on food safely, crop growth and environmental health, especially now most countries are industrializing rapidly. Human contamination occurs through ingestion or inhalation. Contamination by inhalation of dust is important especially for metals that have low vapour pressure which can easily be mobilized from soil and other component of the environment. Mobility and bioavailability of heavy metals determine contamination and can easily be measured but food risk contamination is difficult to determine. Regulation, handling and geo-remediation of hazardous material require an assessment of the risk to some living species and man [3, 4]. Ecosystem risk assessment remains the main task of environmental food scientists. The use of total concentration of heavy metal in food for health assessment is not healthy and reliable because exposure and risk depends on the quantity of food consumed [4].

In Nigeria, the annual production of yam from the year 2008-2010 was put at 37 million metric tones [5]. Report has shown that half of the human lead intake is from food and half from plant [6, 7]. This has unimaginable consequences to human and ecological health. Also, Nigeria, ravaged by corruption and hold 159th position out of 192 countries on human development index, life expectancy is 57yrs for men and 59year for women, aspire

Corresponding Author: V.I. Onwukeme, Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Nigeria.

to improve all these and become one of the 20 best economies of the world by 2020, signed the millennium Development Goal (MDG), (specified and signed by 192 countries of the world in 2010) geared toward moving humanity forward needs adequate food security [8]. Report has shown that half of the human lead intake is from food and half from plant [6, 7]. This has unimaginable consequences to human and ecological health. No work has been done on dietary exposure and risk assessment of heavy metals through the consumption of carbohydrate food and fruit juice in Awka metropolis, Anambra State, Nigeria.

This work is aimed at the exposure /intake of heavy metal contaminants in some fruit juice and carbohydrate food, as well as to estimate their health risk using analysis of individual food item and food frequency questionnaire. This is because food is an important source of overall exposure and undertaking its risk assessment becomes very important too. Contribution of each food to heavy metal contamination is beneficial for epidemiological study of diseases.

MATERIALS AND METHOD

The Following Materials Were Used:

Glasswares: Volumetric flask ($250cm^3$), graduated cylinders, funnel and calibrated pipette.

Breakers: $250cm^3$ Pyrex and $250cm^3$ cornical flasks. Philips reagent bottles ($200cm^3$ and $250cm^3$),

Philips Thermometers ranging from O°C to 100°C.
Stirrer – $5cm^3$ length
Electronic weighing balance (pioneer)
Bunsen burner
Storage bottles – 125 and $250cm^3$, narrow mouth, Teflon.
Atomic Absorption spectrophotometer (Variant AAs 220Fs).

Collection of Fruit Juice Sample: Some fruit juice samples were brought from Eke Awka market. The samples were taken to the laboratory for preparation and analysis.

Preparation of Sample–Degestion of Friut Juice Sample: $2cm^3$ of each juice sample was measured into the cornical flask containing $10cm^3$ of aqua rajia. The solution was heated in a fume cupboard for 15min, allowed to cool. Another $10cm^3$ of aqua rajia was added and heated until a clean fume was obtained. The flask was brought down, cooled and distilled water was added to it and filtered. The Filtrate was kept for analysis.

Collection of Carbohdrate Food Sample: Some carbohydrate food samples were brought from Eke Awka Market. The samples were taken to the laboratory for preparation and analysis.

Digestion of Carbohydrate Food Sample: Ig of each sample was weighed and added into a $10cm^3$

Of aqua rajia and heated on a hotplate in fume cupboard for 20min. After complete digestion of the sample, the flask was allowed to cool and the $10cm^3$ of distilled water was added to the digested samples and the solution filtered was made up to $50cm^3$ with distilled water and kept for AAS analysis.

RESULTS AND DISCUSSION

The results of this analysis are presented in Tables 1and 3 and the risk assessment estimates in Tables 2 and 4.

