Investigation of Heavy Metals in Different Tissues of Domestic Chicken

*Muhammad N.U.1,2, Ahmad M.G3, Nuhu Tanko2 Nafi'u Aminu1,2

1Department of Pharmaceutical Technology, Universiti Sains Malaysia (USM), Penang, Malaysia
2Department of Pharmaceutics and Pharmaceutical Microbiology, UDUS, P.M.B. 2346, Sokoto, Nigeria.
3Department of Pure and Applied Chemistry, Usmanu Danfodiyo University, P.M.B. 2346, Sokoto, Nigeria.
*Corresponding Author’s e-mail: chemistnuratbw@gmail.com

Abstract-- The study was aimed at investigating the concentration and bioaccumulation of heavy metals in the tissues of domestic avian specie chicken (Gallus gallus domesticus) in Sokoto, Northern Nigeria by using Flame atomic absorption spectrophotometry (FAAS). Tissues selected include gizzard, pectoral muscle, liver, lungs and kidney. Heavy metals studied are Iron (Fe), Copper (Cu), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb) and Zinc (Zn). The mean concentration of Fe, Cu, and Zn were found below the official tolerable/safety limit set by Food and Agricultural Organization (FAO) and World Health Organization (WHO). However, the concentration of Pb in lungs and liver are (0.77 ± 0.17mg/kg) and (0.38 ±0.11mg/kg) respectively, all of which were above tolerable limits, likewise the concentration of Cd (0.77±0.35mg/kg) and Cr (3.03±0.10mg/kg) in pectoral muscle. Ni was not detected in liver, lungs and kidneys, whereas concentration of Cr was found very low in liver (2.04±0.01mg/kg) and gizzard (1.04±0.02mg/kg) but absent in lungs and kidneys. The significant elevation in the concentration level of Cd and Pb above the FAO/WHO tolerable limit may expose the consumers to health risk.

Index Term-- Tissues; Domestic Chicken; Heavy metals; Investigations; Health effects.

INTRODUCTION

Broilers are chickens (Gallus gallus domesticus) bred and rose specifically for meat production. Chickens are one of the most common and widespread domestic animals. However, research showed that, global population of broilers has decreased from more than 24 billion in 2003 to 19 billion in 2011 and yet there are more chickens in the world than any other species of bird (Oforka et al., 2012). Typical broilers have white feathers and yellowish skin. Most commercial broilers bred for meat reach slaughter weight between 5 to 7 weeks of age, although slower growing strains reach slaughter weight at approximately 14 weeks of age (Demirezen et al., 2006). Because of this young age, much of their behavior and physiology is that of an immature bird (Imran et al., 2015). Broilers and egg laying hen are the same species and share many characteristics, however, due to the rapid growth and selection for enlarged breast muscles, broilers are susceptible to different welfare concerns, particularly skeletal (Imran et al., 2015). Broilers are usually grown as mixed-sex flocks in large sheds under intensive conditions, but some strains can be grown as free-range flocks (Kruchten, 2002).

Heavy or toxic metals are trace metals with a density at least five times that of water. As such, they are stable elements (meaning they cannot be metabolized by the body) and bio-accumulative (passed up through the food chain to the humans) (Dibner et al, 2005). These heavy metals include: mercury (Hg), nickel (Ni), lead (Pb), arsenic (As), cadmium (Cd), aluminum (Al), platinum (Pt), and copper (Cu). Heavy metals have no function in the body and can be highly toxic (Mohammad et al, 2010). These are found everywhere in nature and tends to pollute air, rivers, canals and underground water resources. These contaminants consist of a large variety of biological and chemical agents of diseases. The most dangerous heavy metals contaminants are lead, cadmium, and mercury and entrance of these toxic metals to human body results in various harmful diseases (Uluozlu et al, 2009).

Organic trace minerals have been used in broiler feeds for some time, showing a promising improvement in live performance, bird health, processing yield and meat quality characteristics (Pasad, et al., 2007). The most commonly used organically-complexed minerals include Zn, manganese (Mn), selenium (Se), Cu, and Fe (Sharmeen, et al., 2014). The sources of Zn have been the most studied of these compounds and a number of researchers have reported improvements in broiler growth rate and/or feed conversion with organic zinc sources (Khan, et al., 2012).

