

Evaluation of Heavy metals in Local Chickens sold at Central Markets in Ado-Ekiti, Akure and Owena Towns

ABSTRACT

Local chickens sold in the central markets of Ado-Ekiti, Akure and Owena were randomly sampled and slaughtered. Lead (Pb), cadmium (Cd) and zinc (Zn) in their blood and selected organs (intestine, heart, liver and gizzard) were isolated using wet digestion and their concentrations determined using atomic absorption spectrophotometer. Apart from the blood of chickens from Ado-Ekiti and Owena where Pb was not detected, its concentrations in the blood and organs of the chickens obtained from the three towns ranged from 2.00 to 7.33 mg/kg, exceeding the maximum tolerance levels (0.1 mg/kg) in internal organs of poultry birds set by EU, ANZFA and FAO/WHO. With the exception of intestine of chickens from the three towns, Cd was only detected in the heart, blood and gizzard of chickens from Akure as well as liver and gizzard of chickens from Owena, covering a range of 0.11 to 0.67. The upper limit exceeded the maximum limits (0.5 mg/kg) according to FAO/WHO. Zn was detected in all selected parts of chickens from the three towns ranging 5.67 to 183.17 mg/kg. Its concentrations were within the permissible limit (10-50 mg/kg) by EU and FAO/WHO in certain selected parts of some chickens while it exceeded the permissible limit (150 mg/kg) by ANZFA especially in the liver of chicken from Ado-Ekiti. Some organs and blood of local chickens sold in the central markets at Ado-Ekiti, Akure and Owena may pose health risks.

Keywords: Local chicken, Central markets, Lead, Cadmium and Zinc

1.0 INTRODUCTION

Meat and meat products are nutritional diets necessary for human growth and development. They contain necessary trace elements, particularly zinc and iron [1], and are important source of vitamins B including B12, which is not found naturally in foods of plant origin. They also contain fat, protein and other important minerals such as potassium and selenium. Selenium, for example, is an important antioxidant which has been linked to reduction in risk of heart disease and certain cancers [2]. Meat refers to the flesh and organ of animals. The flesh of cattle, pigs and sheep are termed red meat while the flesh of poultry such as chicken, turkey, duck, pigeon and guinea fowl is known as white meat. Due to the fact that meat and meat products are concentrated sources of high-quality protein, their amino acid composition usually compensates for shortcomings in staple food [3].

Poultry in Nigeria is predominantly made of chicken and sales of these live birds is usually in a specific area of the general market [4]. They have been one of the sources of animal protein to the ever-growing teeming population, making significant contribution to human nutrition and economic development [5]. It produces 454 billion tonnes of meat and 3.8 million eggs yearly from 180 million birds [6]. The increase in poultry production over years is due to many advantages of poultry over cattle. These include ability of poultry birds to convert feed into useable protein in meat and eggs, very tender meat with high acceptability to consumers, small take-off capital, relatively low cost of production per unit and high return on investment. Besides, the production cycle is quite short so that capital is not tied up over a long period [7].

Poultry meat is considered a luxurious food in Nigeria and is usually reserved for special occasions in rural areas. Those who dwell in urban areas consume large amount of poultry due to their relatively higher income levels and greater access to fresh and frozen products in market and fast food outlets [8]. Poultry meat is used in the manufacture of many seasonings; leading to its high demand and influencing its production. Moreover, this has extensively resulted to several technological inputs [9].

Metals are natural constituents of the earth's crust and Khan *et al.* [10] observed this to be the source of some metallic elements present in the ecosystem. Trace metals (well below 50 mg/kg) may occur in food with nutritional or toxicological importance. While some like calcium, potassium and sodium are essential for man, arsenic, cadmium and lead have poisonous effects at relatively low concentration. Also, zinc, copper and iron which are necessary at very low levels pose health risk at high concentrations.

Heavy metal sources including industrial wastes, irrigation with effluent water and others result in soil contamination. Ping *et al.* [11] reported that long term contamination of soil could be a potential source of contamination for plants and animals. Plants grown in such soil and consumed as food by poultry birds, fish and human beings, expose organisms to these metals. Accumulation of heavy metals in poultry feeds and water sources is a major source of heavy metal intake to poultry products [9]. Exposure of poultry meat to different heavy metals through poultry feeds and environmental pollution of poultry breeding areas lead to contamination in the food chain. This is of great importance due to its role in nutrition and human health. The main route of human exposure to these metals is ingestion of contaminated food, especially poultry birds and fish.

