Assessment of Heavy Metal Contamination in Three Popular Sources of Animal Protein in Owo

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Abstract- This study was carried out to assess the heavy metal contamination in three popular sources of animal protein in Owo, Ondo state, Nigeria. Samples of the animal feeds, chicken meat (muscle, liver, gizzard), pork (liver, muscle and kidney) and catfish were purchased at the distribution centers aseptically and immediately transported to the Laboratory for analysis. The respective animal parts were cleaned and washed with deionized water and then pulverized with pestle and mortal. The samples were ashed and extracted in heated aqua regia followed by filteration and heavy metals were assessed using Atomic Absorption Spectrophotometer. The results revealed that Cu ranged between 0.14 (PM, CM, CG) and 0.21 (PL) mg/Kg, Co ranged between 0.02 (PM) and 0.07 (CFF) mg/Kg whereas, Cr ranged between 0.05 and 0.65 mg/Kg. Also, Cd ranged between 0.03 and 0.10 mg/Kg in the meat samples, Mn ranged between 0.09 and 0.31 mg/Kg while Ni ranged between 0.04 and 0.15 mg/Kg in the meat samples. Moreover, Fe concentration in the meat samples ranged from 0.21 to 1.12 mg/Kg, Mg ranged between 4.72 and 13.1 mg/Kg while Pb ranged from 0.03 to 0.07 mg/Kg whereas, Zn ranged between 0.78 and 1.49 mg/Kg. These results reveals a safe level of heavy metals in pork, chicken, and catfish in Owo,

Indexed Terms- Heavy metal, contamination, food, pork, chicken, catfish

I. INTRODUCTION

Heavy metal contamination in the environment, food, and water has emerged as a significant global concern due to its detrimental effects on animals, human health and the ecosystem. Heavy metals, such as lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As), are non-biodegradable and can persist in ecosystems for long periods. These metals can enter the food chain through various pathways, including water, soil, and air, eventually accumulating in plant and animal tissues. The consumption of contaminated animal proteins, such as meat, fish, dairy, and eggs, has become a public health concern, as these metals can bioaccumulate in animal tissues and be transferred to humans through diet (Oyekunle et al., 2021).

Livestock, being a crucial food source, can be exposed to heavy metals through their feed, water, and surrounding environment. These elements can originate naturally or be introduced into the environment as a result of human activities, such as mining, industrial processes, and waste disposal (FAO, 2011).

Heavy metal contamination in animal-derived food products is influenced by multiple factors, including the environmental conditions where animals are raised, the quality of feed, and the exposure of animals to contaminated water sources. Animals that graze in industrial regions or near mining areas are particularly susceptible to heavy metal uptake. This contamination can lead to acute or chronic toxicity in humans, resulting in various health issues such as neurotoxicity, kidney damage, and cardiovascular diseases (Järup, 2003).

Earlier studies have indicated that the monitoring of heavy metals in animal protein is crucial for food safety and public health. Alizadeh and Ebrahimi (2016) highlighted the alarming levels of mercury in fish species from polluted water bodies, while Aljazzar et al. (2021) found elevated lead levels in livestock products from industrial regions.

Heavy metal contamination in food sources such as pork, chicken, and catfish is an issue of growing concern worldwide, particularly in developing

countries like Nigeria. The increased industrial activities, agricultural practices, urbanization, and improper waste disposal in Nigeria contribute significantly to environmental pollution, including the release of heavy metals. These metals can accumulate in the tissues of animals through water, feed, and the environment, posing a risk to human health when these animals are consumed (Oguzie and Ize-Iyamu, 2009). A study by Eneji et al. (2015) found that water bodies used for fish farming in some regions of Nigeria were contaminated with heavy metals due to the discharge of industrial effluents. Similarly, contamination in livestock farming has been linked to the use of contaminated feed and water, as well as the grazing of animals on polluted lands (Oluyemi et al., 2008).
Together with pork and chicken, catfish is one of the two most widely-eaten types of meat globally, with over 70% of the meat supply in 2012 between them (Caswell *et al*., 2015). In Owo, the consumption of meat is a popular practice especially as it is served in the form of pepper soup, roasted meat, barbecue fish, suya etc which are found in almost all the restaurants and relaxation centers doting the town. Pork, chicken and catfish are the major delicacies used for this purpose. Therefore, this study was designed to investigate the heavy metal content of these three popular meat sold in Owo, Ondo state, Nigeria as well as their feed.

