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# Health risk assessment of selected heavy metals in gari (cassava flake) sold in some major markets in Yenagoa metropolis, Nigeria


## Abstract

*Gari* (cassava flake) is a major staple food in Nigeria. It's also a major source of energy food to several families. This study evaluated the health risk assessment of selected heavy metals in *gari* sold in some major markets in Yenagoa metropolis, Nigeria. Triplicate *gari* sample were obtained from four different markets in Yenagoa metropolis, Nigeria. The samples were ashed, digested and analyzed using atomic adsorption spectrophotometer. Health risk assessment was carried out using target hazard quotient, health risk index and daily intake index. Result revealed that the heavy metals concentration ranged from 1.32–3.81 mg/kg (manganese), 2.21–5.66 mg/kg (zinc), 1.00–3.72 mg/kg (copper) and 11.16-38.75 mg/kg (iron). There was significant difference ($P<0.05$) in each of the heavy metals among the various locations. The target hazard quotient and health risk index values were <1. This indicates no potential health risk of the studied heavy metals in the *gari* among the population under study.


**Keywords:** *gari*, health risk assessment, heavy metals, human health effects

Research Article

Volume 4 Issue 2 - 2018

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**Received:** December 22, 2017 | **Published:** March 07, 2018

## Introduction

Cassava is a major source of staple food to several families in tropical Africa Emurotu et al.[1] especially in Nigeria that is the largest producing nation in the world Izah et al.,[2–10] Izah & Ohimain,[11] Ohimain et al.[12] Cassava cultivation and processing is carried out predominantly by smallholder in Nigeria. According to Kigigha et al.[13] cassava cultivation, processing and marketing of its associated products is a major source of livelihood to several families especially in rural setting in Nigeria. Cassava is a typical carbohydrate food crop. Kigigha et al.[13] Ukwuru & Egbonu.[14] is with the opinion that cassava meals provide energy for over 2 billion people in the tropical regions. Cassava is typically used as food in the form of *gari, lafun* and *fufu*, livestock feeds, confectionaries, sweeteners production Adebayo-Oyetoro et al.,[15] additives to several pasteries such as bread cookies, biscuits and rolls, doughnut, cakes, flakes etc especially in private house hold level Emurotu et al.[1] Beside food, cassava have also found application in several sector including glues, textiles, pharmaceuticals Adebayo-Oyetoro et al.[15] and bioethanol production Ukwuru & Egbonu et al.[14] Cassava is a tuber crop that is propagated by stem.[16–19]According to Izah & Aigberua,[20] cassava matures between 6–12 months of planting depending on the variety. The authors further reported that the utilization rate of cassava vary according to the income size and source of income of the farmer especially in the rural area. As such some individuals still harvest their cassava between 12 – 24 months of planting Izah & Aigberua.[20]

Cassava requires essential nutrients for optimum productivity. Some of the elements are required in trace amount. Some of these heavy metals that are required by cassava at trace concentration include nickel, chromium, zinc, copper, manganese, iron etc. While some others such as cadmium, lead, arsenic, mercury etc do not have any known biological function and as such its presence in biodiversity depicts contamination/ toxicity. Like most plants, cassava has the tendency to bioaccumulate heavy metals in their various parts from the environment and thus can transfer to the food chain. Some heavy metals enters the environment (surface/ ground water, soils etc) through human/anthropogenic activities such as industrial and agricultural activities, mining, transportation, waste disposal etc Seiyaboh & Izah,[21] Ben-Eledo et al.[22] Izah et al.[23] Izah & Angaye,[24] Izah & Aigberua.[25] Adejoh.[26] Heavy metals are also from natural earth's crust Khan et al.[27]

Heavy metals contamination of the environment and food materials are major source of concern. In human, heavy metals are up taken through consumption of heavy metal laden food, water and inhalation of heavy metal contaminated air. Information about food consumed is invaluable for estimating the suitability of intakes of essential nutrients and assessing exposure risks of heavy metals Moremi et al.[28] As such, food safety is a major global concern Khan et al.[27] Specifically, health risk assessment of heavy metals in food of a given population is a good technique because it provides useful information about any threat regarding heavy metals contamination in a given food samples Khan et al.[27] Therefore, this study aimed at assessing health risk assessment of selected heavy metals in *gari* (cassava flake) sold in some major markets in Yenagoa Metropolis, Nigeria.