Heavy metal contamination has become an issue of global concern because it poses risk to food safety, human health and the environment in general. Heavy metals alter DNA structure and a number of parameters of the host's immune system as well as increase the susceptibility to infectious diseases [10]. Moreover, it causes bioaccumulation in biological tissues and biomagnification through the food chain. Cuadrado *et al.* [12] reported that meat and meat products were major sources of total lead intake. Local chickens are often reared on free range basis. Besides the poultry feeds and the water sources they are exposed to, they could feed around waste disposal sites with diverse contaminants. In view of the above, this study was aimed at determining the concentration of some heavy metals in local chickens sold in some central markets in South-western Nigeria.

2.0 MATERIALS AND METHOD

2.1 Materials

The laboratory materials used include analytical balance, digestion flasks, bunsen burner, heating mantle, fume chamber, funnels, digestion tubes, aluminium foil, spatula, gloves, Whatman grade II filter papers, transparent polyethene bag, pre-treated sample bottles and glassware. Distilled water, as well as analar grade reagents by Sigma Aldrich like Nitric acid (HNO_3), Sulphuric acid (H_2SO_4) and Perchloric acid (HClO_4) were also used.

2.2 Sampling

Live local chickens were randomly sampled from central markets in Ado-Ekiti, Akure and Owena towns. The chickens were slaughtered by using a sharp stainless knife to cut their throat, thereby severing the jugular vein and carotid artery. Immediately, the blood was collected into an EDTA bottle and stored in the refrigerator until used.

2.3 Sample preparation and digestion

2.3.1 Solid sample digestion

Solid chicken heart, gizzard, liver and intestine samples were cut into tiny bits and dried in an oven at 105°C for three days. The dried samples were separately crushed using porcelain mortar and pestle. Each was then kept in a polythene bag and stored in a desiccator. Wet digestion was used to solubilise the heavy metals in 1.0 g dried sample of gizzard, liver and intestine separately as well as 0.5 g heart sample using 10 mL of 3:2 65% v/v HNO_3 and 70% v/v HClO_4 in a 100 mL beaker. The content of each beaker was gently swirled and allowed to stand overnight. It was then digested on a water bath at 70°C for three hours, swirling at intervals to ensure complete digestion. The digest was allowed to cool, filtered into a 50 mL

volumetric flask and made up to the mark. The solution was transferred into a sample bottle for analysis. A blank sample was prepared while each sample type was done in triplicate [13].

2.3.2 Liquid sample digestion

A 0.5 mL solution of HNO₃ and H₂SO₄ in the ratio 20:1 was added to 1.5 mL of each blood sample and 10 mL of water was also added. The mixture was thoroughly mixed by swirling and heated in a water bath at 60 °C until the sample reached half of its initial volume. HNO₃ (1 mL) was then added and heating continued until the sample became clear. It was cooled, filtered into a 50 mL volumetric flask using 110 mm Whatman filter paper and made up to mark. It was then stored in labelled sample bottles and analysed. Blank for each sample was prepared and each of the samples was made in triplicate.

2.4 Elemental analysis of samples

Heavy metals concentration in digestates of each sample were determined using BUCK Scientific 210 VGP Atomic Absorption Spectrophotometer (Serial No. 1619). For each heavy metal, there was a specific “hollow cathode lamp” and the machine set at a particular wavelength for the analysis. The absorbance was measured at 15 mA of lamp and the peak height mode of the wavelengths used were 283.3 nm, 228.8 nm, 213.9 nm for lead, cadmium and zinc respectively.

2.5 Statistical Analysis

Data obtained were presented as mean and standard deviation. SPSS 20.0 was used to compare the heavy metals in each selected sample as well as among all the samples using one-way analysis of variance (ANOVA) at p=0.05 to assess the significance of variation.

3.0 RESULTS AND DISCUSSION

The mean concentrations of metals in chicken organs (intestine, heart, liver and gizzard) and blood samples from the three towns (Ado-Ekiti, Akure and Owena) are shown in Table 1. Also, Table 2 shows the concentrations of heavy metals in internal tissues and organs of poultry birds from similar studies and this study while the maximum tolerance limits of some heavy metals in the internal tissues and organs of poultry birds are shown in Table 3.

