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Metals Loads in Organs of Local and Poultry Gallus Gallus Domesticus and Health Implications among the Young and Old Consumers

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Abstract

This work examined the levels of Cd, Cu, Pb, and Zn in the gizzards and muscles of local and poultry chickens obtained from Ibiono Ibom, Akwa Ibom State, Nigeria. Chicken parts harvested from the local and poultry chickens were treated and analysed for the concentrations of Cd, Cu, and Pb using absorption spectrophotometer (AA Dual Model). The results revealed that Cd, Cu, and Pb in all the parts and breeds of the chickens were above the acceptable limits by FAO/WHO. The mean concentrations of Cd, Cu, and Pb were higher in hen than in cock. Cd, Cu, and Zn were higher in gizzards than the muscles, whereas higher levels of Pb were recorded in the muscles. The levels of Cd, Cu, and Zn were higher in broilers than in layers, while Pb was higher in layers. Cu and Zn were higher in local chickens, while Cd and Pb were high in poultry chickens. The estimated daily intake of the metals was within their recommended limits for the young and old consumers. The consumption of gizzards may expose the both classes of consumers to cancer and non-cancer risks and the young consumers were more vulnerable.

Keywords: *Trace metals; Chicken; Human health risks; Ibiono Ibom; Nigeria.*

INTRODUCTION

Over the world, chicken (the free range and domesticated ones) is one of the most consumed meats due to its nutritious nature and white meat potentials (Morshdy *et al*., 2022; Emami *et al*., 2023). The free range (local) chickens are mostly produced and consumed in Nigeria and other sub- Saharan countries of the world (Kyarisiima *et al*., 2011; Salawu *et al*., 2024; Manyelo *et al*., 2020; Quaye *et al*., 2023). However, the poultry chickens are mostly produced and are in very high demand among the developed nations such as USA, Brazil etc (Miller *et al*., 2022; Belarmino *et al*., 2023). The value of chicken meat could be influenced by their feeds, water, environment, and method of processing (Kodani *et al*., 2022; Zakanova *et al*., 2023). Hence, these factors should be properly examined to ascertain the quality of chicken and chicken-related foods consumed by human to forestall unpleasant consequences.

Local chickens move freely within an area and consume any available food and water no matter the level of contamination. Hence, it is expected that the local chickens are exposed to higher levels of contaminants than the domesticated ones. Nonetheless, it has been documented that chickens harvested from poultry farms are more exposed to toxic metals than the local ones due to food processing (Ajai *et al*., 2021; Igwemmar and Kakulu, 2022). Reports have also shown that, chickens harvested from poultry farms mostly within the developing nations such as Nigeria are highly loaded with toxic metals (Adekanmi, 2021; Ebong *et al*., 2023a; Ebong *et al.,* 2023b; 2022; Etuk *et al*., 2024). Most Africans prefer the local chickens hoping that they are more nutritious and safer than the ones harvested from poultry farms. In most families within the study area, the men perceive the eating of gizzards of chickens as a rite and should not be compromised. In some African cultures women are prohibited from eating the gizzard of chicken (Uwameiye and Aluyor, 2018; Martina, 2021). Nevertheless, gizzards harvested from chickens accumulate elevated levels of metals than most other parts (Okoye *et al*., 2015; Chijioke *et al*., 2020; Edet *et al*., 2024). Toxic metals posses very high prospective of causing deadly ailments including cancer in those exposed to them overtime (Attiq, 2023; Okon *et al*., 2023; Shi *et al*., 2023). Hitherto, studies

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on the concentrations of trace metals in chickens reared within the study area investigated mostly the poultry birds hence; there are no information concerning the free range (local) birds (Ebong *et al*., 2023b; Etuk *et al*., 2023; Ebong *et al*., 2024a; Edet *et al*., 2024). Accordingly, this study assessed the variations in metals loads between gizzards and muscles of local and poultry chickens. The factors affecting the metals loads in these samples among the studied chickens have also been elucidated using principal component analysis. The variations in health implications due to the consumption of the studied chicken parts and breeds between the young and adult consumers were also evaluated. It is hoped that the results obtained will be of benefits to poultry farmers and the consumers of these schickens' parts.