Calculations:
Exposure= contaminant data * consumption data.
Intake µg/person/day = conc in mg/L * consumption data in g/person/day

Table 1: Concentration of Heavy Metal in Fruit Juice Drink Mg/l

Juice drink/metal	Pb*	Cu	Co	Zn	As*	Cd*	Cr
Lucozade Boost	2.03 ± 0.47	0.50 ± 0.28	2.04 ± 0.02	1.40 ± 1.14	0.03 ± 0.03	0.28 ± 0.06	0.38 ± 0.03
Viju BB Star	0.69 ± 0.16	0.23 ± 0.03	8.25 ± 0.16	2.11 ± 0.03	0.79 ± 0.01	0.90 ± 0.18	0.90 ± 0.1
Supreme Juice	2.50 ± 0.69	2.11 ± 0.9	1.4 ± 0.0002	1.06 ± 0.005	2.10 ± 0.003	0.41 ± 0.10	0.61 ± 0.25
Ziza Fruit drink	4.0 ± 0.80	0.67 ± 0.64	0.50 ± 0.40	2.190 ± 0.05	3.00 ± 0.03	0.10 ± 0.02	0.70 ± 0.001
Danse Fruit drink	5.01 ± 1.18	0.43 ± 0.20	2.89 ± 0.30	2.340 ± 0.04	5.09 ± 0.6	0.22 ± 0.05	0.09 ± 0.02
Yollandia Yoghurt	9.02 ± 2.16	0.20 ± 0.05	6.17 ± 6.1	0.40 ± 0.004	9.10 ± 0.36	0.78 ± 0.10	0.88 ± 0.10
Ribena	1.70 ± 0.39	0.74 ± 0.09	3.72 ± 2.3	2.70 ± 0.0005	1.78 ± 0.05	0.05 ± 0.01	0.40 ± 0.30
Lacasara	9.55 ± 2.14	1.73 ± 1.37	7.28 ± 0.0009	2.87 ± 0.01	9.58 ± 0.31	0.15 ± 0.03	0.75 ± 0.33
Nutri Milk way	1.90 ± 0.45	1.49 ± 1.03	4.50 ± 0.80	1.22 ± 0.03	1.20 ± 0.0002	0.06 ± 0.01	0.96 ± 0.40
Delite Apple Fruit Juice	0.22 ± 0.05	1.49 ± 1.00	9.82 ± 0.01	0.54 ± 0.03	2.20 ± 0.007	0.40 ± 0.09	0.66 ± 0.01
Raphia wine (cool)	0.092 ± 0.1	0.13 ± 0.04	1.73 ± 0.03	3.00 ± 0.20	0.003 ± 0.01	0.025 ± 0.2	0.083± 0.02

*=Toxic metal

Table 2: Estimated Daily intake in µg /L bw /day (PTDI) of Heavy metal in juice /wine sample.

Metal/Juice	Pb (PTDI)	Cu (ADI)	Co (ADI)	Zn (ADI)	As (PTDI)	Cd (PTDI)	Cr (ADI)
Lucozade Boost							
µg/person/day		71.8	817.8	403.2			109.2
µg/kg bw/ day	9.74	2.4	13.63	6.72	0.144	1.344	1.82
Viju BB Star							
µg/person/day		66	2376	607.8			260.4
µg/kg bw/ day	3.31	1.1	39.6	10.13	3.79	6.32	4.34
Supreme Juaice							
µg/person/day		607.2	403.2	304.8			172.8
µg/kg bw/ day	12	10.13	6.72	5.08	10.08	1.96	2.88
Ziza Fruit Drink							
µg/person/day		193.2	144	634.2			201.6
µg/kg bw/ day	19.2	3.22	2.4	10.57	14.4	0.48	3.36
Dause Fruit Drink							
µg/person/day		123.6	82.8	673.8			25.8
µg/kg bw/ day	24	2.06	1.38	11.23	24.43	1.06	0.43
Yollandia Yoghurt							
µg/person/day		57.6	1276.6	115.2			453.2
µg/kg bw/ day	43.29	0.96	29.61	1.92	43.68	3.74	4.22
Ribenna							
µg/person/day		213	2096.4	826.2			115.2
µg/kg bw/ day	8.16	3.55	34.94	13.77	8.54	0.24	1.92
Lacasara							
µg/person/day		498	2094	822			216
µg/kg bw/ day	45.8	8.3	34.9	13.7	45.9	0.72	3.6
Nutria Milkway							
µg/person/day		492	1296	351			276
µg/kg bw/ day	9.12	7.15	21.6	5.85	5.76	0.28	4.6
Delite Apple Fruit							
µg/person/day		492	2827.8	155.4			189.6
µg/kg bw/ day	1.05	7.15	47.13	2.59	10.50	1.92	3.16
Raphia Wine							
µg/person/day		37.2	498	864			21
µg/kg bw/ day	0.43	0.62	8.3	14.4	0.01	0.12	0.35
European Commission Std PTD1	3.5µg/kg bw/dry				7.1µg/kg 50µg/kg	1.0µg/kg bw/dry	
PTWI	25µg/kg bw/week				15µg/kg bw/wk 50µg/kg bw/wk	7.0µg/kg bw/wk	
ADI STDS							
USA STD AD1		900-10000µg/kg		11mg/kg	(Inorganic Ar)		35µg/kg
European Commission Stds ADI	3.50µg/kg	500.00µg/kg	3.0µg/kg	11µg/kg	7.1µg/kg	1.0µg/kg	35µg/kg
WHO 2001 Stds		900-10000µg/kg/day		3.0µg/kg	15ppm		
ANCFA Stds		200ppm					

