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ASSESSMENT OF SELECTED HEAVY METALS CONCENTRATION IN SOME POULTRY FEEDS SOLD IN LAFIA METROPOLIS, NORTH CENTRAL, NIGERIA.

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ABSTRACT
This study assessed the selected heavy metals concentration in some poultry feed samples in Lafia Metropolis. Absorption Atomic Spectroscopy (AAS) method was used to assess the selected heavy metals concentration in mg/kg. The results obtained indicated different concentration levels of Cadmium (Cd), Zinc (Zn), Chromium (Cr), Nickel (Ni), Manganese (Mn) and Iron (Fe) in all the analyzed sampled poultry feeds. The levels of concentration in mg/kg ranged from 1.21 to 2.27, 0.81 to 1.87, 1.46 to 2.74, 2.88 to 4.23 and 11.02 to 14.37 mg/kg for Cd, Cr, Co, Cu, Pb and Fe while 0.40 to 0.60, 0.55 to 1.64, 14.10 to 22.94 and 21.18 to 31.39 mg/kg were recorded for Pd, Mn, Ni and Zn respectively. These levels of concentration were found to be a little above the minimum permissible levels set by WHO, SON and FAO, except for Cr, Co, Ni and Pb that were below WHO, SON and FAO standard. The heavy metals were found to be statistically significant ($P \geq 0.05$) using analysis of variance (ANOVA) except for Pb metal in all the feed brands. 80% of the feed sellers were ignorant of the health hazards of the heavy metals in poultry feeds and the WHO, SON and FAO permissible levels.

Keywords*: Heavy metals, poultry feeds, finisher, layer, starter.*

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INTRODUCTION

Certain mineral elements such as copper (Cu), Iron(Fe), Manganese (Mn), Zinc (Zn) and soil are usually added to poultry feeds as essential dietary nutrients. These minerals can have adverse effects upon humans and animals if they are included in the diet at excessively high concentration levels (Atara and Joseph, 2021). This study aimed at assessing the concentration of selected heavy metals in poultry feeds sold in Lafia Metropolis. Poultry farming is a very important sector of the economy that produces more than 30% of poultry products such as eggs and meat. The meat and the eggs are the most widely consumed in the world after beef, mutton (goat meat) and pork (Raloff, 2003 and Bukar & Sa'id, 2014). Basically, poultry meat is a source of economical, healthy and palatable food protein (Bukar & Sa'id, 2014 and Mahesar *et al*., 2010). According to these authors at different times, commercial poultry feed producers do not meet up with the international regulatory requirement standard of heavy metal contents in poultry bird feeds. Also, that the raw materials source and use for the feeds production is usually associated with heavy metals contamination. Although some heavy metal elements such as Cu, Fe, Mn and Zn are essential nutrients required by poultry and even humans in their diets, combined with other nutrients(Atara and Joseph, 2021). It should be noted that all mineral elements especially heavy metals, can be considered as potentially toxic with adverse effects upon humans and animals when added in diet at an excessively high concentration levels (Atara *et al*., 2020; Atara & Joseph, 2021; Okoye *et al*., 2011 and Bukar & Sa'id, 2014).

Poultry feed is considered as an excellent food for chickens, ducks and other birds being enriched with proteins, energy, minerals, vitamins and other nutrients (Field work, 2023). It is therefore necessary to control the quality of commercially produced feeds at the companies where it is produced. According to available reports, some of the companies do not follow the correct method of producing the feed. Some use contaminated raw materials containing toxic metals during production processes (Atara *et al*., 2020). The toxic metal pollutants have various side effects in the human body as they are non-biodegradable (Okoye *et al*., 2011 and Raloff, 2003). Adverse effects of toxic metals are numerous, hence, there is need to assess the heavy metals concentrations present in poultry feeds and to proffer possible solutions if they are found to violate the international bodies permissible minimum concentration levels and to educate the populace on some of the health benefits and hazards of heavy metals in poultry feeds. Therefore, there is need for a definite standard for heavy metals concentration level in poultry feed to strictly be followed as recommended by WHO, SON and FAO. Available literature revealed that contamination of animal foods by toxic metals cannot be entirely avoided or completely eliminated due to the prevalence of these pollutants in the environment (Atara *et al*., 2020 and Atara & Joseph, 2021). However, such contaminants need to be minimized to the barest minimum level, so as to reduce their direct effects on animal health and indirectly on human health (SCAN, 2003 and Santhi *et al*, 2008). The manufacturers must take extra care to eliminate or reduce the concentration of heavy metals in their poultry feed and to ensure there is increase in the supplement quantity added so that the nutritional values of the feeds can be increased.

