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# Assessment of Heavy Metals Content in African Giant Rat (*Cricetomys gambianus*)

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

This study was undertaken to evaluate the concentrations of heavy metals in the liver, kidney and tissue of Africa giant rat (*Cricetomys gambianus)* in three (3) processing centers in Abeokuta, Ogun State, Nigeria with a view to determine its safeness for consumption. Atomic Absorption Spectroscopy was used to determine the concentrations of heavy metals in the liver, tissue and kidney of Africa giant rat. Data collected were analyzed using descriptive and inferential statistics. The study found out that Mn, Zn and Cu are present in liver, tissue and kidney of *Cricetomys gambianus* while cobalt, cadmium, chromium, lead and nickel are below detection limit. Mn levels ranged between 0.015±0.002, 0.01±0.002 and 0.005±0.003 for liver, tissue and kidney respectively. Zn levels ranged between 0.070±0.016, 0.032±0.013 and0.044±0.006 for liver, tissue and kidney respectively. Cu levels ranged between 0.0087±0.0061, 0.000±0.000 and 0.0057±0.0001 for liver, tissue and kidney respectively. Highest manganese concentration was observed in the liver (0.015±0.002 mg/kg) while highest copper concentration was observed in the liver (0.0087±0.0061 mg/kg).The levels of heavy metals in the liver, tissue and kidney ranged from 1.91±0.00 to

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3.96±0.00 mg/kg Zn; 0.15±0.00 to 0.17±0.00 mg/kg Pb; 0.20±0.00 to 1.98±0.00 mg/kg Cu; 0.03±0.00 to 0.27±0.00 mg/kg Cd; and 0.00±0.02 to 0.00±0.00 mg/kg Co; on average. The highest concentration of zinc and copper were found in the liver while manganese is also deposited more in the liver. The Analysis of Variance (ANOVA) test on the distribution and concentrations of all the metals in the liver, tissue and kidney shows that ($p<0.05$), i.e. there is significant difference in the amount of the elements in this samples and are not safe for human consumption.

*Keywords: Assessment; consumption; giant rat; health; heavy metals.*

## 1. INTRODUCTION

The African Giant rat is one of the most common source of bust meat and wild delicacy in West Africa sub-region including Nigeria [1]. They are hunted for food in tropical forest and serve as one of the major source of protein. A study carried out in Nigera showed that 71.4% of the people find it acceptable to use the animal as food [2]. *Cricetomys gambianus* are omnivorous animals that feed on plants, insects, snails, crab and other items [3]. In Nigeria, they are often characterized as pest animals and are not found in an open place, they are usually located in areas where there is large amount of waste or heat.

Heavy metals are also referred to as metals having atomic weight greater than sodium, and possess some level of toxicity [4]. They may cause damage to vital organs of the body like heart, liver, kidneys and brain [5]. Heavy metals are toxic and when ingested into the body system it can cause harm because they may not be metabolized by the body. Heavy metals are directly associated to health issues in humans [6]. Heavy metals pollution is a severe risk due to their bioaccumulation, toxic effects, and then continuity in different food chains [7]. These environmental unfriendly pollutants have direct deadly special effects since they are incorporated in body tissues [8]. These metals enter the human body mainly by two routes i.e. inhalation and ingestion [9] Concentration of heavy metals in the environment greater than the permissible value can be destructive to all living species. Intake of above mentioned heavy metals through inhalation, ingestion or by any mean can result in health issues and complications like damage nervous system, cancer and ultimate death [10]. *Cricetomys gambianus* an easily accessible rodent is more susceptible to heavy metals due to direct contact to industrial effluents and this is passed on to humans by ingestion.