II. MATERIALS AND METHOD

- Sample Collection

Layer breed Chicken (muscles, gizzard and kidneys), Pork (muscle, liver and kidneys) and catfish were collected randomly from the major distribution centres in Owo while the popular feeds used by major farmers in the town were also bought at different animal feed stores. They were collected aseptically and immediately transported to the Laboratory for analysis.

- Sample Preparation

The meat samples were cleaned and washed with distilled water. They were then placed in separate clean and dry glass beakers and thereafter cut into small pieces. The pieces of the breast, thigh and wing muscles were pounded in a mortar and pestle and a composite sample was taken, same was done for the pork and fish. The livers, kidneys and gizzard pieces were also pounded separately using a clean mortar and pestle. The feeds were also pulverized powdery form using a clean mortar and pestle.

- Digestion of Samples

About 20 g of each sample was weighed into a crucible using an Analytical Weighing balance. The crucibles were placed inside the muffle furnace at 500 ºC for about 6 hrs for complete ashing. After the ashing, crucibles were removed from the muffle furnace and immediately transferred into desiccator for them to become cool. The ashed samples were transferred into a beaker and 10ml of Aqua reqia (the mixture of HNO_3 and HCl at ratio 1:3) was added to the samples for digestion. The samples were heated vigorously until a clear solution was obtained and the samples volume reduced. The content of the beakers were filtered into 100 ml volumetric flasks through Whatman filter paper, and were made up to the mark with distilled water in accordance with Bawa et al. (2017) method.

- Elemental Analysis of Samples

Heavy metals concentration in digestates of each sample were determined using Buck Scientific 210 VGP Atomic Absorption Spectrophotometer. For each heavy metal, there was a specific"hollow cathode lamp" and the machine set at a particular wavelength for the analysis.

- Statistical Analysis

Data was presented as mean±standard error (SE) of triplicate data. Significance difference between different groups was tested using two-way analysis of variance (ANOVA) and treatment means was compared with Duncan's New Multiple Range Test (DNMRT) using SSPS window 10, version 25.0 software. The significance was determined at the level of $p \leq 0.05$.

III. RESULTS AND DISCUSSION

The results shown in table 1 revealed that Cu ranged between 0.14 (PM, CM, CG) and 0.21 (PL) mg/Kg, Co ranged between 0.02 (PM) and 0.07 (CFF) mg/Kg whereas, Cr ranged between 0.05 and 0.65 mg/Kg. Also, Cd ranged between 0.03 and 0.10 mg/Kg in the meat samples, Mn ranged between 0.09 and 0.31 mg/Kg while Ni ranged between 0.04 and 0.15 mg/Kg in the meat samples. Moreover, Fe concentration in the meat samples ranged from 0.21 to 1.12 mg/Kg, Mg ranged between 4.72 and 13.1 mg/Kg while Pb ranged from 0.03 to 0.07 mg/Kg whereas, Zn ranged between 0.78 and 1.49 mg/Kg.

In table 2, the animal feed samples had Cu concentration ranged from 0.12 (PF) to 0.21 (FF) mg/Kg, whereas, Cr ranged between 0.03 and 0.07 mg/Kg. Also, Cd ranged between 0.01 and 0.03 mg/Kg, Mn ranged between 0.07 and 0.32 mg/Kg while Ni ranged between 0.05 and 0.10 mg/Kg. Besides, Fe concentration ranged from 0.17 to 1.04 mg/Kg, Mg ranged between 4.13 and 10.7 mg/Kg while Pb ranged from 0.03 to 0.05 mg/Kg whereas, Zn ranged between 0.86 and 1.57 mg/Kg.