Heavy metals have been defined as metals with a specific weight more than $5gcm^{-3}$ (Atara *et al*., 2020 and Sotan, 2016). These metals are a serious threat to life because of their toxicity, bioaccumulation, non-biodegradable nature and easy assimilation through direct ingestion (Atara *et al*., 2020 and Okoye *et al*., 2011). Heavy metal contamination biohazards include causes of many diseases that can lead to death, severe long-life disabilities, kidney damage, seizure, coma and a host of other problems (Atara *et al*., 2020; Atara & Joseph, 2021 and Damirezan & Uric, 2006). Thus, there is risk and hazards to humans and the ecosystem through direct ingestion or contact with the food chain.

Despite the potential biohazardous effects of heavy metals, they still have several uses that are linked to their characteristic properties. Heavy metals are reported to be used as essential elements in diets. For example, Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn) are often used as essential dietary nutrients for poultry (animals) and even humans (Atara *et al*., 2020; Okoye *et al*., 2011 and Bukar & Sa'id, 2014). Medically, heavy metals when in small quantities, for example, Zn help in busting body immune functions wound and skin sore healing while Cu functions as cofactor for enzymes in humans. Manganese (Mn) help in blood clotting, prevent skin problems and forms part of hemoglobin, the oxygen carriers of the blood in the body. It is also essential for both human and plants growth (Atara *et al*, 2020; Gerberding, 2005 and Okoye *et al*., 2011). Heavy metals can also be used in medicine as components in blood tonic drugs as they help in hemoglobin formation and in blood clotting. Some are usually mixed in skin lotions as cure for some skin problems (Koplar, 2000). However, heavy metals should be used with caution so as not to exceed the maximum acceptable limit nor below as both could result in great adverse effects (Atara *et al*., 2020).their contamination is a serious major health and environmental problem, therefore, there is need for a definite standard for the use of heavy metals in poultry feeds to minimize contamination, maintain the food chain safety and future consequences.

METHODOLOGY

SAMPLING OF MATERIALS:

Plastic bowls and glass bottled cups were used in collecting the samples with plastic spoons. All the materials were washed with detergent, rinsed with distilled water then immersed in 10% trioxonitrate (V) acid (HNO_3) and finally rinsed with deionized water. Analytical reagents (AnaloR) and distilled water deionized water were used throughout the laboratory analysis.

SAMPLE COLLECTION

Four brand feed type rations namely, finisher, layer, grower and starter feeds from ten (10) different feed companies were purchased in mudus (measure) and coded as A_1 to A_{10} respectively, from available stores in Lafia metropolis.