Furthermore, high level of metal concentrations in soils negatively influence and pose health risk to various wildlife species [11,12]. Soils may become contaminated by the accumulation of heavy metals through usage of nanomaterials [13], emissions from rapidly expanding industrial activities, mining and smelting, land application of fertilizers, sewage sludge, pesticides, and atmospheric deposition [14]. The consumers of Giant rat meat are unaware of the level of heavy metal occurrence. Moreover, heavy metal concentrations in Giant rat are a critical issue for consumer safety. However, Studies on the level of heavy metals in organs of various wild animal species particularly Giant rat in Nigeria are largely unavailable. This study is to ensure safe consumption of Giant rat in minimizing the toxic effects of these metals on human health. The need for a better understanding of heavy metal composition in this animal is essential if human communities are to be safe from these metals and its adverse effects.

## 2. MATERIALS AND METHOD

### 2.1 Study Area

The study area is Abeokuta south and Odeda local government area of Ogun State. Abeokuta South is a Local Government Area in Ogun State, Nigeria. The headquarters of the LGA are at Ake Abeokuta 7°09′00″ N 3°21′00″ E. It has an area of 71 km² and a population of 250,278 at the 2006 census. Odeda is a Local Government Area and town in Ogun State, Nigeria. The headquarters of the LGA are at Odeda on the A5 highway 7°13′00″ N 3°31′00″ E. It has an area of 1,560 km² and a population of 109,449 at the 2006 census. Ogun State is situated in rainforest zone with annual rainfall of 100 – 150 cm [15,16]. The Köppen Climate Classification subtype for this climate is "Aw" (Tropical Savanna Climate). The average temperature for the year in Abeokuta is 80.8°F (27.1°C). The warmest month, on average, is February with an average temperature of 84.2°F (29°C). The coolest month on average is August, with an average temperature of 77.2°F (25.1°C). The average amount of precipitation for the year in Abeokuta

is 55.8" (1417.3 mm). The month with the most precipitation on average is June with 10.2" (259.1 mm) of precipitation. The month with the least precipitation on average is December with an average of 0.4" (10.2 mm). There is an average of 104.7 days of precipitation, with the most precipitation occurring in June with 15.4 days and the least precipitation occurring in January.

The state has estimated population of 3,486,683 people for the year 2005. It is located in the southwest zone of Nigeria with a total land area of 16,409.26 km$^2$ [17]. It is bounded on the west by the Benin Republic, on the south by Lagos State and the Atlantic Ocean, on the east by Ondo State and on the north by Oyo and Osun States. Olomore bushmeat market is located in Abeokuta North local government area, Itoku bushmeat market is located in Abeokuta South local government while Alabata bushmeat market is located in Odeda local government area of the state.