These results show a significant variability in terms of values in the accumulation level of heavy metals in different animal meat. However, the values obtained in all the meat samples were all lesser than the tolerable limit (0.5mg/kg) set by World Health Organization (WHO). The findings of Nickel concentration in the pork, chicken and catfish in this study agrees with the result reported by Nduka et al. (2016). Also, the mean concentration of iron in the meat sample used in this study, does not exceed the permissible limit for iron in food, which is generally 30 - 150 mg/kg as stated by Ahmed et al. (2017).

Table 1: Comparative analysis of metal content of selected popular protein sources in Owo

Sample	Cu	Co	Cr	Cd	Mn	Ni	Fe	Mg	Pb	Zn
PM	0.14±0.01^{a}	0.02±0.00^{a}	0.08±0.00^{a}	0.03±0.00^{a}	0.28±0.01^{c}	0.09±0.00^{b}	0.76±0.02^{b}	13.1±0.05^{e}	0.04±0.00^{a}	0.93±0.06^{b}
PL	0.21±0.00^{c}	0.06±0.00^{b}	0.08±0.00^{a}	0.05±0.00^{a}	0.29±0.01^{cd}	0.11±0.00^{c}	0.84±0.02^{b}	12.9±0.07^{e}	0.06±0.00^{b}	1.02±0.10^{b}
PK	0.17±0.00^{b}	0.04±0.00^{b}	0.06±0.00^{a}	0.05±0.00^{a}	0.31±0.01^{d}	0.09±0.00^{b}	1.02±0.03^{c}	9.25±0.03^{d}	0.04±0.00^{a}	0.78±0.05^{a}
CFF	0.19±0.01^{b}	0.07±0.00^{b}	0.05±0.00^{a}	0.04±0.00^{a}	0.23±0.01^{c}	0.10±0.00^{b}	1.12±0.07^{c}	8.03±0.05^{d}	0.07±0.00^{b}	1.49±0.15^{c}
CM	0.14±0.00^{a}	0.05±0.00^{b}	0.65±0.00^{b}	0.10±0.00^{b}	0.09±0.00^{a}	0.15±0.00^{d}	0.21±0.00^{a}	5.715±0.04^{b}	0.03±0.00^{a}	0.96±0.01^{b}
CL	0.18±0.00^{b}	0.06±0.00^{b}	0.08±0.00^{a}	0.03±0.00^{a}	0.10±0.00^{b}	0.04±0.00^{a}	0.22±0.00^{a}	7.14±0.05^{c}	0.03±0.00^{a}	1.43±0.02^{c}
CG	0.14±0.00^{a}	0.05±0.00^{b}	0.65±0.01^{b}	0.10±0.00^{b}	0.09±0.00^{a}	0.14±0.00^{d}	0.23±0.00^{a}	4.72±0.02^{a}	0.03±0.00^{a}	1.00±0.05^{b}

Key: PM = Pig tissue, PL = Pig liver, PK = Pig kidney, CFF = Catfish flesh, CM = Chicken muscle, CL = chicken liver, CG = chicken gizzard, Value = Mean ±SE and different superscript along columns are significantly different

Table 2: Comparative analysis of metal content of selected popular animal feeds sold in Owo