Contaminations by heavy metals are among the key issues of major concern worldwide, regional and local level and influence the functional and structural integrity of an ecosystem (Suleiman et al., 2015). The concentration of heavy metals in internal tissues of chicken has been extensively determined by several researchers (Demirbras, 2000; Mariam et al., 2004.; Nick et al; 2012). Bioaccumulation of heavy metals in tissues of chickens has received attention because of the lethal and sub- lethal effect of their accumulation, apart from the fact that chickens are often located in high levels in the food chain which makes them suitable for use in bioaccumulation studies (Burger et al, 1994).

The risk of heavy metals contamination in meat is of great concern for both food safety and human because of the toxic nature of these metals at relatively minute concentrations (Suleiman et al., 2015). According to Dibner et al, (2005), some heavy metal ions that are known to be potentially toxic include Cd and also essential metals such as Fe, Mn, Cu, Zn, Se, Ni and cobalt (Co). Excessive levels of heavy metals may occur in the biosphere as a result of normal geological phenomena such as ore formation, and weathering of rocks (Demirbras, 2000).
The rate of urbanization and industrialization has been in the increase for the last decade in Nigeria. Besides many problems associated with such social changes, the pollution is considered to be a major concern for the health of the nation. Among the numerous types of environmental pollutions that constitute as a danger to humanity, the contamination of food chain appears to be a growing threat that requires immediate attention and action. Thus industrialisation and heavy metal pollution are positively correlated (Nick et al., 2012).

This study therefore aimed at determining the concentration of heavy metals (Cr, Fe, Ni, Cu, Zn Cd and Pb) in different tissues of domestic avian specie chicken (Gallus gallus domesticus).

MATERIALS AND METHODS
All solvents and reagent used were of analytical grade. Glass wares were soaked in dilute nitric acid (10%) over night to sterilize, then later rinsed with deionised water and turned upside down on a clean surface in order to dry without being contaminated.

Sample Collection and Preparation
The chicken (Gallus Gallus domesticus) samples were collected from commercial poultry farm in Sokoto, located along Dandima round about, Sokoto State, Nigeria. Only healthy chicken aged 6 weeks and above that weighed 1kg and above are included in this study. The chickens were slaughtered and tissues dissected were liver, lungs, gizzard, kidney and pectoral muscle. The tissues were washed with deionised water to remove blood as described in standard method and adopted by Salwa et al. (2012) with slight modification. All the samples were dried in an oven at 70°C for 24h, grounded using mortar and pestle to powder and sieved.

Moisture Content Determination
The fresh samples of each tissue were weighed three times on an electronic weighing balance. An empty foil paper was laid in an oven the sample was placed on the empty foil paper and was heated in the oven at 70°C for 24 hours until complete dryness was attained. The moisture content was determined using the relation below;

\[
\% \text{ moisture content} = \frac{\text{Fresh Weight} - \text{Dry weight}}{\text{Fresh Weight}} \times 100
\]

Sample Analysis
After determining the moisture content in each sample, about 1.00g of each dried sample was weighed using an electronic weighing balance and transferred into a test tube and 10ml of concentrated nitric acid (HNO₃) was added followed by 5ml of concentrated hydrochloric acid (HCl) was added using pipette and shake thoroughly under a fume cup board. The sample were heated in a block thermostat for about 3 minutes until dense white fume appear and then allowed to cool. The solutions were filtered using Whitman filter paper of size 1.0µm. After filtering, the solutions were transferred to acid-leached polyethylene bottles and made up to 60ml using deionised water and kept at room temperature until analysis. Sample blanks were prepared by taking 10ml of the reagents mixture through the same procedure.

A flame atomic absorption spectrometer (FAAS Perkin Elmer Analyst 350) was used to quantify the heavy metal concentrations. Calibration standard curves provided the basis for quantifying the metal contents.

RESULTS AND DISCUSSION
The results shows that Gizzard has the highest moisture content (32.62 ± 0.71) while the kidney has the least (12.83 ± 0.86) as shown in table 2.