TDI-Provisional Tolerable Daily Intake:µg/kg bw/day

PTWI-Provisional Tolerable Weekly Intake:µ/kg bw/wk

ADI -Acceptable Daily Intake:µg/kg

Table 3: Concentration of Heavy Metals in Carbohydrate Food Mg/Kg

Carbohydrate food	Pb	Cu	Co	Zn	As	Cd	Cr	Average Consumption data in g/day
Yam	1.25±0.0004	0.54±0.46	0.55±0.002	1.23 ± 0.30	0.15±0.02	1.26±0.005	0.34±0.01	365.3g
Rice	2.50 ± 0.01	0.90±02	0.71± 0.3	3.45±0.04	1.40±0.2	1.63± 0.22	1.35± 0.27	712.5g
ADI								

Table 4.0: Estimated Daily Intake of Heavy Metal in Carbohydrate Food in µg/kg bw/Dry (PTDI) and µg/kg (ADI)

	Pb (PTDI)	Cu (ADI)	Co (ADI)	Zn(ADI)	As(PTDI)	Cd(PTDI)	Cr(ADI)
Yam	7.61	197.40	201.00	449.4			124.26
		3.29	3.35	7.49	0.91	7.67	2.071
Rice	29.66	641.40	505.80	2457.60			961.80
		10.69	8.43	40.96	16.62	19.35	16.03
European Commission	3.5µg/kg bw/dry			7.1µg/kg			
Std PTD1				50µg/kg	1.0µg/kg bw/dry		
PTWI	25µg/kg bw/week				15µg/kgbw/wk		
					50µg/kg bw/wk	7.0µg/kg bw/wk	
ADI Stds							
ADI Stds		900-10000µg/kg		11mg/kg	(Inorganic Ar)		35µg/kg
European Commission							
Stds ADI	3.50µg/kg	500.00µg/kg	3.0µg/kg	11µg/kg	7.1µg/kg		
WHO 2001 Stds		900-10000µg/kg/day	3.0µg/kg	15ppm			
ANCFA Stds		200ppm					

TDI- Provisional Tolerance Daily Intake:µg/kg bw/day

PTWI-Provisional Tolerance Weekly Intake:µg/kg bw/wk

ADI- Acceptable Daily Intake:µg/kg

$$\frac{\text{Intake in µg/person/day}}{\text{60 yrs Adult of 60kg}} = \text{Intake µg/kg bw/day}$$

$$= \text{PTDI or ADI}$$

$$\text{\% ADI or \% PTWI} = \frac{\text{PTDI cal}}{\text{PTDI safe}} * \frac{100}{1}$$

OR

$$\frac{\text{ADI cal}}{\text{ADI safe}} * \frac{100}{1}$$

Based on 288cm^3 average consumption estimate from food frequency questionnaire for all he fruit juice/wine sample the daily intake of pb in all the fruit juice drink samples exceeded the tolerable daily Intake TDI of 3.50µg/kg bw/day [7]. This high concentration in most fruit juice sample may be due to plant used in juice preparation, the water and the processing equipment.

The weekly intake of Lacasara exceeded the PTWI of 25.0ug/kg bw/week by 1208%, yallondia yoghurt by 12.36%, lucozade boost by 27.820% and the supreme juice drink by 32.85%.