## Materials and methods

### Study area

Bayelsa State is one of the Niger Delta states. Yenagoa is the state capital of Baylesa state. The region is characterized by high water table/ level and multiple flooding events that typically occur between May and late October annually. Yenagoa is one of the fast developing city with few industries and several business activities.[29,30]

Some notable food crops such as *gari* that is consumed in Yenagoa metropolis comes from neighboring states such as Delta and Rivers states. Typically the Niger Delta region area is characterized by temperature of 24–37 ºC and relative humidity of 50–95% all year round.[31–34]

## Sample collection

Triplicate samples of red *gari* were purchased from four major markets in Yenagoa metropolis viz: Etegwe Junction, Agudam-Epie, Akenfa and Igbogene market. The samples were packaged in sterile Ziploc bag and transported to the laboratory for analysis.

## Sample preparation and Heavy metal analysis

The *gari* samples were oven dried at 105 ºC to constant minimum moisture content for 6 hours. Then the samples were dry-ashed in a muffle furnace at 450 ºC. The ashed sample was digested using nitric and hydrochloric acid. The digested samples were analyzed at varying wavelength of 213.9nm, 324.70nm, 248.3nm, 279.5nm and 357.90nm for zinc, copper, iron, manganese and chromium respectively using Atomic Absorption Spectrophotometer (Model: GBC Avanta PM A6600).

## Health risk assessment

Health risk assessment has been widely applied in studies related to human health. Some of the notable indices used for health risk assessment include target hazard quotients, total target hazard quotient, health risk index and daily intake of metal estimated daily intake Wang et al.[35–48]

## Daily intake of metals

Daily intake of metals has been widely calculated by authors using the equation 1 Iwegbue et al.[43] Orisakwe et al.;[45] Chen et al.[46]

$$\text{DIM} = \frac{C_{metal}\ x\ D_{intake\ of\ food}}{B_{Average\ body\ weight}} \quad (1)$$

Where: Cmetal = concentration of heavy metal in the *gari* sample (mg/kg)

Dintake of food = daily intake of *gari*

The daily maximum intake of 800g for cassava meals was assumed for this study Hayford et al.;[49] Zango et al.[41] The daily intake of cassava was converted to kg/ person/ day) Osu et al.[36]

## Health risk index

Health risk index is calculated by using daily intake of metals and the corresponding reference oral dose for each of the heavy metals under study. The health risk index has been calculated by authors based on equation 2 Osu et al.;[36] Jan et al.[50]

$$\text{HRI} = \frac{\text{DIM}}{\text{RfD}} \quad (2)$$

DIM,Daily Intake of Metals for each of the heavy metals; RfD, oral reference dose for the heavy metals under study viz: copper (0.04), Manganese (0.14), iron (0.7), Zinc (0.3)

When the health risk index is <1, it pose no health effect but when the ratio is ≥ 1 it indicate that the population will experience health risk Osu et al.;[36] Khan et al.[27]

## Target hazard quotients

Target hazard quotient is one method of assessing lifelong exposure to heavy metals through diets Iwegbue et al.[42]; Ihedioha et al.[47] Typically, target hazard quotients was developed by the United State Environmental Protection Agency (EPA) for estimation of potential health risk associated with long term exposure to chemical pollutants (US EPA, 1989).[51] The Target Hazard Quotients have been widely applied by authors Naughton & Petroczi.;[39,40] Iwegbue et al.,[42] Ihedioha et al.;[47] Wang et al.;[35] Osu.;[36] Chien et al.;[37] Kigigha et al.[13]

$$\text{Target Hazard Quotients} = \frac{\text{EF x ED x FIR x CHM}}{\text{RFD x BaW x AT}} x 10^{-3} \quad (3)$$