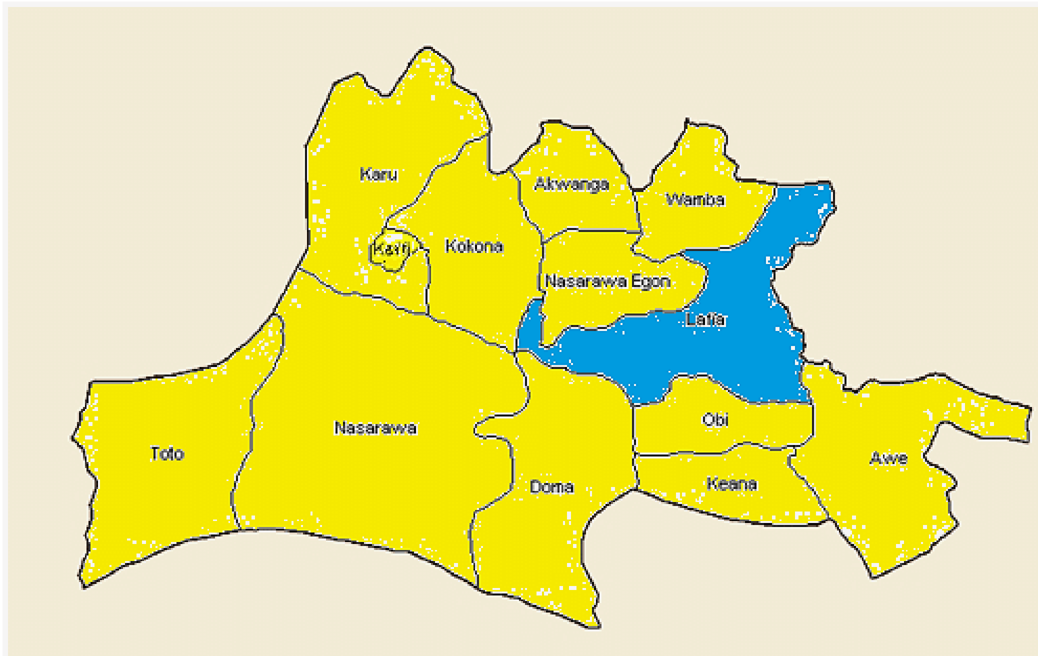

Fig 1: Map of Nasarawa State Showing the location of the Study Area (Source: NAGIS, 2023).

Sample Preparation. Each company's same type of rations was taken and mixed together into one composite sample.

Carefully weighed 2.0g of the sample was placed in a crucible and $1cm^3$ HNO_3 acid solution added as pre-ashing acid. The crucible was then placed on a heater to chare the contents so as to pre-ash. The pre-ashed contents were carefully transferred into a covered furnace and heated to a temperature of about 470 to 480°C for 2 to 3½ hours to obtain a constant weight. These are allowed to cool and the cooled samples were dissolved in $5cm^3$ of 30% hydrochloric acid ($HCl_{(aq)}$). Whatman filter papers wereused to filter the dissolved samples. The filtrates were poured individually into $50cm^3$ volumetric flasks and topped up to the mark with deionized water. The solutions were kept in labelled sample reagent bottles for further analysis. The prepared sample solutions were analyzed for heavy metal concentration using Atomic Absorption Spectrometer (AAS).

STATISTICAL ANALYSIS

The results from the data collected were subjected to one-way analysis of variance (ANOVA) ($P<0.05$) to assess any statistically significant difference between the concentration of heavy metals in the sampled poultry feeds. Statistical Package for Social Sciences (SPSS) version 23.0 was used in performing all statistical analysis.

RESULTS AND DISCUSSION

The results obtained from the study showed that the selected heavy metals analyzed were detected in different concentration levels in all the ten companies' feed tested.

Table 1: Heavy metal concentration (mg/kg) in finisher feed rations of the different company feed brand

Company feed brand	Heavy metals (mg/kg)								
	Cd	Cr	Co	Cu	Fe	Pb	Ni	Mn	Zn
A_1	2.14	1.43	2.52	2.71	10.97	0.28	2.07	18.89	21.75
A_2	2.14	0.95	0.84	3.38	10.97	0.28	1.04	25.02	21.75
A_3	1.60	0.94	3.33	3.38	10.97	0.26	1.72	12.50	16.31
A_4	2.68	2.68	1.68	4.05	15.41	0.28	2.05	12.51	16.75
A_5	1.64	2.48	2.51	3.37	10.98	10.28	1.38	18.89	21.78
A_6	1.07	0.95	2.55	4.06	13.34	0.26	1.77	25.01	21.75
A_7	1.61	1.48	2.53	4.06	13.34	0.26	1.36	18.86	32.60
A_8	1.67	0.95	2.56	4.06	13.35	0.28	1.77	25.03	21.75
A_9	1.61	0.95	2.51	4.06	13.36	0.28	0.38	18.89	32.62
A_{10}	2.15	1.43	1.68	2.80	17.55	0.82	1.38	12.51	32.60
MEAN	1.83	1.33	1.27	3.59	13.03	1.33	1.49	18.81	23.97

Table 2: Heavy metal concentration (mg/kg) in grower feed ration.

Company feed brand	Heavy metals								
	Cd	Cr	Co	Cu	Fe	Pb	Ni	Mn	Zn
A_1	1.70	0.43	1.68	2.71	8.80	0.90	1.38	26.02	32.69
A_2	2.13	1.43	2.52	3.39	13.32	0.80	1.37	12.51	32.66
A_3	0.54	1.42	1.68	3.38	13.33	0.81	1.71	12.51	21.75
A_4	2.14	2.13	1.66	2.73	19.80	0.55	1.05	18.88	27.76
A_5	1.60	0.84	0.82	2.02	10.97	0.82	1.38	18.73	27.78
A_6	2.72	1.43	2.14	4.06	13.37	0.80	1.70	12.49	32.62
A_7	1.07	0.94	2.51	4.75	13.31	0.78	1.36	12.49	32.60
A_8	2.72	1.43	2.13	4.06	13.33	0.82	1.79	12.51	32.62
A_9	1.55	0.96	2.51	4.75	13.33	0.82	1.38	12.51	32.62
A_{10}	1.66	0.48	1.68	2.80	13.33	0.80	1.38	18.90	32.60
MEAN	1.61	1.15	1.93	3.47	13.29	0.79	1.45	15.76	30.57

Table 3: Heavy metal concentration (mg/kg) in the layer feed ration of the different company feed brand.