MATERIALS AND METHODS

Study Area

The chickens (Local and poultry birds) used for this study were bought from Ikot Ambang Market in Ibiono Ibom, Akwa Ibom State, Nigeria. Ikot Ambang Market is located along Uyo-Ikot Ekpene Road between latitude 05° 06! N and longitude 07° 86! E. Ibiono Ibom was chosen for this research because the area is basically without a major source of contaminants. Ibiono Ibom as one among the biggest local governments within Nigeria has a total of two hundred and eight villages (Umoren *et al*., 2009). The area is surrounded in the South by Uyo local government area, in the East by Itu, in the North by Cross River State, and in the West by Ikono. The study area lies within the Equatorial rain forest southern geopolitical Region of Nigeria with an estimated landmass of 2761.76 square kilometers (Atser *et al*., 2014). The average yearly temperature of the area varies between 25 and 29°C. The mean annual rainfall ranges between 2000 and 3000 mm with a high relative humidity (Afangideh *et al*., 2005). Ibiono Ibom local government area has two outstanding seasons (dry and wet). The wet season is experienced between April and November, while the dry season last from December to March. Ibiono Ibom as a local government locates between latitudes 04° 15! East and longitude 08° 22! North. Ikot Ambang Market is within Uyo Metropolis of Akwa Ibom State. Thus, due to its closeness to Uyo, the population of people consuming chickens (local and poultry ones) harvested from the area is very high. Consequently, the quality of chickens in the region should be examined to evade human health problems related to the ingestion of contaminated chicken meat.

Sample Collection, Treatment, and Digestion

Matured chickens (Local and poultry birds) (*Gallus gallus domesticus*) were bought from Ikot Ambang Market in Ibiono Ibom. Five of each of the different breeds were bought and transported to the laboratory. At the laboratory, the chickens were weighed and their weight ranged between 1.26 and 1.43 kg. These chickens were disemboweled by means of a stainless steel knife, the gizzards and muscles were collected. The samples collected were washed with distilled water and those of similar breeds were kept together in clean containers. The gizzards and muscles harvested were severed into smaller parts with stainless steel knife. The parts to be assessed were dried inside oven at 105 °C for 120 minutes. To two grams of each of the chicken parts in a flask, a combination of 1mL Conc. $HClO_4$ and 5mL Conc. HNO_3 was introduced then, the mixture was digested using a hot plate at 100 °C for two hours. The digestion was carried on till the colour of the solution became clear. The digest in flask was kept to cool, on cooling it was filtered into a 100 mL volumetric flask and filled to the level with distilled water. The samples were stored at 4 °C for metal analysis (Enuneku *et al*., 2018; Igwemmar and Kakulu, 2022; Hossain *et al*., 2023). Levels of Cd, Cu, Pb, and Zn in the preserved samples were analysed for with AA Dual atomic absorption spectrophotometer (AAS) following the procedures by AOAC, (2004).

RESULTS AND DISCUSSIONS

Table 1. Trace Metals in Local and Poultry Chickens

Breed		Part	Cd	Cu	Pb	Zn
Local Chicken	Cock	Gizzard	0.125±0.03	6.236±1.022	0.193±0.033	8.513±0.614
		Muscle	0.044±0.021	4.117±0.852	0.104±0.062	6.602±0.661
	Hen	Gizzard	0.138±0.025	7.180±1.073	0.169±0.091	7.214±0.825
		Muscle	0.053±0.011	6.255±0.861	0.541±0.087	5.872±0.672
		Mean	0.090±0.048	5.947±1.297	0.252±0.197	7.050±1.119
Poultry Chicken	Broiler	Gizzard	0.306±0.021	6.104±0.051	0.217±0.014	6.148±0.725
		Muscle	0.271±0.040	4.329±0.065	0.185±0.006	5.630±0.011
	Layer	Gizzard	0.263±0.018	5.835±0.022	0.172±0.028	5.106±0.032
		Muscle	0.218±0.020	4.014±0.047	0.464±0.020	3.863±0.008
		Mean	0.265±0.036	5.071±1.052	0.260±0.138	5.187±0.980