Where

i. EF=the exposure frequency (365days/year) Osu et al.;[36] Bennett et al.[52]

ii. ED=the exposure duration =70 years Osu et al.;[36] Bennett et al.[52]

iii. FIR=Food ingestion rate

iv. CHM=concentration of heavy metal in the *gari*

v. RfD=oral reference dose for the heavy metals under study were Copper (0.04), iron (0.7), Zinc (0.3), Manganese (0.14)

vi. BaW= body average weight for adult =70kg Abubakar et al.;[44] Kigigha et al.[13]

vii. AT=average time for non-carcinogen (days) (365days/year) Ihedioha et al.;[47] Osu et al.;[36] Bennett et al.[52]

When the target hazard quotients is <1, it suggest no potential adverse effects Ihedioha et al.;[47] Zhuang et al.;[53] Osu et al.;[36] Wang et al.;[35] Kigigha et al.;[13] Chien et al.[37]

Furthermore, the summation of the individual target hazard quotients for each of the metals is referred to as total Target Hazard Quotients.

Total Target Hazard Quotients =

*∑total hazard quotients of individual heavy metals under study*

## Statistical analysis

Statistical Package for Social Sciences software version 20 was used for the statistical analysis. A one way analysis of variance (ANOVA) was carried out and significance variation was determined at P = 0.05 and Tukey Honestly Significance Difference was used to determine the source of the observed variation. Paleontological statistics software package by Hammer et al.[54] was used to plot chart for the overall heavy metal concentration in the study. Standard error bar was determined at 95% interval level.

# Results and discussion

Table 1 presents some selected heavy metal concentration in *gari* sold in some market in Yenagoa metropolis, Nigeria. While the correlation matrix of the heavy metals under study is presented in Table 2. Furthermore, chromium was not detected (viz: <0.001mg/kg) in the *gari* samples. The heavy metals concentration ranged from 1.32–3.81 mg/kg (manganese), 2.21–5.66 mg/kg (zinc), 1.00–3.72 mg/kg (copper) and 11.16- 38.75 mg/kg (iron). There was significant difference (P<0.05) among the various locations the samples were obtained for each of the heavy metals under study. Among the heavy metals under studied, manganese showed positive significant relationship with iron (r=0.853, P<0.01) while copper also showed positive significant correlation with iron (r=0.651, P<0.05) (Table 2). The significant variation (P<0.05) that exits among the *gari* samples from different markets under study could be due variation in the source viz: heavy metals concentration in the soil that the cassava tuber was cultivated. The heavy metals under study were in the order; chromium < copper <manganese < zinc < Iron (Figure 1). The trend in this study were slightly different from the trend of iron> manganese > zinc > copper reported in cassava tuber in Eleme Local Government Area of River state by Moremi et al. (2016). These heavy metals are essential nutrients required by the body at certain concentration. For instance, iron in the body play essential roles. The values reported in this study were close to the value of 12.08 – 28.80 mg/kg reported in cassava tuber in Eleme Local Government Area of River state by Moremi et al. (2016). But lower than the value of 557.03 mg/kg and 10542mg/kg reported in un-impacted and crude oil impacted soil in Ikot Ada Udo in Ikot Abasi Local Government Area of Akwa Ibom State Osu et al.[36] The values in this study showed iron deficiency. This is a major source of concern considering the role of iron in diets. Some of the associated role of iron in the human body have been variously reported in literature by authors Izah et al.[55] According to Moremi et al.[28] the human body requires higher concentration of iron for several physiological functions compared to the amount required for other essential heavy metals. Diet low in iron could predispose the body to condition such as lead (Pb) toxicity. According to Moremi et al.[28] deficiency of iron could enhance lead (which is neuro toxic) absorption in the body. The authors further reported that individuals with iron deficient can absorb more lead in their system up to 7 fold as the body responds to iron deficiency by dispatching increasing amounts of the iron transporter and Divalent Metal Transporter 1 into the gut.