Company feed brand	Heavy metals								
	Cd	Cr	Co	Cu	Fe	Pb	Ni	Mn	Zn
A_1	1.70	1.43	1.68	3.39	10.97	0.54	1.72	18.87	38.10
A_2	3.20	1.90	1.66	2.71	13.33	0.80	1.71	25.02	32.65
A_3	1.61	1.91	2.51	2.71	13.32	0.53	1.04	12.50	21.75
A_4	1.61	1.61	1.67	5.41	13.33	0.56	1.73	18.80	27.74
A_5	1.56	1.81	0.84	3.39	10.97	0.28	2.56	12.50	21.75
A_6	1.07	1.48	2.56	3.40	13.31	0.26	1.72	18.95	37.62
A_7	1.61	2.40	2.55	4.66	10.96	0.26	1.34	18.89	27.72
A_8	1.07	1.50	2.57	3.40	13.33	0.28	1.72	18.95	32.62
A_9	1.61	2.40	2.56	4.06	10.97	0.29	1.38	18.90	27.73
A_{10}	1.67	1.43	1.68	3.40	13.33	0.27	1.38	18.88	32.62
MEAN	1.67	1.59	2.03	3.65	12.38	0.41	1.63	18.23	30.03

Table 4: Heavy metals concentration (mg/kg) in starter feed ration of the different company feed brands.

Company feed brand	Heavy metals								
	Cd	Cr	Co	Cu	Fe	Pb	Ni	Mn	Zn
A_1	2.14	1.43	1.68	3.39	13.33	0.28	1.38	26.01	16.31
A_2	1.61	0.48	1.68	2.70	10.96	0.53	1.38	25.02	27.77
A_3	1.07	0.95	0.84	2.03	10.97	0.58	1.04	18.89	38.08
A_4	1.06	1.07	2.54	2.72	10.97	0.56	1.73	12.52	32.64
A_5	2.68	1.68	1.66	4.06	10.80	0.56	1.75	18.92	16.30
A_6	1.61	0.95	2.54	2.10	17.50	0.26	1.07	35.26	27.73
A_7	1.65	0.95	3.38	4.06	13.33	0.79	1.09	37.51	27.71
A_8	1.61	0.95	2.56	2.09	17.66	0.28	1.05	13.26	21.73
A_9	1.62	0.96	3.40	4.07	13.32	0.82	1.09	37.51	27.73
A_{10}	2.15	1.43	2.53	3.40	13.34	0.29	1.39	37.51	27.72
MEAN	1.72	1.09	2.28	3.06	13.22	0.50	1.30	26.24	26.37

Table 5: Heavy Metals Concentration (mg/kg) in the Different Company Feed Brands

Company Feed Brand	Cd	Cr	Co	Cu	Fe	Pb	Ni	Mn	Zn
A_1	1.92	1.93	1.89	3.05	11.02	0.50	1.64	22.45	25.85
A_2	2.27	1.19	1.68	3.05	12.16	0.60	1.13	21.89	28.71
A_3	1.21	0.81	2.09	2.88	12.15	0.55	1.38	14.10	24.47
A_4	1.87	1.87	1.88	3.73	12.38	0.49	1.64	15.69	26.22
A_5	1.87	1.46	1.46	3.21	13.63	0.49	1.64	17.31	21.91
A_6	1.82	1.20	2.46	3.40	14.37	0.40	1.56	22.93	29.93
A_7	1.49	1.44	2.74	4.23	12.73	0.52	1.28	21.94	30.16
A_8	1.78	1.21	2.46	3.37	14.40	0.42	1.59	22.94	21.18
A_9	1.60	1.32	2.75	4.23	12.76	0.56	0.55	21.85	30.18
A_{10}	1.81	1.19	1.88	3.10	14.39	0.54	1.38	21.95	31.39
MEAN	1.76	1.36	2.13	3.43	13.00	0.51	1.38	20.31	27.00