The mean values of metals in chicken parts assessed for the local and poultry chickens are in Table 1. The mean level of Cadmium (Cd) in the local chicken varied between 0.044 $mgkg^{-1}$in the muscles and 0.138 $mgkg^{-1}$ in the gizzards,

respectively. For poultry chicken, the concentrations of Cd varied from 0.218 $mgkg^{-1}$ in the muscle to 0.306 $mgkg^{-1}$ in the gizzard. The results indicated that, concentrations of Cd in all the chicken parts examined were above the acceptable limit (0.05 $mgkg^{-1}$) except for muscle of cock (FAO/WHO, 2011). Copper (Cu) concentrations in the studied parts from the local chicken ranged from 4.117 $mgkg^{-1}$ in the muscle of cock to 7.180 $mgkg^{-1}$ in the gizzard of hen. The levels of Cu in the local birds were higher in hen than in cock. While the levels of Cu in poultry chicken varied between 4.014 $mgkg^{-1}$ in the muscle of layer and 6.104 $mgkg^{-1}$ in gizzard of broiler. The average values of Cu reported for both the local and poultry birds were above the stipulated limit (0.40 $mgkg^{-1}$) by FAO/WHO (2011). The levels of lead (Pb) in local birds fluctuated between 0.104 $mgkg^{-1}$ and 0.541 $mgkg^{-1}$ in the muscles of cock and hen, respectively. For the poultry chickens, the concentrations of Pb varied from 0.172 to 0.464 $mgkg^{-1}$ in gizzards and muscles, respectively. The average levels of Pb in all the chicken parts assessed were above 0.1 $mgkg^{-1}$ limit (FAO/WHO, 2011). The levels of zinc (Zn) recorded for the chicken parts obtained from local chickens ranged from 5.872 to 8.513 $mgkg^{-1}$ in the muscles and gizzards, respectively. However, in the studied poultry chickens, Zn varied between 3.863 and 6.148 $mgkg^{-1}$ in the muscles and gizzards, respectively. The average levels of Zn in the entire parts harvested from local and poultry chickens were lower than the recommended 150.0 $mgkg^{-1}$ (FAO/WHO, 2011).

Deductions

The following observations were deduced from the results in Table 1:

(a) For the local birds (i) The average levels of Cd, Cu, and Pb were higher in hen than in the cock, whereas higher levels of Zn were reported in the cock, (ii) The levels of Cd, Cu, and Zn were higher in the gizzards than muscles, while the levels of Pb were higher in the muscles than in the gizzards, and (iii) Higher mean levels of essential metals were reported for the free range (local) chickens.

(b) For the domesticated (poultry) chickens: (i) Higher levels of Cd, Cu, and Zn were reported for broilers than the layers however; higher mean values of Pb were recorded for the layers, (ii) Higher levels of Cd, Cu, and Zn were recorded for gizzard than the muscles, while higher concentrations of Pb were recorded for the muscles, (iii) The levels of toxic metals were higher in poultry chickens than essential metals.

The higher levels of toxic metals recorded for poultry chickens could be caused by the quality of feeds (Mottalib *et al*., 2018; Adekanmi, 2021, Etuk *et al*., 2023). The relative higher concentrations of essential metals in the local chickens than their poultry counterparts are consistent with the findings by Adeyinka *et al*. (2022) in a related work. Hence, excessive consumption of poultry chickens harvested from farms within the area investigated might be hazardous to the consumers (Ebong *et al*., 2023b; Okon *et al*., 2023). The low levels of Zn reported should be complemented in their feeds to enhance normal metabolic and growth activities (Huang *et al*., 2019; Mayer *et al*., 2019). The research has indicated that, the persistent consumption of gizzards of local hens might result in severe health issues related to toxic metals toxicity. It could also be inferred from the study that, it is safer to consume more of the local birds than the ones from poultry farms as the poultry chickens are heavily loaded with toxic metals.