The concs. of Pb in yam and rice were above the PTWI. The implication is that at the moment, it is dangerous to consume this particular fruit juice drink and the carbohydrate food sold in Awka. Excess accumulation of Pb in the body causes problem in the synthesis of hemoglobin, kidney and liver function as well as reproductive system of human [8]. Also typical disease such as Pb entoxification, esteoporisis, saturime encephalopathy, anemia, radical nerve paralysis and saturime colic may be common [6].Excess lead disrupts Ca, Fe, Cu and Zn absorption [9].

The concentration of copper ranged from 0.13±0.04mg/L in raphia palm wine to 2.11±0.90mg /L in supreme juice drink and the estimated daily intake ranged from 37.20.00µg/person/day (0.62µg/kg bw/day) in Raffia palm wine to 609.20µg/person (10.13µg/kg bw/day) in supreme juice drink for the fruit juice sample, 197.40µg/person/day (3.29µg/kg bw/day) in yam to 641.40µg/person /day (10.69µg/kg bw/day) in rice for the carbohydrate food sample.

The implication is that there is no danger of copper consumption from these food substances as the levels obtained fell well below the limit set by USRRA and WHO [10].

The concentration of cobalt ranged from 0.50 ±0.40µg/L in ziza juice drink to 9.82 ± 0.01µg/L in delite apple drink for the juice /wine sample, 0.55±0.00.2µg/kg in yam to 0.71±0.30µg/kg in rice for the carbohydrate sample.

The estimated daily intake ranged from 82.80µg/person/day in Dansa fruit drink(1.38µg/kg bw/day) to 2827.80 µg /person/day (47.13µg / kg bw /day) in delite apple drink for the fruit juice drink. 201.00µg/person/day (3.35µg/kg bw/day) in yam to 505.80µg/person/day (8.43µg/kg bw/day) in rice for the crbohydrate food sample.

The highest metal intake was observed in fruit juice /wine drink as well as the carbohydrate food. The concentration of zinc ranged from 0.40±0.004mg/L in yallondia yogurt fruit juice to 2.87±0.0mg/L in Lacasara fruit drink for the fruit juice drink and 1.23+0.30mg /kg in yam to 3.45±0.0.4mg/kg in rice for the carbohydrate samples [11].

The estimated average daily intake ranged from 1115.20µg/person/day (1.921kg bw /day) in yallondia yogurt to 864.00µg /person/day (14.40µg/kg/day) in raffia wine for the fruit juice /wine sample and 449.40µg/person/day (7.49µg/bw/day) in rice for the carbohydrate samples.

The estimated daily intakes of zinc for the entire sample studied were well below the acceptable daily intake of 11.00µg /kg /day European Commisson ADI Standard Zinc is an essential trace metals that act as cofactor in metacoenzyme, but high concentration of zinc in human has been reported to damage pancreas and disrupt protein synthesis [12].

However, Zn consumption from the selected food does not portend any inherent danger for the people in Awka, Nigeria.

The concentration of arsenic ranged from 0.003±0.0mg /L in raffia wine to 9.58±0.31mg/L in Lacasara for the juice / wine samples and 0.15± 0.02µg / kg in yam to 1.40±0.20mg /kg in rice for the carbohydrate samples.

The estimated Provisional Tolerance daily intake for arsenic ranged from 0.01µg/kg bw / day in raffia wine to 45.90 µg /kg bw /day in Lacasara drink for the fruit juice drink and 0.91µg/bw/kg in yam to 16.62µg /kg in rice for the carbohydrate sample.

The estimated provisional tolerable daily intake of arsenic fell within the tolerable limit by European standard, WHO standard of 7.1µg/ kg bw/day. The percentage PTWI of arsenic in all food samples fell within the range of 70.14% to 64.64%.The values for most of the fruit juice and rice exceeded the 30% PTWl.

The concentration of Cd ranged from 0.05±0.01mg /L in Ribenna to 0.90±0.8mg/L in viju BB star for the fruit juice with juice with and 1.26±0.005mg/kg in yam to1.63±0.22mg/kg in rice for the carbohydrate sample.

The estimated daily intake of cadmium ranged from 7.67µg/kg bw/day in yam to 19.35µg/kg bw/day in rice for the carbohydrate sample and 0.12µg/kg bw/day in raffia wine to 6.32µg/kg bw/day in viju BB star for the fruit juice wine sample. Similarly Cd concentration in raffia wine, nutri milk way, Lacasara, Ribenna and ziza fruit drink had values below PDTI for the juice /wine samples.