Lead is not a natural constituent of living systems. Its presence in the blood has serious health implication like acute encephalopathy, especially for children [14]. It was however detected in all the organs and blood samples analysed except in the blood samples of chickens from Ado-Ekiti and Owena. This suggests anthropogenic influence. The trends generally observed

for lead are Ado-Ekiti > Owena > Akure for intestine and heart, Ado-Ekiti>Akure>Owena for liver and Akure>Ado-Ekiti>Owena for gizzard Table 1. Low lead level in the trend for some organs from Owena was probably because it was not as populated and industrialized as Ado-Ekiti and Akure. Kalogeropoulos *et al.* [15] reported that a positive correlation exists between urbanisation and heavy metal pollution. Gizzard of chicken samples from Owena also had the lowest lead mean concentration (2.00 mg/kg) while the highest occurred in heart of chicken from Ado-Ekiti (7.33 mg/kg). Lead for this study ranged as 3.50-4.33 mg/kg for intestine, 3.00-7.33 mg/kg for heart, 2.50-6.50 mg/kg for liver, 2.00-6.50 mg/kg for gizzard. The trend was heart>liver>gizzard>intestine>blood (Table 2), its concentration in liver being higher than in gizzard as also observed by Elsharawy, [16].

Also, there was significant difference ($p < 0.05$) in the concentration of lead in the blood and organs of chicken samples from the three towns. This could be as a result of variation in the chicken rearing practise used; whether it is free range which could expose the chicken to scavenging waste sites of diverse composition, exposure to contaminated sources including feed, water, container [17,18] and sanitation [19], among others. Lead concentration in the blood of chicken from Akure and all the organs of chickens from the three towns exceeded the maximum tolerance limit of 0.1 mg/kg by Egyptian Organization for Standardization and Quality Control (EOS) [20], European Union (EU) [21], Food and Agriculture organization and World Health Organization and 1.0 mg/kg by Australia New Zealand Food Authority [23] as seen in Table 3.

Cadmium was the most undetected metal in blood and organs of chickens sampled from the three towns (Table 1). It was not detected in liver of chicken from Akure as well as heart and blood of chicken samples from Owena while in chickens from Ado-Ekiti, it was detected only in the intestine. There is paucity of data for cadmium in intestine, heart and blood of poultry.

Table 1: Concentration of heavy metals in chicken blood and organs from Ado-Ekiti, Akure and Owena

Chicken Part	Ado-Ekiti			Akure			Owena		
	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)
Intestine	4.33±1.53 ^c	0.50±0.50 ^c	72.00±13.48 ^b	3.50±1.73 ^a	0.33±0.29 ^a	59.83±1.26 ^a	3.83±2.08 ^b	0.17±0.29 ^a	92.33±5.03 ^c
Heart	7.33±4.73 ^c	N.D ^a	55.47±8.50 ^c	3.00±1.00 ^a	0.33±0.58 ^b	50.33±5.13 ^b	3.50±0.71 ^b	N.D ^a	27.00±19.80 ^a
Liver	6.50±6.08 ^c	N.D ^a	183.17±18.45 ^c	3.17±1.26 ^b	N.D ^a	73.00±0.50 ^a	2.50±7.26 ^a	0.33±1.04 ^b	135.50±11.53 ^b
Gizzard	6.17±1.61 ^b	N.D ^a	67.33±5.84 ^b	6.50±1.32 ^c	0.33±0.29 ^b	58.00±1.00 ^a	2.00±5.29 ^a	0.67±0.76 ^c	86.83±13.90 ^c
Blood	N.D ^a	N.D ^a	15.67±11.55 ^b	2.67±1.34 ^b	0.11±0.19 ^b	5.67±15.72 ^a	N.D ^a	N.D ^a	18.27±18.58 ^b

N.D = Not detected; Values are mean±S.D and n = 3

Same metal with different letters in the same row means significant difference.

Table 2: Concentration of heavy metals in the internal tissues and organs of poultry birds from this study and similar ones

Chicken part	Similar studies						Range for this study		
	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)
Intestine	-	-	-	-	-	-	3.50-4.33	0.17-0.50	59.83-92.33
Heart	0.11-0.15 ^e	N.D ^e	28.68-36.84 ^e	-	-	-	3.00-7.33	N.D-0.33	27.00-50.33
Liver	0.10-0.18 ^e	0.007-0.013 ^e	18.25-23.21 ^e	-	-	-	2.50-6.50	N.D-0.33	73.00-183.17
Gizzard	0.10-0.18 ^e	N.D ^e	31.22-48.50 ^e	0.01-3.22 ^g	0.01-1.02 ^g	9.63-37.03 ^g	2.00-6.50	N.D-0.67	58.00-86.83
Blood	-	-	-	-	-	-	N.D-2.67	N.D-0.11	5.67-18.27

