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Assessment and Daily Intake Rates of Heavy Metals Concentrations in Rice, Cowpea and Garri, in Akoto Market, Ibadan, Oyo State

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ABSTRACT

Heavy metals are increasingly becoming threats to human health. The concentration levels and daily intake rate (DIR) of cadmium, chromium, zinc, iron, lead, copper were assessed in three commonly-consumed food stuffs: rice (*Oryza sativa* L.), cowpea (*Phaseolus vulgaris* L.), garri (processed *Manihot esculentus* Crantz). purchased at two randomly selected stores at Akoto market, Ibadan, Oyo state, Nigeria. Samples were washed, oven-dried and powdered. Samples were digested with nitric acid and analyzed with Atomic Absorption Spectrophotometer. In store I; Iron has the highest occurrence of 0.83mg/kg in rice (*Oryza sativa*). Cd, Cr, Zn, Cu were found in cowpea, Ni and Pb in garri and Fe in rice. In store II, Fe has the highest occurrence of 0.64mg/kg in cowpea (*Phaseolus vulgaris*). The highest level of Cd was in garri, Cr, Ni and Cu in rice, while Zn and Fe in cowpea. Garri was generally safe except for Pb levels in store I and Cd levels in store II. Cd was at safe levels in cowpea except for store I. Across both stores, heavy metal levels of Cd and Zn were similar. Store I had higher levels of Cr and Fe than store two. Cu and Ni levels were higher in store II. Overall 71.8% of the sampled food stuff had levels of metals below the WHO permissible limit, which varied based on food stuff, 20.5% were above the permissible limit and 7.7% were not detected. Cowpea and garri had the highest DIR of 0.2512 and 0.1395 respectively for Fe, while rice had the highest DIR of 0.2088 for Cr. This study on foodstuffs purchased at Akoto market elucidated levels of heavy metals that are of public health concern.

KEYWORDS: Heavy metals, *Oryza sativa*, *Phaseolus vulgaris*, processed *Manihot esculentus*, Daily intake rate

INTRODUCTION

According to the Global Food Security Index (GFSI), Nigeria ranked 91 in 109 countries (GFSI, 2015). However, there is an increase in the number of motorcycles and poorly maintained vehicles on the road, resulting into more emission of heavy metals to the atmosphere. Malnutrition due to high cost of foodstuff, improper storage and methods of preservation of food stuffs and many more will result in an increase in the heavy metal burden in the environment.

Most markets in the rural and sub-urban areas are not well structured. Some markets even have petrol stations beside food stalls. Some food stalls are directly located beside the road. Heavy traffic of some of these poorly-managed vehicles leads to more exposure of foodstuffs to heavy metals. Heavy metals are one of the pollutants of economic importance due to their health hazard potentials and ability to bio-accumulate in the organs of the body over a long period of time and inability to biodegrade.

The dietary intake of metals through contaminated foodstuffs is the main route of exposure to heavy metals for human beings, which can cause serious health hazards (Amin et al., 2013). It must be noted that although metals can change their chemical form, they cannot be degraded or destroyed (Saha M and Zaman M R, 2012). Unsafe levels of heavy metals from anthropogenic sources that enter into the ecosystem may lead to geo-accumulation and bioaccumulation, which in turn pollute the environment and also affect the food chain and ultimately pose serious human health risks (Weldegebriel *et al.* 2012).

Numerous studies have been carried out to indicate the levels of exposure of heavy metals in various sites and soil samples in Ibadan, Oyo state. Odewande and Abimbola (2008) carried out a study on contamination indices and heavy metal concentrations in urban soil of Ibadan. Thomas (2015) and Ogundele *et al.* (2019) worked on heavy metals in soil samples in abandoned dumpsite. Ganiyu *et al*. (2021) worked on shallow groundwater sources in three different residential areas, all within Ibadan, Oyo state, Nigeria. This is dangerous because plants and animals take up metals from contaminated soil and water as well as from deposits on parts of the plants exposed to the air from polluted environment (Santos *et al.* 2006). These contaminated plants and animals when consumed contributes to the major route of exposure of humans to heavy metals and greater than 90% of human exposure to heavy metals is through diet (Loutfy *et al.* 2006).