Results of Estimated Daily Intake Rate (EDI) of Trace Metals

Table 2. Estimated daily intake rate (EDI) of trace metals due to the intake of local and poultry chickens

Breed		Part	Cd	Cu	Pb	Zn
Young Consumers	Cock	Gizzard	6.00E-4	2.96E-2	9.00E-4	4.04E-2
		Muscle	2.00E-4	1.96E-2	5.00E-4	3.14E-2
	Hen	Gizzard	7.00E-4	3.41E-2	8.00E-4	3.43E-2
		Muscle	3.00E-4	2.97E-2	2.60E-3	2.79E-2
Mean		**Mean**	5.00E-4	2.83E-2	1.20E-3	3.35E-2
Old Consumers	Cock	Gizzard	4.05E-4	2.02E-2	6.26E-4	2.76E-2
		Muscle	1.43E-4	1.34E-2	3.37E-4	2.14E-2
	Hen	Gizzard	4.47E-4	2.33E-2	5.48E-4	2.34E-2
		Muscle	1.72E-4	2.03E-2	1.80E-3	1.90E-2
		Mean	4.00E-4	1.93E-2	8.00E-4	2.29E-2
Young Consumers	Broiler	Gizzard	1.50E-3	2.90E-2	1.00E-3	2.92E-2
		Muscle	1.30E-3	2.06E-2	9.00E-4	2.67E-2
	Layer	Gizzard	1.30E-3	2.77E-2	8.00E-4	2.43E-2
		Muscle	1.00E-3	1.91E-2	2.20E-3	1.84E-2
		Mean	1.30E-3	2.41E-2	1.20E-3	2.47E-2

Old Consumers	Broiler	Gizzard	9.92E-4	1.98E-2	7.00E-4	1.99E-2
		Muscle	8.79E-4	1.40E-2	5.99E-4	1.83E-2
	Layer	Gizzard	8.53E-4	1.89E-2	5.58E-4	1.66E-2
		Muscle	7.07E-4	1.30E-2	1.50E-3	1.25E-2

The average EDI values of trace metals via the intake of local chicken by the young ones were 5.00E-04, 2.83E-02, 1.20E-03, and 3.35E-02 $mgkg^{-1}day^{-1}$for Cd, Cu, Pb, and Zn, correspondingly (Table 2). The average EDI values of Cd, Cu, Pb, and Zn via the intake of local chicken by the old consumers were 4.00E-04, 1.93E-02, 8.00E-04, and 2.29E-02 $mgkg^{-1}day^{-1}$, respectively. The mean EDI values of the trace metals for the young and old consumers via the consumption of local chicken were lower than their stipulated oral reference doses (Rfd) (USEPA, 2021). This corroborates the reports of Igwemmar and Kakulu (2022) in related work. Consequently, persistent exposure to trace metals due to the intake of local chicken examined could cause non-carcinogenic threats. The mean EDI values of metals through the ingestion of poultry chicken by young consumers were 1.30E-03, 2.41E-02, 1.20E-03, and 2.47E-02 $mgkg^{-1}day^{-1}$ for Cd, Cu, Pb, and Zn, correspondingly. The mean EDI values recorded for the trace metals due to the intake of poultry chicken by the old consumers were 5.00E-04, 1.64E-02, 8.00E-04, and 1.68E-02 $mgkg^{-1}day^{-1}$, for Cd, Cu, Pb, and Zn, correspondingly. The EDI values obtained for both categories of consumers were less than their Rfd values according to USEPA (2021). Accordingly, constant exposure to the trace metals due to the ingestion of broiler and layer meats obtained from the area investigated might not result in non-carcinogenic problems in the consumers. The average EDI values of trace metals due to the intake of local and poultry chickens by young consumers were higher than those recorded for the old consumers. This is similar to the report obtained from a study on local and poultry birds by Njoga *et al*. (2021). Consequently, the younger consumers were more disposed to the non-carcinogenic health problems related to the trace metals.