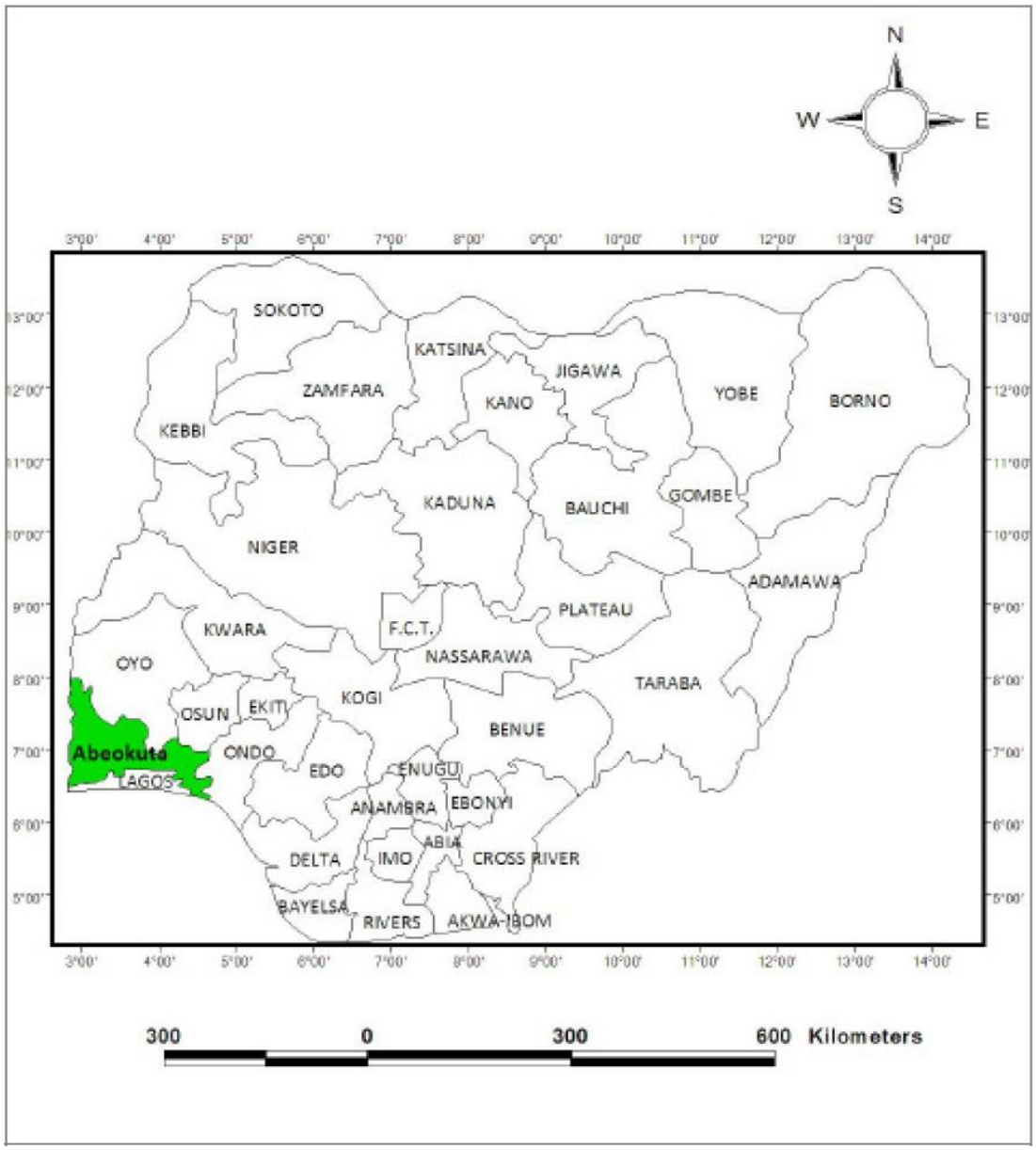


**Fig. 1. Map of the study area**

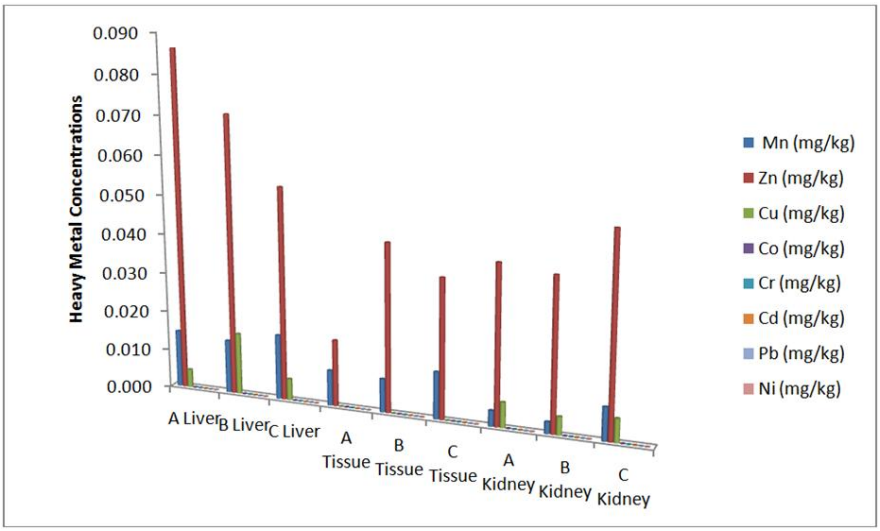


**Fig. 2. Heavy metal concentrations in each organ**

## 2.2 Sample Collection and Heavy Metal Analysis

Six (6) samples of African giant rat were selected for this study in order to test the level of heavy metals in the liver, kidney and tissue of the animal in which 2 samples each were purchased from three bushmeat market in Abeokuta Ogun state. The selected bushmeat markets are; Olomore, Itoku and Alabata. In each fresh-kill of the animal, the organs were removed immediately so as to avoid autolysis and the abdominal part of the samples was carefully macerated to remove the kidneys and liver, while lung were removed from the thoracic cavity. Internal tissue was then cut. Each set of organs were put in a separate glass container and labeled accordingly. This procedure was repeated for all the samples that were collected in the three bush meat markets.

The collected samples were decomposed by wet chemical digestion method for determination of various metals. In the laboratory, 1 g of the samples (liver, kidney and tissue) was weighed into the digestion flask. To each portion of sample in the flask, 5 ml of perchloric acid and 15 ml of 0.1 N concentrated HNO3 in a ratio 1:3 were added and then heated in an electric plate until sample became clear [18]. After digestion, 5 ml of 20% HCl (0.1 N) was added to the content. The content of the flask was filtered using Whatman filter NO42 