Akoto is a residential area, around elebu, Ibadan, Oyo state. Keeping in view of the potential toxicity persistent in nature, leading to environmental pollution, it is deemed necessary to have the baseline environmental data on potential metal contamination so that pollutants can be judged in the environment (Saha M and Zaman M R, 2012). This study was carried out to assess the levels of concentrations of some heavy metals (Pb, Cd, Mn, Cr, and As) in selected foodstuffs purchased from the market of Akoto in Ibadan, Oyo state.

MATERIALS AND METHODS

Study area and sampling

Three commonly consumed food samples; rice (*Oryza sativa*), cowpea (*Phaseolus vulgaris*), and garri (processed *Manihot esculentus*) were purchased from two different randomly selected stores in Akoto market, Ibadan, Oyo state, Nigeria, with GPS coordinates of 7.3499^0Latitude and 3.8203^0Longitude.

Sample preparation

All the collected samples of various food stuffs were washed with deionised water to remove airborne pollutants. They were then grounded into fine powders in a ceramic mortar and pestle and passed through a sieve. 1.0g of the powdered samples was weighed using a weighing balance (model OHAUS) and kept in the already labelled paper wrap for further analysis.

Digestion of the samples

The already weighed samples were poured into a 50ml beaker; 15 ml of HNO_3 was added to the beaker to dissolve the sample (HNO_3 was used as solvent because it dissolves possibly all metals). It was then placed on a hot plate at 350℃ in a fume cupboard so as to digest and trap in all possible poisonous gases. After heating, the samples were brought out from the fume cupboard and allowed to cool.

After cooling, it was transferred into a 100ml volumetric flask and diluted with de-ionized water up to the lower meniscus at the mark of 100ml and filtered into a sample bottle using Whatman No. 1 filter paper and a funnel. It was then stored for further analysis. All the glass apparatus used throughout the process of this digestion were washed with de-ionized water.

Determination of heavy metals concentration

The digested samples were carried to the multipurpose laboratory of the Federal College of Animal Health and Production Technology and were analysed using the atomic absorption spectrophotometer (AAS) model Bio-base-AA320N.

Daily Intake Rate of Foodstuffs

A survey was created on google form and sent to 23 respondents to carry out indirect assessment method, according to Kroes et al., (2002). Retrieved data was used to calculate the daily intake rate of the three foodstuffs. The quantity of food and rate were retrieved from the survey.

Data analysis

Data was analysed using Microsoft Excel (2010 Version):

The daily intake rate of metals (DIR) was calculated using:

$DIR = C_{metal} X D_{food\ intake} / B_{average\ weight}$

C_{metal}= heavy metal concentration in plants (mg/kg)

$D_{food\ intake}$ = daily intake of foodstuff (kg/person)

$B_{average\ weight}$ = average body weight (55.9kg).

RESULTS AND DISCUSSION

Table 1 elucidates the concentration levels (mg/kg) of cadmium, chromium, nickel, zinc, iron, lead and copper present in commonly consumed food stuffs purchased at Akoto store I. Iron has the highest occurrence of 0.83mg/kg in rice (*Oryza sativa*). The range of metals were 0.03 – 0.09, 0.46 – 0.69, ND – 0.02, 0.07 – 0.29, 0.40 – 0.83, 0.01 – 0.10 and 0.10 – 0.32mg/kg for cadmium (Cd), chromium (Cr), nickel (Ni), zinc (Zn), iron (Fe), copper (Cu) and lead (Pb) respectively.

The highest concentration levels of Cd, Cr, Zn, Cu were in cowpea, Ni and Pb in Garri and Fe in rice.

Iron has the highest occurrence of 0.64mg/kg in Cowpea. The range of metals were ND – 0.10, 0.36 – 0.53, Nd – 0.19, 0.08 – 0.33, 0.13 – 0.64 and 0.03 – 0.36 for cadmium (Cd), chromium (Cr), nickel (Ni), zinc (Zn), iron (Fe) and copper (Cu) respectively. The highest level of Cd was in Garri, Cr, Ni and Cu in rice, while Zn and Fe in Cowpea (Table 2).

Concentration levels of Cd and Zn were similar in both stores. Conversely store I had higher levels of Cr and Fe than store II while Cu and Ni levels were higher in store II.