Table one showed the heavy metal concentration (mg/kg) in finisher rations of feed. As shown in table 1, the concentrations (mg/kg) of Cd ranged from 1.07 to 2.68; Cr 0.94 to 2.68; Co 0.84 to 2.56; Cu 2.71 to 4.06; Fe 10.97 to 17.55; Pb 0.82 to 10.28; Ni 0.38 to 2.07; Mn 12.50 to 25.03 and Zn 16.31 to 32.62. Ni has the least concentration of 0.38mg/kg while Zn has the highest concentration of 32.62mg/kg in finisher rations of feed. Considering the requirement of heavy metals in poultry feeds as essential nutrient, all the sampled company feeds contained heavy metals at below nutritional requirement for Cu, Fe and Mn in the finisher rations feed (NRC, 2014).

Table 2 shows the concentration of the heavy metals' ranges in mg/kg for grower feed rations as Cd, 0.54 to 2.72; Cr, 0.48 to 2.13; Co, 0.82 to 2.51; Cu, 2.02 to 4.75; Fe, 0.80 to 13.37; Pb, 0.55 to 0.82. Ni, Mn and Zn ranged in mg/kg from 1.05 to 1.79, 12.51 to 18.88 and 21.75 to 32.62 respectively. Cd had the lowest concentration of 0.54mg/kg while the highest concentration was obtained for Zn, 32.62 mg/kg. These values were obtained in feed $A_3$for Cd and A_8 for Zn metals.

Also, table 3 and 4 showed the various ranges of the heavy metals' concentration in the analyzed samples for layer feed ration and starter feed rations respectively.Pb had the lowest concentration of 2.06 mg/kg in both the layer feed ration and the starter feed ration in A_6, while Zn had the highest concentration (38.10) in the layer feed ration, A_1.

Table 5 showed the concentration of heavy metals in the different company feed brands, that is in the different poultry feed rations. It is shown that Zn has the highest mean values of 27.00mg/kg while Pb has the lowest mean value of 0.51 mg/kg. Generally, metal concentration levels in the feed varied from metal to metal as indicated in the results in table 5.

The Standard Organization of Nigeria (SON) in their prepared poultry feed reference standard only mentioned heavy metals as required micronutrients but gave no standard as a contaminant in terms of permissible maximum limit for these metals (Field work, 2023). The poultry feed companies, therefore, included Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn) to fulfill the micronutrients requirements even though these are heavy metals. Nutrients requirement for chickens vary greatly according to the purpose for which they have been developed. According to Gleaves et al., (1991), minerals are required for formation of the skeleton as components of various compounds with particular functions within the body, as activators of enzymes and for the maintenance of necessary osmotic relationships within the bird's body. However, they further explained that excessive concentrations of an element may result in a deficiency in the amount available for the birds of some element. Therefore, dietary supplementation with trace elements should be undertaken with great care and consideration for the possible interactions.

The results indicated in the study showed that the concentration level obtained for copper were a little below the required mean value range of 0.50 to 3.64 mg/kg as suggested by Gleaves *et al*., (1991). The values obtained from this study were also far below values reported by Okoye et al., (2011). Zn was found to be higher with a mean value of 27.00 mg/kg. Gleaves *et al*., (1991) reported that layers of 0 to 6, 6 to 14 and 14 to 20 weeks required 18.18mg/kg, 15.91 mg/kg and 22.73mg/kg respectively as maximum nutrients intake. Gleaves also reported that broilers required 18.18 mg/kg intake of minerals. However, Bukar & Sa'id (2014) reported that Zn was obtained as a nutrient in starter, grower and finisher at 40.0to 55.0 mg/kg and 30.0 to 40.0 mg/kg in layer feed. Zn levels (table 1-5) was reported in all the sampled feeds to be above the required minimum limits of Food and agriculture Organization (FAO), Standard Organization of Nigeria (SON) and World Health Organization (WHO). Gleaves *et al*., (1991) reported that permissible limits of 15.91 mg/kg to 18.18 mg/kg are the nutrient requirement of layer and broiler type fowls.