paper into a 100 ml volumetric flask and was made up to the mark with a distilled water and then stored in a plastic reagent bottle, ready for Atomic Absorption Spectroscopy (AAS) analysis to determine Cu, Fe, Se, Zn [19] which was done at the laboratory of College of Veterinary Medicine University of Agriculture Abeokuta. In the laboratory, 5 g of the fresh and dried samples (liver, kidney and tissue) were also weighed in separate beakers and oven dried at 100°C.

## 2.3 Atomic Absorption Spectroscopy (AAS)

Atomic Absorption Spectrometry (AAS) is an instrument for estimating the ingestion of follow components introduce in soil tests by estimating the radiation consumed by the compound component of absorption spectrometric. (AAS) methods are very suitable methods for monitoring the levels of heavy metals. They provide accurate and rapid determinations, but for the extremely low concentration of these pollutant, a direct apply of AAS is impossible without any previous concentration and separation of analysts from the sample.

## 2.4 Method of Data Analysis

The collected data were analyzed using descriptive and inferential statistics. One way Analysis of Variance (ANOVA) at 5% significant level was used to determine the association between the heavy metals and the organs in the animals. Mean values were separated using Duncan Multiple Range Test (DMRT) to determine variations due to sampling errors and differences in mean values were determined and accepted as being significantly different if $P< 0.05$.