Table 2 also indicates the mean EDI values of Cd, Cu, and Zn recorded for the gizzards were the highest for all the breeds and species of chickens examined. Though, higher EDI values of Pb were reported for the muscles of all the classes of consumers and chickens assessed. Invariably, the consumption of gizzards harvested from either the local or poultry birds may expose the consumer to higher non-carcinogenic risks than other parts irrespective of the age of the consumer. Persistent exposure to Pb via the intake of muscles of chickens harvested from poultry farms investigated may results in non-carcinogenic problems overtime. Though, the EDI values of metals through the intake of local chicken were higher than those of their poultry counterparts. The relatively higher hazards linked to the consumption of local chicken is consistent with the report by Enuneku *et al*. (2018). The EDI values of metals for the different categories of consumers and the different breeds of chickens followed the trend Zn > Cu > Cd > Pb. This indicates higher EDI values for the essential elements (Zn and Cu) for all classes of consumers and chickens.

Results of of Target Hazard Quotient (THQ) and Total Hazard Index (THI) of Trace Metals

Table 3. Results of target hazard quotient (THQ) and total hazard index (THI) of trace metals via the consumption of local and poultry chickens

Breed		Part	Cd	Cu	Pb	Zn	THI
Young Consumers	Cock	Gizzard	6.00E-1	7.40E-1	2.30E-1	1.40E-1	1.71
		Muscle	2.00E-1	4.90E-1	1.30E-1	1.10E-1	0.93
	Hen	Gizzard	7.00E-1	8.50E-1	2.00E-1	1.10E-1	1.86
		Muscle	3.00E-1	7.40E-1	6.50E-1	9.00E-2	1.78
		Mean	4.50E-1	7.10E-1	3.00E-1	1.10E-1	-
Old Consumers	Cock	Gizzard	4.10E-1	5.10E-1	1.60E-1	9.00E-2	1.17
		Muscle	1.40E-1	3.40E-1	8.00E-2	7.00E-2	0.63
	Hen	Gizzard	4.50E-1	5.80E-1	1.40E-1	8.00E-2	1.25
		Muscle	1.70E-1	5.10E-1	4.50E-1	6.00E-2	1.19
		Mean	2.90E-1	4.90E-1	2.10E-1	8.00E-2	-
Young Consumers	Broiler	Gizzard	1.50E+0	5.10E-1	2.50E-1	1.00E-1	2.36
		Muscle	1.30E+0	3.40E-1	2.30E-1	9.00E-2	1.96
	Layer	Gizzard	1.30E+0	6.90E-1	2.00E-1	8.00E-2	2.27
		Muscle	1.00E+0	4.80E-1	5.50E-1	6.00E-2	2.09
Mean		**Mean**	1.30E+0	5.10E-1	3.10E-1	8.00E-2	-

Old Consumers	Broiler	Gizzard	9.90E-1	5.00E-1	1.80E-1	7.00E-2	1.74
		Muscle	8.80E-1	3.50E-1	1.50E-1	6.00E-2	1.44
	Layer	Gizzard	8.50E-1	4.70E-1	1.40E-1	6.00E-2	1.52
		Muscle	7.10E-1	3.30E-1	3.80E-1	4.00E-2	1.46
Mean		**Mean**	8.60E-1	4.10E-1	2.10E-1	6.00E-2	-

The average THQ values of metals via the ingestion of local chickens are in Table 3. The average THQ values of trace metals through the intake of local chickens by young consumers were 0.45, 0.71, 0.30, and 0.11 for Cd, Cu, Pb, and Zn, correspondingly. The average THQ values of Cd, Cu, Pb, and Zn recorded for the old consumers were 0.29, 0.49, 0.21, and 0.08, respectively. Consequently, higher THQ values of the trace metals were reported for the young consumers of local chickens than the old ones. Though, the average THQ values of trace metals obtained for the young and old consumers were below one thus; the consumers of local chickens may not be exposed to significant non-carcinogenic hazards (Hassan *et al*., 2022; Ain *et al*., 2023). Nevertheless, the younger consumers could be susceptible to more non-carcinogenic hazards than the old ones. This is consistent with the report published from a related study by Naseri *et al*. (2020). The sequence for the THQ values of trace metals via the intake of local chickens followed the trend: Cu > Cd > Pb > Zn.