Table 1: Concentrations of Heavy Metals (mg/kg) in Rice, Cowpea and Garri from Akoto Store I

Samples	Cd	Cr	Ni	Zn	Fe	Cu	Pb
Garri	0.03	0.60	0.02	0.07	0.40	0.01	0.32
Cowpea	0.09	0.69	0.01	0.29	0.78	0.10	0.10
Rice	0.06	0.46	ND	0.09	0.83	0.04	0.30
Average	0.06	0.58	0.01	0.15	0.67	0.05	0.24

*ND = Not Detected

Table 2: Concentrations of Heavy Metals (mg/kg) in Rice, Cowpea and Garri from Akoto Store II

Samples	Cd	Cr	Ni	Zn	Fe	Cu
Garri	0.10	0.36	ND	0.08	0.39	0.03
Cowpea	ND	0.48	0.02	0.33	0.64	0.10
Rice	0.08	0.53	0.19	0.09	0.13	0.36
average	0.06	0.46	0.07	0.17	0.39	0.16

*ND = Not Detected

Table 3: Comparisons of ranges of heavy metal concentrations in Rice, Cowpea and Garri between Akoto Stores I and II

Samples	Akoto Store I	Akoto Store II
Cd	0	0
Cr	+	-
Ni	-	+
Zn	0	0
Fe	+	-
Cu	-	+

* 0 = similar range, + = above others, - = below others

Table 4: Concentration levels of heavy metals (mg/kg) in Garri from stores I and II at Akoto in comparison with the WHO standard

			GARRI				
Samples	**Cd**	**Cr**	**Ni**	**Zn**	**Fe**	**Cu**	**Pb**
Akoto I	0.03	0.60	0.02	0.07	0.40	0.01	0.32
Akoto II	0.10	0.36	ND	0.08	0.39	0.03	-
WHO	0.05	2.3	0.67	0.99	0.43	0.74	0.1
> WHO	1						1

*ND = Not Detected

Garri was generally within safe levels of concentrations except for Pb levels in store I and Cd levels in store II, which were higher than the permissible limit. This is of a concern putting into consideration that garri is mostly consumed directly without necessarily being cooked. The mean value of Fe (0.43mg/kg), Cu (0.74mg/kg) and Zn (0.99mg/kg) in this study (Table 4) is far below mean values reported Fe (29.16mg/kg), Cu (2.67mg/kg) and Zn (4.55mg/kg) in a study done in Nigeria in assessing chemical and trace metal of dried cassava products (Abass *et al*., 2019). However, the bio-accumulation of lead and cadmium is very hazardous to human health and should not be over looked.

Cd was at safe levels in cowpea except for store 1. Cr, Ni, Zn, Cu and Pb were within the safe limit. Converesly, Fe was above the permissible level across the two stores. The range of Cr levels (Table 5) (0.48mg/kg – 0.69mg/kg) falls within Cr levels range (0.189mg/kg – 0.586mg/kg) in a study carried out in selected markets in Katsina state on unprocessed cowpea (Yaradua *et al*, 2017). However levels of metals in the processed bean porridge had lower levels (ND– 0.16mg/kg) in the study, suggesting that processing reduced the concentration of Cd, Mn, Ni and Cr. Also, this corroborates with the findings of Watzke (1998) and Ersoy *et al*. (2006) who stated that toxic elements are sensitive to processing effects. Peeling, washing, cooking, frying, and other culinary activities can have a significant influence on the content of heavy metals in foodstuffs. Pb levels are same with the permissible limit unlike what was reported for market sold cowpea in eastern Nigeria by Okoye *et al*. (2009) and in katsina state (Yaradua *et al*, 2017).

Table 5: Concentration levels of heavy metals (mg/kg) in Cowpea from stores I and II at Akoto in comparison with the WHO standard

					COWPEA		
Samples	**Cd**	**Cr**	**Ni**	**Zn**	**Fe**	**Cu**	**Pb**
Akoto 1	0.09	0.69	0.01	0.29	0.78	0.10	0.10
Akoto 2	ND	0.48	0.02	0.33	0.64	0.10	
WHO	0.05	2.3	0.67	0.99	0.43	0.74	0.1
> WHO	1				2		

*ND = Not Detected

Table 6: Concentration levels of heavy metals (mg/kg) in Rice from stores I and II at Akoto in comparison with the WHO standard