Table 1 shows the mean concentrations of the metals analysed. Heavy metals were found in lower concentration in the pectoral muscle than other tissues. Similar observation was also reported by Salwa et al; (2012) and Uluozlu et al; (2009), especially Cr, Ni, Pb, which was reported to be found in low concentration in pectoral muscle than in other internal tissues like liver or gizzard. The concentration of Ni in pectoral muscle of the chicken was found to be 0.017mg/kg and 0.027mg/kg for Cr. Meanwhile, the values of Cr, Ni, and Pb in the tissues of the chicken were found always low as in present study and previous study as reported by Nick et al; (2012).
Iron (Fe):
Iron has been reported to play important role as an essential element in all the living system (Kanakaraju et al., 2008), but bioaccumulation of Fe in the body is associated with life threatening diseases such as hereditary hemochromatosis, arthritis, arthralgia’s, diabetes mellitus, liver fibrosis, cirrhosis, hepatic cancer and/or cardiac failure, Parkinson’s disease, Alzheimer’s disease, Huntington’s disease (Papamikolaoou and Pantopoulos, 2005). The concentration of Fe is generally higher than any other metal detected in all tissue samples. The highest concentration of Fe was found in the gizzard (19.53±1.37 mg/kg) and lowest concentration in the lungs (10.14±1.49 mg/kg). Our findings correspond with Iwegbue et al., (2008) and Mohammed et al., (2013). However, the concentrations of Fe in the present study were all far below that reported by Rehman et al., (2012) and Imran et al., (2015). Although, there is no guideline on tolerance or permissible level of Fe set by World Health Organization (WHO), Food and Agricultural Organization (FAO) or European Union (EU) but National Research council (NRC) recommends Fe concentration of 40 mg/kg as nutritional requirement of broiler chicken.

Lead (Pb):
The highest concentration of Pb (0.77±0.17 mg/kg) was found in the gizzard and lowest concentration (0.07±0.02 mg/kg) in the pectoral muscles. Similar results were reported by Iwegbue et al., (2008). Although, the concentration of Pb in this study exceeded the maximum limit of 0.1 mg/kg set by WHO and EU, Oforka et al., 2012 and Imran et al., 2015, reported significantly higher levels in Nigeria and Pakistan respectively. Although lead is considered as one of the major environmental pollutants and it is also cancer-causing and affects the liver and thyroid functions (Eisler, 1977). Excess lead is known to reduce the cognitive development and intellectual performance in children and to increase blood pressure and cardio vascular disease incidence in adults (Commission of the European Communities, 2001). The high concentration of Pb found in the liver may be attributed to its function of transferring these elements to the whole body (IAEA, 1980). In a research carried out by Hameed et al, 2013, it was found that Pb was high in the gizzard (1.01 mg/kg) and low in the kidney (0.04 mg/kg). Though it was not detected in pectoral muscle and liver. While Salwa et al. 2012 found Pb concentration in gizzard (0.30 mg/kg), lungs (0.26 mg/kg), liver (0.35 mg/kg) and pectoral muscle (0.21 mg/kg).

Cadmium (Cd):
Despite the fact that food is one of the principal environmental sources of cadmium (Baykov et al., 1996), this study shows the highest concentration of Cd in pectoral muscle (0.77±0.35 mg/kg) followed by kidney (0.40±0.13 mg/kg), gizzard (0.29±0.03 mg/kg). liver (0.15±0.08 mg/kg) and the least is contained in the lung (0.14±0.09 mg/kg). Cd levels found in this study were higher than the Cd level of Nick et al., (2012) but comparable to the level of Cd reported by Salwa et al., 2012. The concentrations of Cd were within the permissible limit of World Health Organization (WHO). Cadmium is highly toxic to midlife. The recommended legal limit of Cd is (2 μg/g) for human consumption. It is cancer-

### Table I

<table>
<thead>
<tr>
<th>TISSUE</th>
<th>IRON</th>
<th>COPPER</th>
<th>CADMIUM</th>
<th>CROMIUM</th>
<th>NICKEL</th>
<th>LEAD</th>
<th>ZINC</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIZZARD</td>
<td>19.53±1.37</td>
<td>5.83±0.23</td>
<td>0.29±0.03</td>
<td>1.04±0.02</td>
<td>0.02±0.01</td>
<td>0.77±0.11</td>
<td>14.47±1.13</td>
</tr>
<tr>
<td>PECTORAL MUSCLE</td>
<td>14.39±1.66</td>
<td>3.36±0.48</td>
<td>0.78±0.35</td>
<td>3.03±0.10</td>
<td>0.13±0.03</td>
<td>0.07±0.02</td>
<td>12.23±1.38</td>
</tr>
<tr>
<td>LIVER</td>
<td>12.37±1.55</td>
<td>8.38±0.26</td>
<td>0.15±0.08</td>
<td>2.04±0.01</td>
<td>ND</td>
<td>ND</td>
<td>13.93±1.41</td>
</tr>
<tr>
<td>LUNGS</td>
<td>10.14±1.49</td>
<td>2.73±0.13</td>
<td>0.14±0.09</td>
<td>ND</td>
<td>ND</td>
<td>0.38±0.11</td>
<td>11.13±1.60</td>
</tr>
<tr>
<td>KIDNEY</td>
<td>16.42±1.16</td>
<td>3.28±0.32</td>
<td>0.40±0.13</td>
<td>ND</td>
<td>ND</td>
<td>0.16±0.02</td>
<td>11.12±1.10</td>
</tr>
</tbody>
</table>