The average THQ values of Cd, Cu, Pb, and Zn due to the intake of poultry chickens by the young consumers were 1.30, 0.51, 0.31, and 0.08, correspondingly. The average THQ values of Cd, Cu, Pb, and Zn recorded for the old consumers of poultry chickens were 0.86, 0.41, 0.21, and 0.06, respectively (Table 3). The mean THQ values of the metals were also higher for the young than the old consumers. The mean THQ values of Cd via the intake of poultry chicken by the young consumers were above one. Thus, the young consumers of broilers and layers obtained from the farms examined could be susceptible to the non-carcinogenic hazards associated with Cd toxicity (Edet *et al*., 2024). Relatively, the THQ values of the trace metals through the intake of poultry chickens were much higher than those of the local chickens. Hence, the consumers of poultry chicken especially the boilers are more prone to non-carcinogenic health problems. THQ values of the metals due to the intake of poultry chickens by the young and old consumers followed the pattern: Cd > Cu > Pb > Zn.

The total hazard indices (THI) of trace metals due to the intake of local and poultry chickens by the young and old consumers are in Table 3. The THI values of trace metals due to the consumption of local chickens by the young consumers indicated the following: 1.71 and 0.93 for the gizzards and muscles of cock, respectively. The THI values of trace metals for the gizzards and muscles of hen were 1.86 and 1.78, respectively. For the old consumers of cock, the THI values for the gizzards and muscles were 1.17 and 0.63, respectively. The gizzards and muscles of the hen had THI values of 1.25 and 1.19, respectively. Thus, the young and old consumers of the gizzards of local cock and hen obtained from the location examined could be vulnerable to the related non-carcinogenic risks (Chowdhury and Alam, 2024). Nonetheless, the THI values of trace metals through the intake of the muscles of local chickens were below one hence; the consumers might not be exposed to non-carcinogenic hazards (Kia *et al*., 2024).

The THI values of trace metals due to the intake of poultry chickens by the young ones were 2.36 and 1.96 for the gizzards and muscles of the broilers, respectively (Table 3). THI values of the trace metals due to the intake of gizzards and muscles of layers by the young consumers were 2.27 and 2.09, respectively. For the adult consumers of broilers, the THI values of the trace metals obtained were 1.74 and 1.44 for the gizzards and muscles, respectively. THI values of the metals due to the intake of gizzards as well as the muscles of layers by the old consumers were 1.52 and 1.46, respectively. Nevertheless, the THI values of metals caused by the intake of poultry chickens by the young consumers were higher than those of the adult consumers as reported by Chowdhury and Alam (2024). Thus, the young consumers might be more exposed to the non-carcinogenic threats than the adults. This study revealed that, THI values of trace metals due to the intake of chickens by both classes of consumers were higher in poultry than the local chickens. This is in agreement with the findings by Igwemmar and Kakulu (2022) in a similar research. Consequently, the consumption of the gizzards and muscles of the poultry chickens by the young and old consumers could expose the consumers to severe non-carcinogenic hazards.

Results of Incremental Lifetime Cancer Risk (ILCR) and Total Cancer Risk (TCR) of Trace Metals

Table 4. Incremental lifetime cancer risk (ILCR) and total cancer risk (TCR) of trace metals via the consumption of local and poultry chickens

Breed		Part	Cd	Cu	Pb	Zn	TCR
Young Consumers	Cock	Gizzard	2.28E-4	-	7.65E-6	-	2.36E-4
		Muscle	7.60E-5	-	4.25E-6	-	8.03E-5
	Hen	Gizzard	2.66E-4	-	6.80E-6	-	2.73E-4
		Muscle	1.14E-4	-	2.21E-5	-	1.36E-4