			RICE				
Samples	**Cd**	**Cr**	**Ni**	**Zn**	**Fe**	**Cu**	**Pb**
Akoto 1	0.06	0.46	ND	0.09	0.83	0.04	0.30
Akoto 2	0.08	0.53	0.19	0.09	0.13	0.36	
WHO	0.05	2.3	0.67	0.99	0.43	0.74	0.2
> WHO	2				1		1

*ND = Not Detected

Generally, levels of the selected heavy metals in rice were within safe limits for both stores except for Pb 0.3mg/kg which was higher than the WHO safe level (Table 6) of 0.2mg/kg for rice, Cd (0.06mg/kg and 0.08mg/kg in both stores) and Fe (0.83mg/kg) in store one. Highest levels of Cd, Cr and Pb (0.08mg/kg, 0.53mg/kg, 0.30mg/kg) in this study are lower than levels reported in various rice samples Cd (1.12 – 1.30) mg/kg, Cr (0.86 – 0.93)mg/kg and Pb (0.89 – 0.98)mg/kg purchased from Ofada in Ogun state of Nigeria (Olalekan *et al.*, 2019).

In general, highest levels of Cr, Zn, and Cu were detected in cowpea, Fe, Ni and Pb in rice, and Cd in garri. Rice and cowpea appear to be the most contaminated (Table 6). Overall 71.8% of the sampled food stuffs had levels of metals below the WHO permissible limit, which varied based on food stuff, 20.5% violated the permissible limit and 7.7% were not detected (Table 7). Cowpea (*P. vulgaris*) and garri had the highest DIR of 0.2512 and 0.1395 respectively for iron while rice (*O. sativa)* had the highest DIR of 0.2088 for Chromium (Table 8).

Table 7: Stores with the highest occurrences of heavy metals based in the food stuffs and the percentage undetected heavy metals.

Samples	Cd	Cr	Ni	Zn	Fe	Cu	Pb
Highest occurrence	Akoto II(Garri)	Akoto I(cowpea)	Akoto II(rice)	Akoto II(cowpea)	Akoto I(Rice)	Akoto II(cowpea)	Akoto II(rice)
ND levels (%)	16.7	0	33.3	0	0	0	0

*ND= Not detected

Table 8: Average Daily intake rate (DIR) (g person^{-1} day^{-1}) of heavy metals through consumption of contaminated food stuffs in Akoto.

Samples	**Cd**	**Cr**	**Ni**	**Zn**	**Fe**	**Pb**	**Cu**
Garri	0.024 ± 0.019	0.1706 ± 0.059	0.0085 ± 0.006	0.027 ± 0.001	0.1395 ± 0.002	0.115 ± 0	0.0074 ± 0.006
Cowpea	0.033 ± 0.023	0.2057 ± 0.051	0.0051 ± 0.002	0.1102 ± 0.011	0.2512 ± 0.034	0.0341 ± 0	0.0338 ± 0.0001
Rice	0.0297 ± 0.006	0.2088 ± 0.02	0.0801 ± 0.057	0.0382 ± 0.001	0.2021 ± 0.21	0.1274 ± 0	0.0856 ± 0.095

The study investigated the levels of contamination across two various stores within the market to see if there were any variations or perhaps other influences to heavy metals levels of concentrations in three most commonly consumed foodstuffs and found to be contaminated. Conversely, the results elucidated variation in the levels of contamination in the foodstuff, within the same Akoto market.

Akoto being a residential area with less commercial and industries activities showed lower levels compared to other areas as stated above. This indicates the effect of industries and commercial activities as contributors to heavy metal loads in the environment. The variation in the levels also is an indication of other activities present within the environment such as generators, cars, and other processing items particularly releasing exhaust into the environment.

CONCLUSION

Heavy metals contamination remains a threat to humanity especially because of their bio accumulative potential. Our study has elucidated higher levels of Cadmium and varying levels of Lead and other essential metals when compared to the recommended WHO permissible level. The daily intake rate of heavy metals in Akoto market remains an area of public health concern. More studies should be carried out to capture and determine the likely causes of varying levels of heavy metals in the food stuffs within the location and there is need for consistent monitoring and public sensitisation on particularly concentrations of heavy metals beyond WHO permissible levels and DIR.

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