N.D = Not detected; ^e(Al Bratty *et al.*, 2018); ^g(Iwegbue *et al.*, 2008)

Table 3: Maximum tolerance limits of some heavy metals in the internal tissues and organs of poultry birds

Heavy metal	EOS (2010) ^k	ANZFA (2001) ^m	EU (2006) ⁿ	FAO/WHO (2000) ^m
Pb (mg/kg)	0.1	1.0	0.1	0.1 ^m
Cd (mg/kg)	0.05	-	0.05	0.06-0.07 ⁿ
Zn (mg/kg)	150	150	50	10-50 ^m

^k(Elsharawy, 2015) ^m(Akan *et al.*, 2010) ⁿ(Khan *et al.*, 2016)

In this study, the respective concentrations obtained for intestine, heart and blood were 0.17-0.50 mg/kg, 0.33 mg/kg and 0.11 mg/kg (Table 1). Cadmium was highest in gizzard of chicken from Owena (0.67 mg/kg) and lowest in blood of chicken from Akure (0.11 mg/kg), the blood samples where it was only detected. Nasef and Hamouda [24] and Khalafalla *et al.* [25] reported bioaccumulation of cadmium in the gizzard. Cadmium affects the health of children [26] (Järup and Åkesson, 2009) and interferes with calcium, phosphorus and bone metabolism [27].

Where detected, the trend for cadmium in chicken was Owena>Ado-Ekiti>Akure. No significant difference was observed in cadmium concentration for chicken intestine from Akure and Owena whereas a significant difference existed in gizzard of chicken from Akure and Owena ($p < 0.05$). Similar studies vary in their reports on cadmium (Table 2). In one of such, cadmium was not detected in the heart while it was 0.33 mg/kg for this study. The range of cadmium concentration in liver for two studies was from 0.007 to 0.23 mg/kg while 0.3 mg/kg was observed for this study. Similarly, cadmium in gizzard ranged from 0.01 to 1.02 mg/kg in a study whereas in this study, the range was 0.33 to 0.67 mg/kg. Besides, concentration of cadmium in parts where it was detected was higher than the tolerance limit (0.05 mg/kg) set by EOS and EU [20,21] as well as 0.06-0.07 mg/kg set by WHO/FAO [28].

Zinc is a trace element essential for protein synthesis [28]. Poultry meat has been observed to be a source of zinc and that the metal functions as a cofactor in metalloenzymes and in regulation of gene expression [29]. A level of it (35-45 mg/kg) is needed in poultry birds [30], for consumption by man as a deficiency of it causes retardation in growth and impaired immune response, among others [29]. From Table 1, zinc concentration in the organs and blood of chickens from the three towns trend as liver>intestine>gizzard>heart>blood and the general trend observed in this study (Zn>Pb>Cd) agrees with that reported by Ogu *et al.* [19]. Besides, highest level of zinc found in the liver of chickens from the three towns agrees with the report of Akan [31]. Zinc was also observed in the blood of chickens from Ado-Ekiti and Owena, unlike lead and cadmium. Moreover, zinc was significantly different ($p < 0.05$) in the same sample type from the three towns.

As for the two metals earlier discussed, Table 2 gives the range of values for this study for intestine (59.83-92.33 mg/kg) and for blood (5.67-18.27 mg/kg), hitherto uncommon. The results of similar studies fall within the ranges obtained for this study. The mean concentration of Zinc in liver of chicken from Ado-Ekiti (183.17 ± 18.45 mg/kg) is above the

tolerance limit of 50 mg/kg by FAO/WHO [22] and EU [21] as well as 150 mg/kg by EOS [20] and ANZFA [23] (Table 3). Above this tolerance limit, zinc becomes deleterious and results in copper deficiency, increased possibility of prostate cancer and respiratory disorder [32,33].

4.0 CONCLUSION

The results of this study reveal that concentrations of lead, cadmium and zinc in organs and blood of local chicken sold at the central markets of Ado-Ekiti, Akure and Owena varied in concentration and trend. Zinc was the only metal detected in all the five sample types from all the three towns; its levels in each sample type from the three towns were significantly different ($p < 0.05$) and it was generally the metal with the highest concentration, the trend being zinc>lead>cadmium. The trend observed for zinc in organs and blood was liver>intestine>gizzard>heart>blood, the liver and the gizzard showing a higher concentration of the three metals. The concentrations of all the metals exceed the tolerance limit set by some standard organisations (FAO/WHO, EU, ANZFA and ESO) and the chicken samples could therefore pose health risk to consumers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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