Old Consumers	Cock	Gizzard	1.54E-4	-	5.32E-6	-	1.59E-4
		Muscle	5.42E-5	-	2.87E-6	-	5.71E-5
	Hen	Gizzard	1.70E-4	-	4.66E-6	-	1.75E-4
		Muscle	6.53E-5	-	1.53E-5	-	8.06E-5
Young Consumers	Broiler	Gizzard	5.70E-4	-	8.50E-6	-	5.79E-4
		Muscle	4.94E-4	-	7.65E-6	-	5.02E-4
	Layer	Gizzard	4.94E-4	-	6.80E-6	-	5.01E-4
		Muscle	3.80E-4	-	1.87E-5	-	3.99E-4
Old Consumers	Broiler	Gizzard	3.77E-4	-	5.95E-6	-	3.83E-4
		Muscle	3.34E-4	-	5.10E-6	-	3.39E-4
	Layer	Gizzard	3.24E-4	-	4.74E-6	-	3.29E-4
		Muscle	2.69E-4	-	1.28E-5	-	2.82E-4

Persistent contact with Cd and Pb due to the intake of local and poultry chickens can result in cancer (Naseri *et al*., 2020). The probability of these metals causing cancer could be assessed by estimating their ILCR and total cancer risk (TCR) values as opined by Goudarzi *et al*. (2021) and Bambara *et al*. (2023). The ILCR values of Cd due to the intake of local chicken by the young consumers belong to the high cancer risk group except for the muscles of hen that was in the medium class (USEPA, 1999) Thus, apart from the muscles of hen, the consumption of other parts of local birds examined by the young ones may result in severe cancer risks (Tochukwu and Ebong, 2024; Ugwu *et al*., 2024). The ILCR values of Cd through the ingestion of gizzards harvested from the studied cock and hen by the old consumers belong to the high cancer hazard group and they were above the recommended safe limit (10^{-6}-10^{-4}) by USEPA (2010). Nevertheless, ILCR values of Cd via the intake of muscles of cock and hen by the old consumers belong to the medium cancer risk group, they were also within the acceptable limit (10^{-6}-10^{-4}) by USEPA (2010). Consequently, the consumption of gizzards harvested from local chickens by the old consumers could result in cancer however; the muscles may not have the potentials to manifest cancer risks in the consumers (Usman *et al*., 2022; Ebong *et al*., 2024b). Higher ILCR values of Cd due to the consumption of local chickens by young than the adult consumers were recorded. This corroborates the reports by Emmanuel *et al*. (2022) and Belew *et al*. (2024). Table 4 shows that the ILCR value of Cd due to the intake of chickens from poultry farms by the young and old consumers belongs to the high cancer hazard category and were higher than the 10^{-4} limit stipulated by USEPA (2010). The ILCR values of Cd due to the consumption of poultry chickens were relatively higher than values recorded for the local ones. Hence, the consumption of poultry chickens by both the young and old consumers has higher cancer potentials than the local ones.

The ILCR values of Pb due to the consumption of local and poultry chickens by the young and adult consumers belong to the low cancer risk group except for the muscles of hen and layers (USEPA, 1999). Table 4 shows that the ILCR values of Pb through the consumption of poultry chickens by both the young and old consumers belong to the low cancer risk category as well, while those of the muscles of the layers are in the medium cancer risk group (USEPA, 1999). Nevertheless, the ILCR values of Pb obtained for all the categories of chickens and consumers were within the 10^{-6}-10^{-4} limit according to USEPA (2010). Thus, the consumption of local and poultry chickens from the studied location might not have adverse carcinogenic risks related to Pb on the consumers.

The total cancer risk (TCR) values of Cd and Pb via the intake of local chickens by the young and old consumers are in Table 4. The TCR values of trace metals in the gizzards and muscles harvested from cock were 2.36E-04 and 8.03E-05, respectively. The TCR values for the gizzards and muscles of the local hens were 2.73 and 1.36E-04, respectively. Consequently, the TCR value for the muscles of cock belongs to the intermediate cancer risk group, while those of the gizzards of cock and hen, and muscles of local hen belong to the high cancer hazard group.