*ND = not detected

### Table II

<table>
<thead>
<tr>
<th>Chicken parts</th>
<th>Mean moisture content % (S.D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizzard</td>
<td>32.62 ± 0.71</td>
</tr>
<tr>
<td>Muscle</td>
<td>17.66 ± 0.25</td>
</tr>
<tr>
<td>Liver</td>
<td>25.85 ± 0.03</td>
</tr>
<tr>
<td>Lung</td>
<td>20.30 ± 0.21</td>
</tr>
<tr>
<td>Kidney</td>
<td>12.83 ± 0.86</td>
</tr>
</tbody>
</table>
causing and potentially mutation-causing, with severe sub-lethal and lethal effects at low environmental concentrations (Eisler, 1975).

**Zinc (Zn):**
This study indicated that chicken gizzard (14.47±1.3mg/kg) and liver (13.93±1.41mg/kg) contained the highest concentrations of zinc which was lower than the required limit set by both NRC, 1994 and WHO. Zinc plays an important role in the biochemical pathways and it deficiency can interfere with many biochemical system such as gastrointestinal track, nervous system, skeletal, immune and reproductive system (Okoye, et al., 2011). The broilers have the highest concentration of zinc in the gizzard and liver. On the other hand, the level of zinc detected in the internal organs of chicken were below the maximum allowable limits (100µg/g). The efficiency of zinc absorption is related inversely to both current intake of zinc and existing zinc status. It was shown by the use of vascular per fused intestinal preparations that the efficiency of zinc absorption and transfer to vascular system. The concentration of Zn was found to be lower than that detected by Imran et al., (2015) but higher than salwa et al., (2012).The result were comparably to the level of Suleiman et al., (2015).The differences in the concentration of Zinc could be due to errors and differences in the mixing of chicken feed and supplement.

**Copper (Cu):**
Gizzard was found to contain the highest level of Cu (5.83±0.23mg/kg) and lung has the least(2.73 ±0.13mg/kg). While Hameed et al found the highest concentration of Cu in the liver (8.38± 0.26mg/kg) and lowest in the muscle (3.36±0.48mg/kg). Although, most reported instances of copper deficiency has been attributed specifically to inadequate copper intake, it is likely that susceptibility to this deficiency may be aggravated by overenthusiastic and excessive chronic administration of iron or zinc supplements. The present studies shows that copper are lower than the permissible limits set by World Health Organization.

**Chromium (Cr):**
Chromium was not detected in lung and kidney of broiler chicken. Chromium was detected at very low level in gizzard (1.045±0.02mg/kg), pectoral muscle (3.03±0.10mg/kg) and (2.04±0.01mg/kg) in liver. Chromium toxicity as a result of oral ingestion is very unlikely, Chromium toxicity usually occurs in an industrial environment where the concentration in the air is high, or contact with the skin is frequent. Chromium has such low toxicity that deleterious effects of excessive intake of chromium do not readily occur.

**Nickel (Ni):**
Nickel was only detected at very low concentration in gizzard 0.018mg/kg and 0.017mg/kg in pectoral muscle. Nickel can cause respiratory problem and is a carcinogen. The permissible limit of Ni in food according to WHO and USSR standard is 0.5mg/kg. In this study, concentration of Ni was below the permissible limit. Table three compares the results obtained in this study which were in good agreement with previous studies available from the structure as well as the limits set by Word Health Organization (WHO).

**CONCLUSION**
This study provides information about accumulation of heavy metals in broiler meat and can be helpful in risk assessment of consumers. High concentration of heavy metals in broiler feed resulted in their bioaccumulation in body tissues of broiler and excretion in litter. That is not only harmful for broiler itself but can also be harmful for consumers on excessive consumption considering the high use of poultry meat as a food source in our country.

**REFERENCES**


[25] Uluozlu Ozgur Dogan, Mustafa Tuzen, Mustafa Soylak, (2009). Speciation and separation of Cr(VI) and Cr(III) using coprecipitation with Ni2+/2-Nitroso-1-naphthol-4-sulfonic acid and determination by FAAS in water and food samples, Food and Chemical Toxicology, 47 (10): 2601-2605.