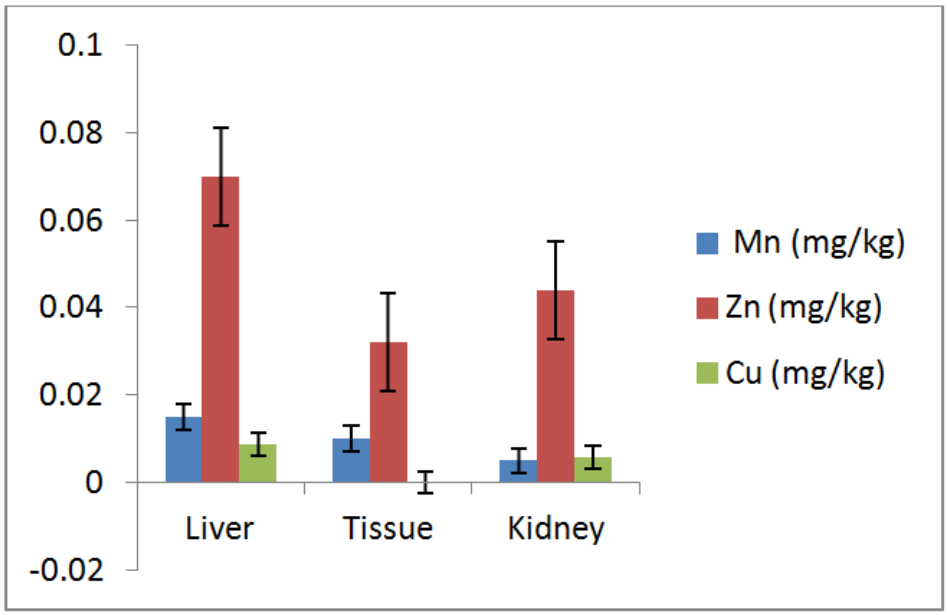


**Fig. 3. Mean error bar of metal concentration**

## 3. RESULTS

### 3.1 Metal Analysis

The result in Table 1 shows the mean concentration of heavy metal content found in liver, tissue and kidney of giant rat. The result showed the presence of three heavy metals namely; manganese, zinc and copper while cobalt, cadmium, chromium, lead and nickel are below detection limit. Mn levels ranged between $0.015\pm0.002^{a}$, $0.01\pm0.002^{b}$ and $0.005\pm0.003^{c}$ for liver, tissue and kidney respectively. Zn levels ranged between $0.070\pm0.016^{a}$, $0.032\pm0.013^{b}$ and$0.044\pm0.006^{bc}$ for liver, tissue and kidney respectively. Cu levels ranged between $0.0087\pm0.0061^{a}$, $0.000\pm0.000^{b}$ and $0.0057\pm0.0001^{bc}$ for liver, tissue and kidney respectively.

The result shows that there was significant difference in manganese concentration in liver, tissue and kidney, while there is significant difference between zinc and manganese concentration in liver and kidney, liver and tissue, but there is no significant difference in tissue and kidney.

### 3.2 Distribution of Heavy Metal Content in Various Part of Giant Rat

Table 2 shows the comparison of distribution of heavy metals concentration in Giant rat. It revealed that there was significant difference in manganese distribution in liver compare to tissue and kidney, while manganese distribution in skin compared to liver and kidney is also significantly different at ($p<0.05$). The kidney manganese distribution also shows significant difference when compared to liver and tissue. The result also showed that there was significant difference in zinc concentration in liver compared to tissue and kidney. Significant difference exists between zinc concentration in tissue compare to liver but not with kidney. Zinc concentration in kidney also shows significant difference with liver but not in tissue. The result of copper distribution shows that significant difference only occurs in liver compared to tissue.

**Table 1. Mean concentration of heavy metals in liver, kidney and skin (mg/kg)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Liver | $0.015\pm0.002^{a}$ | $0.070\pm0.016^{a}$ | $0.0087\pm0.0061^{a}$ | BLD | BLD | BLD | BLD | BLD |
| 2 | Tissue | $0.01\pm0.002^{b}$ | $0.032\pm0.013^{b}$ | $0.000\pm0.000^{b}$ | BLD | BLD | BLD | BLD | BLD |
| 3 | Kidney | $0.005\pm0.003^{c}$ | $0.044\pm0.006^{bc}$ | $0.0057\pm0.0001^{bc}$ | BLD | BLD | BLD | BLD | BLD |

*Used one way anova….*
*Concentration with same superscript is not significantly different and vice versa*
*BLD- Below Detection Limit*