**Table 1** Heavy metal concentration of *gari* sold in some market in Yenagoa metropolis, Nigeria

| Location | Mn, mg/kg | Zn, mg/kg | Cu, mg/kg | Fe, mg/kg |
|---|---|---|---|---|
| Akenfa | 2.85±0.36b | 5.66±0.31c | 1.00±0.06a | 18.40±0.50ab |
| Agudama-Epie | 3.81±0.46b | 3.74±0.44b | 3.72±0.87b | 38.75±2.18c |
| Igbogene | 1.32±0.12a | 2.21±0.11a | 1.46±0.24a | 11.16±1.12a |
| Etegwe Junction | 2.59±0.32ab | 4.46±0.22bc | 2.72±0.41ab | 21.35±2.05b |

Data is expressed as mean ± Standard Error; Different alphabets along the column indicate significant variation (P<0.05) according to Tukey Honestly Significance Difference.

**Table 2** Spearman rho correlation coefficient of the heavy metals under study

| Locations | Mn | Zn | Cu | Fe |
|---|---|---|---|---|
| Mn | 1.000 | | | |
| Zn | 0.469 | 1.000 | | |
| Cu | 0.340 | -0.228 | 1.000 | |
| Fe | 0.853** | 0.350 | 0.651* | 1.000 |

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

**Table 3** Health Risk assessment of gari samples sold in some major markets in Yenagoa metropolis, Bayelsa state, Nigeria

| Heavy metals | Daily Intake of Metals | Health Risk Index | Target hazard quotients | Total-total hazard quotients |
|---|---|---|---|---|
| Iron | 0.256 | 0.366 | 0.026 | |
| Manganese | 0.030 | 0.216 | 0.015 | |
| Zinc | 0.046 | 0.153 | 0.011 | 0.096 |
| Copper | 0.025 | 0.635 | 0.044 | |
| Chromium | NA | NA | NA | |

The total concentration of Zinc in the *gari* sample was similar to the value of 3.20 - 6.59 mg/kg reported in cassava tuber in Eleme local government area of Rivers state Moremi et al.[28] Also close to the value of 5.33 mg/kg in cassava from un-impacted soil and lower than the value of 22.30 in cassava tuber from crude oil impacted soil in Ikot Ada Udo in Ikot Abasi Local Government Area of Akwa Ibom State Osu et al.,[36] Adejoh.[26] reported that zinc play a vital role in the physiological and metabolic process in living organisms. Typically, zinc is as essential trace element that play essential role as an enzyme co-factor and its occurrence may weaken the chances of lead toxicity Moremi et al.[28] Zinc also play essential role in the functioning of the immune system Adejoh.[26] High concentration in the body could induce several health effects such as vomiting and gastrointestinal irritation (nausea, cramps, diarrhoea), weakness, anorexia, anaemia, diminished growth, loss of hair, lowered food utilization, changes in some liver, brain and kidney functions Izah et al.[55] According to Adejoh.[26] chronic elevation of zinc intake could lead to copper impairment in human.

The concentration of Copper in *gari* samples in the study area were slightly lower than the values of 0.87– 1.23mg/kg reported in cassava tuber is some locations in Eleme local government area of Rivers state Moremi et al.[28] But higher than the value of 0.05 mg/

kg in cassava tuber from un-impacted soil and lower than the value of 18 mg/kg in cassava tuber from crude oil impacted soil in Ikot Ada Udo in Ikot Abasi Local Government Area of Akwa Ibom State.[36] Adejoh.[26] reported that copper is an important metal required by the human body for mental and physical development which is up taken through vegetarian foods such as nuts, seeds and grains. High concentration of copper is diet is characterized by abdominal pains, diarrhoea, vomiting and metallic taste in the mouth.[28] This is because copper could accumulate easily in the body. Hence, chronic low level intakes have damaging effects since there is no good mechanism for their elimination in the body.[26] Furthermore, cirrhosis and other liver disease are some health condition associated with high copper ingestion through diets.[28] Adejoh.[26] further listed condition associated with increased copper concentration in the body to include arthritis, fatigue, insomnia, scoliosis, osteoporosis, heart disease, cancer, migraine, heart seizures, gum diseases, skin and hair problems.