The concentration of Cd in all carbohydrate samples fell above the provisional tolerable daily intake limit of 1.0µg/kg bw/day. The percentage provisional tolerable weekly intake (%PTWI) for juice / wine sample ranged from 12.0% to 6.32% in juice / wine sample, 7.67% to 19.35% for the carbohydrate. Excess Cd in the body causes lung cancer, pulmonary adenocarcinomes, kidney dysfunction and hypertension [11].

The implication is that care must be taken in the consumption of carbohydrate food due to adverse effect of exposure of Cd since most of the levels exceeded the safe limit of 30% PTWT for toxic metals that biaccumulate in human.

The concentration of chromium ranged from 0.083 ±0.01mg/L in raphia wine to 0.96 ± 0.40mg/L in Nutri milk way for the fruit juice sample and 1.34± 0. 01µg/kg in yam to 1.35±0.27µg/kg in rice for the carbohydrate sample [12].

The estimated daily intake of Chromium ranged from 25.80µg/person/day (0.43µg/kg bw/day) in danse fruit drink to 276.00µg/person/day (4.6µg/kg bw/day) in Nutri milk way drink for the juice /wine drinks and 12.26µg/person/day (2.0µg /kg bw /day) in yam to 961.80µg/person/day (16.03µg/kg bw /day) in rice for the carbohydrate food. The results show that all fruit juice drink, raphia palm wine and carbohydrate food were the major sources of contamination for people in Awka, Nigeria, since intake from these substance well exceeded the acceptable daily intake based on the U.S-ADI stds European Commission Standard and the % PTWI for the toxic metals [7].

CONCLUSION

Food contamination is an unavoidable problem because food is an important pathway of human heavy metal exposure. Therefore undertaking risk assessment is very important towards achieving the millennium Development Goals for the country.

REFERENCES

1. Jukowske, J. and M. Biriut, 2008. Methodological Evaluation of Methods for Dietary Heavy Metal Intake, J. of Food Science, 73(2): 21-29.
2. Dudka, S. and P. Miller, 1999. Accumulation of potentially toxic elements in plants and their transfer to human food chain, J. Environmental Sci Health, 314: 681-708.

3. Santhi, D., V. Balakrishnan, A. Kalaikannan and K.T. hakrishnan, 2008. Presence of heavy metals in Pork Products in Chennai India, American J. Food Technology, 3(3): 192-199.
4. Nasiaddinc, L. and D. Parent Massin, 2002. Food contamination by metals and pesticides in the European Union, should we worry? Recent Articles, toxicology letter, 127: 29-41.
5. Aranha, K., 1994. Environmental Chemistry. 3rd Ed., New Age International Ltd Publisher, New Delhi, pp: 213-219.
6. Allen, G., A.C. Robert, D.S.J. O'Reilly, M.J. Stewart and S. James, 1995. clinical Biochemistry 2nd Edn, Harcourt Brace and Company Ltd, pp: 114-115.
7. Ejaz ul Islam xiane, Yung zhen-Li-tte and Quisar Mohamed, 2007. Assessing Potential Dietary Toxicity of Heavy Metal in Selected Vegetables and food, J. of Zhajing University of Sc B., 8(1): 1-13.
8. Onyenuga, V.A., 1969. Nigeria Food and Feeding Stuffs, their Chemistry and Nutrient value, 3rd Edn, Ibantan University Press Ibadan, pp; 215-221.
9. Baykor, B.D., M.P. stoyanov and M.L. Gugova, 1996. cadmium and lead bioaccumulation in male chickens for high food concentration, Toxicol, Environ Chem, 54: 155-159.
10. Akan, J.C., F.I. Abdurrahman, O.A. sedipo and Y.A. Chiroma, 2010. Distribution of heavy metal in Lever Kidney and Meat of Beef Mutton, Caprine and Chicken from Kabuwan Shanu Market Maidugu Bornu State Nigeria, Research J. of Applied Sc, Eng and Tech, 2(8): 743-748.
11. Mclaughlin, M.J., D.R. Parker and J.M. Clarke, 1999. Metal and Micro nutrients Food and Safety issues, Journal of field Crop Resources, 60: 143-163.
12. FAO/WHO, 2000. Report of the 32nd Session of the Codex Committee of the Food Additives Contaminants Beijing People's Republic of China, pp: 20-24.