Sample	Cu	Co	Cr	Cd	Mn	Ni	Fe	Mg	Pb	Zn
PF	0.12±0.01^{a}	0.05±0.00^{a}	0.07±0.00^{b}	0.02±0.00^{a}	0.32±0.00^{b}	0.10±0.00^{b}	1.04±0.00^{c}	10.7±0.00^{c}	0.04±0.00^{b}	0.97±0.00^{a}
FF	0.21±0.01^{b}	0.06±0.00^{a}	0.03±0.00^{a}	0.03±0.00^{a}	0.21±0.00^{b}	0.09±0.00^{ab}	0.87±0.00^{b}	7.35±0.00^{b}	0.03±0.00^{a}	1.57±0.00^{b}
CF	0.14±0.00^{a}	0.05±0.00^{a}	0.05±0.00^{a}	0.01±0.00^{a}	0.07±0.00^{a}	0.05±0.00^{a}	0.17±0.00^{a}	4.13±0.00^{a}	0.05±0.00^{b}	0.86±0.00^{a}

Key: PF = Pig feed, FF = Catfish feed, CF = Chicken feed, Value = Mean ±SE and different superscript along columns are significantly different.

The mean concentration of Manganese in the pig feed (0.32 mg/Kg) far exceeded the concentration level of manganese (0.035mg/g) for animals as reported by Bergamaschi et al. (2018). This may account for the higher level of the element in the pork as revealed in the muscle, liver and kidney. Pigs are often raised in environments where they are exposed to contaminated water, soil, and feed. According to a study conducted by Akinola et al. (2019), pork samples collected from various regions in Nigeria showed high levels of lead and cadmium, exceeding the safe limits established by international food safety authorities. The study attributed this contamination to the consumption of feed grown in contaminated soils and the use of polluted water in pig farming. Another study by Ojekunle et al. (2020) found significant concentrations of mercury and arsenic in pork samples, particularly in urban areas, which are more prone to environmental pollution from industrial and vehicular activities. These results are at variance with our observations in this study.

Abduljaleel (2014) noted that the liver is the site where metabolism occurs; the kidney performs the function of excretion; the gizzard is used for disintegration of the absorbed food particles while the muscle has no known metabolic function. The high levels of Cu, Pb, Zn ,Fe and Mg in the internal organs of the animals could have come from of anthropogenic activities in the environment, feeds and water fed to them while growing.

A study by Onyimonyi and Okeke (2021) investigated the concentration of heavy metals in chicken meat from different regions in Nigeria. The findings indicated that cadmium and lead were present in alarming amounts, particularly in chickens raised near mining areas. The study also pointed out that chickens fed with contaminated feed or water could accumulate these metals in their tissues, leading to potential health risks for consumers. Additionally, Bawa et al. (2017) reported elevated levels of chromium and arsenic in chicken tissues, primarily from industrial regions. All these were at odds with our findings probably because Owo is not an industrial town and the local sources of feed may not be contaminated with these metals.

Furthermore, the results obtained in this study were lower than Pb; (7.76 ± 0.03) mg/g, Cd; (1.39 ± 0.09) mg/g, and Cu; (2.30 ± 0.08) mg/g reported for these metals in chickens raised in Ogun state (Onyimonyi and Okeke, 2021). Darwish et al. (2015) obtained similar results for lead 0.071, 0.472 and 0.398 mg/kg respectively in the muscle, liver and kidney of slaughtered cattle in Mosul, Egypt. Iwegbue, *et al*. (2008) also reported values of 0.46 ± 0.58 mg/kg for Cu, 0.33 ± 0.14 mg/kg for Cr; 0.37 ± 0.15 mg/kg for Cd and 0.77 ± 0.01 mg/kg for Pb in Chicken meat consumed in southern Nigeria which is similar to the result obtained for these metals in this study. Overall, the heavy metals were within the established permissible levels in the meat.

CONCLUSION

The assessment of heavy metal contamination in pork, chicken, and catfish in Owo reveals a safe level of these metals which shows that the food supply may not have been contaminated by industrial wastes. However, further research is needed to study other sources of food particularly those sourced from outside the town to ascertain their level of safety. Moreover, the animal farming practices adopted by Owo farmers may be studied for probable adoption by other farmers to mitigate the risk of heavy metal contamination in Nigeria's food supply chain.

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