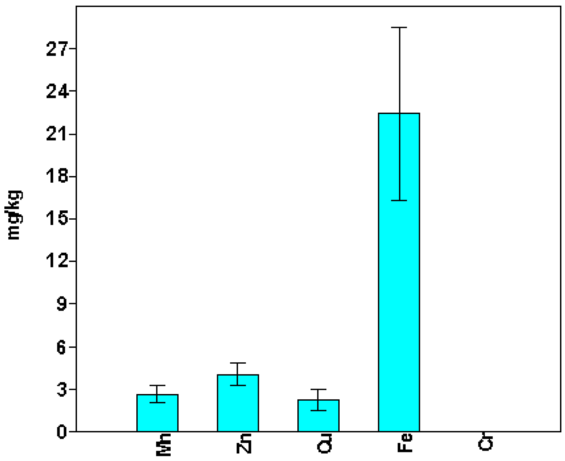


**Figure 1** Mean value of some selected heavy metals in gari sold in some market in Yenagoa metropolis, Nigeria.

The value of manganese concentration recorded in this study were lower than the value of 5.95 - 14.55 mg/kg reported in cassava tuber from some locations in Eleme Local Government Area of Rivers state as reported by Moremi et al.[28] But similar to the value of 3.02 mg/kg in cassava tuber from un-impacted soil and lower than the value of 40.62 mg/kg in cassava tuber from crude oil impacted soil in Ikot Ada Udo in Ikot Abasi Local Government Area of Akwa Ibom State.[36] Typically, manganese toxicity may impair central nervous system and cause progressive disorder of the extra pyramidal system Moremi et al.[28] The daily intake of metals, health risk index, total hazard quotients of heavy metals associated with *gari* sold in some markets in Yenagoa metropolis, Bayelsa state is presented in Table 3. The daily intake were 0.256 (iron), 0.030 (manganese), 0.046 (zinc) and 0.025 (copper). Furthermore, the health risk index were 0.366 (iron), 0.216 (manganese), 0.153 (zinc) and 0.635 (copper), while Target hazard quotients were 0.026 (iron), 0.015 (manganese), 0.011 (zinc) and 0.044 (copper). These values were lower than the upper tolerable daily intake level viz: 45mg/day (iron), 11mg/day (manganese), 40mg/day (zinc) and 10 mg/day (copper) specified by the Institute of Medicine for adults (Institute of Medicine[56]). The findings of this study suggest no potential health risk of the assessed heavy metals for the individuals consuming *gari* samples in the study area. Typically, health risk index <1 is an indication of safe health risk while health risk index>1 suggest severe risk of the metals. Furthermore, target health quotients which is another tool used in assessing lifetime effect of an individual on human health were <1. Authors have reported that target hazard quotients <1 is an indication no obvious risk from the metals under study over a lifetime of exposure, total hazard quotient >1 suggest adverse effect Han et al.[57] The low target hazard quotients value suggests low risk of long term carcinogenic effects.

## Conclusion

*Gari* is a typical carbohydrate crops and consumed by several families in tropical Africa especially in Nigeria. This study assessed the health risk of selected heavy metals in *gari* sold in some major markets in Yenagoa metropolis, Bayelsa state, Nigeria. The study found that there was significant variation (P<0.05) among the heavy metals in the *gari* samples. Furthermore, Health risk assessment showed no potential health effect based on health risk index and target hazard quotients viz:<1 of the heavy metals under study.

## Acknowledgement

None.

## Conflict of interest

The authors there are not conflict of interest.

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