**Table 2. Distribution of heavy metal content in various part of giant rat**

| Multiple comparisons | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Dependent variable** | | **(I) Organ** | **(J) Organ** | **Mean difference (I-J)** | **Std. error** | **Sig.** | **95% confidence interval** | |
| | | | | | | | **Lower bound** | **Upper bound** |
| Mn | LSD | Liver | Tissue | .00533* | .00187 | .029 | .0008 | .0099 |
| | | | Kidney | .01000* | .00187 | .002 | .0054 | .0146 |
| | | Tissue | Liver | -.00533* | .00187 | .029 | -.0099 | -.0008 |
| | | | Kidney | .00467* | .00187 | .046 | .0001 | .0092 |
| | | Kidney | Liver | -.01000* | .00187 | .002 | -.0146 | -.0054 |
| | | | Tissue | -.00467* | .00187 | .046 | -.0092 | -.0001 |
| Zn | LSD | Liver | Tissue | .03833* | .01031 | .010 | .0131 | .0636 |
| | | | Kidney | .02667* | .01031 | .041 | .0014 | .0519 |
| | | Tissue | Liver | -.03833* | .01031 | .010 | -.0636 | -.0131 |
| | | | Kidney | -.01167 | .01031 | .301 | -.0369 | .0136 |
| | | Kidney | Liver | -.02667* | .01031 | .041 | -.0519 | -.0014 |
| | | | Tissue | .01167 | .01031 | .301 | -.0136 | .0369 |
| Cu | LSD | Liver | Tissue | .00867* | .00301 | .028 | .0013 | .0160 |
| | | | Kidney | .00300 | .00301 | .357 | -.0044 | .0104 |
| | | Tissue | Liver | -.00867* | .00301 | .028 | -.0160 | -.0013 |
| | | | Kidney | -.00567 | .00301 | .108 | -.0130 | .0017 |
| | | Kidney | Liver | -.00300 | .00301 | .357 | -.0104 | .0044 |
| | | | Tissue | .00567 | .00301 | .108 | -.0017 | .0130 |

**. The mean difference is significant at the 0.05 level*

## 4. DISCUSSION

The study observed the presence of three heavy metals found in Africa giant rat meat which are manganese (Mn), zinc (Zn), and copper (Cu) while cobalt, cadmium, chromium, lead and nickel are below detection limit. Manganese when present in large amount that exceed the threshold level are harmful to the body system. The concentration of manganese was observed to be the highest in the liver ($0.015\pm0.002^{a}$ mg/kg). The result from this study corroborate with the findings of [20] who reported that the concentration of manganese in the liver is more than that of the kidney of free grazing cattle from abattoirs situated in seven widely spread localities in southern Nigeria. There have been many researches which show that manganese concentrates more in the liver than in the kidney [21]. [22] Also opined that once manganese is absorbed, it accumulates in the body throughout lifetime. The result from this study observes that high level of concentration of Zinc in the liver and kidney. The monitoring of zinc concentration in meat is important for human health. Excessive high level of zinc may enhance susceptibility to carcinogens [23]. The concentration of copper was found to be highest in the liver ($0.0087\pm0.0061^{a}$ mg/kg) as seen from Table 1. The lowest concentration was observed in the skin ($0.000\pm0.000^{b}$ mg/kg). This shows that copper is deposited more in the liver compared to the other organs as observed from the mean result from Table 1. This agrees with the findings of [24] who found out that copper is deposited most in the liver of cattle. Copper is an important component of different enzymes and it plays a vital role in bone formation, skeletal mineralization and the maintenance of integrity of connective tissues. Copper is essential for good health, but very high intake can cause health problems such as liver and kidney damage [25]. The trend of mean manganese concentrations were liver > tissue > kidney, the trend of mean zinc concentrations were liver > kidney > tissue while the trend of mean copper concentrations were liver > kidney > tissue.

## 5. CONCLUSION

Continuous and rapid growth in population, urbanization, industrialization and transportation in Nigeria in recent years has resulted in an indiscriminate exploitation of natural resources and environment. As a result of poor environmental management due to unavailability of some standards and un-operational environmental pollution laws, toxic wastes generated by these industries are discharged into the air, soil and water, with least or no treatment. This results in undue levels of heavy metals in the environment. The study found out

that various parts of giant rats consumed in Abeokuta metropolis in Ogun State, Nigeria seems not to be safe for consumption considering the concentrations of manganese, zinc, and copper present in them. This may be due to high levels of industrialization in the part of the country where the animals are found. The study further shows that health risk associated with the consumption of giant rat in the study area is significant because of the accumulation of toxic metals present in different part of the animal. Therefore, it is recommended that consumption of Giant rats should be minimized especially the liver and kidney.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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