The TCR values of trace metals due to the ingestion of local chickens by the adult consumers were 1.59E-04 and 5.71E-05 for gizzards and muscles of cock, respectively (Table 4). The TCR values of cancer-causing metals due to the intake of gizzards and muscles of hen were 1.75E-04 and 8.06E-05, respectively. The TCR of metals due to the consumption of gizzards of cock and hen belongs to the high cancer hazard group. However, the TCR of the carcinogens due to the intake of the muscles belongs to the medium class. The results indicated higher cancer potentials for the gizzards than the muscles. The younger consumers were the more vulnerable class of consumers.

The TCR values of carcinogens caused by the ingestion of poultry chickens by the young consumers were 5.79E-04 and 5.02E-04 for the gizzards and muscles of the broiler, correspondingly (Table 4). TCR values of the carcinogens through the intake of gizzards and muscles of the layers were 5.01E-04 and 3.99E-04, respectively. For the old consumers, the TCR values of the gizzards and muscles of the broiler were 3.83E-04 and 3.39E-04, correspondingly. The TCR values

of the metals due to the intake of the layers by the adult consumers were 3.29E-04 and 2.82E-03 for the gizzards and muscles, respectively. The TCR of the metals as a result of ingestion of poultry chickens by both the young and old consumers belong to the high cancer hazard category, and they were higher than the safe limit. The cancer potentials of the carcinogens due to the consumption of poultry chickens were much higher than the local ones. Relatively, the younger consumers were more susceptible to the cancer risk than the adult ones. Consequently, excessive intake of chickens harvested from poultry farms examined might have potential cancer risks and the young consumers might be more liable (Yang *et al*., 2019; Demissie *et al*., 2024).

Results of Principal Component Analysis (PCA) of Toxic Metals in Poultry Feeds and Offal

Table 5. Principal component analysis (PCA) of toxic metals in poultry feeds and offal

	LOCAL CHICHEN		POULTRY CHICKEN
	F1	F2	F1
Cd	0.975	0.194	0.969
Cu	0.603	0.786	0.821
Pb	-0.489	0.824	-0.890
Zn	0.880	-0.296	0.958
Eigen value	2.33	1.42	3.32
% Variance	58.2	35.5	83.1
% Cumulative	58.2	93.7	83.1

The outcome of PCA of trace metals in the local and poultry chickens are in Table 5. The PCA of trace metals in the studied local chickens showed two major sources for the metals with Eigen value above one and a cumulative variance of 93.7%. The F1 with Eigen value 2.33 added 58.2% to the cumulative variance and had significant loadings on Cd and Zn. This could be the effects of contaminated feeds since these birds move and eat foods within the environment (Aljohani, 2023). The second factor (F2) with Eigen value 1.42 added 35.5% to the cumulative variance indicated significant loadings on Cu and Pb. This might be the effects of contaminated feeds and the environment (Voica *et al*., 2023).

The PCA results of trace metals for the poultry chickens indicated one factor accountable to the accumulation of these metals in their organs and muscles. The factor (F1) with Eigen value of 3.32 had a cumulative variance of 83.1% (Table 5). This factor contributed 83.1% of the cumulative variance and indicated significant loadings on all the trace metals. This could be caused by the supplements and the introduction of toxic metals during the processing of poultry feeds (Adekanmi, 2021; Oladeji *et al*., 2023; Riboty *et al*., 2024).

CONCLUSIONS

This research has shown the variations in the concentrations of trace metals between the local and poultry chickens. Health problems related to the contact with these trace metals via the intake of these chickens by the young and old consumers have also been exposed. The environmental problems associated with the free range (local) chickens have also been indicated. This study has shown that there are some health issues associated with the persistent consumption of gizzards of poultry chickens especially by the younger consumers. The study has revealed that the local chickens are affected negatively by the environment hence; control measures should be put in place to restrict their movement. As indicated by the outcome of this work, the quality of chickens within an area should be examined regularly to ascertain their suitability or otherwise for human consumption. Quality control procedures should be adopted to minimize or eliminate toxic metals in poultry feeds during processing.

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