In Table 5, Pb mean concentration level was 0.51 mg/kg while in table 1-4 it was 1.33 mg/kg, 0.79, 0.41 and 0.50 mg/kg respectively. These values were however, lower that the minimum acceptable limit of 5.0 mg/kg allowed by FAO and WHO (FAO/WHO, 2001). The mean value of Pb in table 1 is however greater than those reported by Maheser *et al*., (2010) and Okoye *et al*., (2011) when they were analyzing poultry feeds. In either case, whether the values are low or high, there is a serious effect to take note of. Atara& Joseph, (2021) reported that where the concentrations are high can lead to environmental pollution of the surface soil which could result in excessive intake of such heavy metal pollutants by living organisms. This could lead to death according to Mahesar *et al*., (2010). Those that their concentration levels were observed to be lower, will again make the poultry feed not to contain the correct dietary nutrient requirements (Mahesar *et al*., 2010; Okoye *et al*., 2011 and Bukar & Sa'id, 2014).

Lead (Pb) according to Igwemmar *et al*., (2022) is a non-essential element which has direct health effects on humans and its distribution sources include combustion of fossil fuels, agricultural activities and industrial emission.

The result from this study showed that the concentration of Cd assessed in the poultry feed company brands ranged from 1.21 mg/kg to 2.27 mg/kg with a mean value of 1.76 mg/kg (table 5). This obtained value is higher than the maximum permissible limit value of 1 mg/kg in feeds given by FAO and WHO (FAO/WHO, 2001). Mahesar *et al*., (2010), Bukar & Sa'id, (2014) and Okoye *et al*., (2011), differently reported similar higher concentration of Cd in different feeds ranges 0.54-1.66 mg/kg, 1.07-2.68 mg/kg and 1.07-3.20 mg/kg respectively.Reports indicated that Cd element often mimics other divalent metals that are needed for a variety of biological processes but has no recognized biological function in humans or animals (Martelli *et al*., 2006 and Igwemmar *et al*., 2022). The Ni contents obtained from all sampled feeds ranged from 38 mg/kg and 20.7 mg/kg (table 5). These values were within the required range but were however lower than the value reported by Okoye *et al*., (2011). The Ni detected in this study was also found to be lower than the maximum acceptable limit of 4.05 mg/kg (NRC, 2014) and those reported by Islam *et al*., (2007). Suleiman *et al*., (2015) reported that this could be due to unharmonized nutritional requirements of fowl that differ from one area to another and errors during feed processing and mixing of ingredients. Inadequate supplementation could also be another reason.

The results from this study showed the concentration of Mn to range from 14.10 mg/kg to 22.94 mg/kg as shown in table 5. Its highest value was recorded in feed A_8 an table 5 while in the starter ration, it was 37.51 mg/kg in feed A_7, A_9 and A_{10}, while the lowest value of 12.50 was in feed A_3 finisher feed ration. From the study, all the feed samples were found to be deficient of Mn when considering the dietary broiler chicken requirement for Mn (Gleaves *et al*., 1991, NRC, 2014 and Igwemmar *et al*., 2022). Mn is a micronutrient required at 27.27 mg/kg for 0 to 6 weeks broiler chickens (Gleaves *et al*., 1991) and 55-60 mg/kg for starter and finisher, 30-40 mg/kg for grower and 50-60 mg/kg for layer chickens (Bukar & Sa'id, 2014). When the study values obtained are compared with that of the maximum permissible limit of 20-60 mg/kg recommended by FAO, it is seen that all the feed samples' values are below and are deficient of Mn. Therefore, there is need to supplement Mn so as to meet up the nutrient dietary Mn requirement of poultry. This study's finding is in agreement with the finding of Suleiman et al., (2015), Gleaves *et al*., (1991), Oforka (2012) and Igwemmar *et al*., (2022). But it differs as higher Mn values were reported in different feeds brands that are higher than 20 mg/kg and 60mg/kg (NRC, 2014). Mn is required in poultry diet as it has a role in enzyme formation, carbohydrate and lipid metabolism (Olan, 2017).

Iron concentration (mg/kg) in the different company feed brands sampled ranged from 11.02-14.40mg/kgwith a mean value of 13.00mg/kg (Table 5).These values in this study were all lower than the 60-80mg/kg recommended minimum and maximum limit of Fe in feeds by SON and NRC (SON, 2018 and NRC, 2014). The values obtained in this study were similar to those reported by Okoye et al., (2011); Imran *et al*., (2014) and Olan (2017). Therefore, Fe concentration in the sampled feeds were lower than the values required by the birds for good and proper healthy development. SON(2018) stated that Fe is an essential dietary nutrient of poultry and that its presenceis very important. Gleaves *et al*., (1991); Okoye et al., (2011); Olan (2017) and Imran et al., (2014) all recommended that all poultry feed brand need Fe as micronutrients and dietary requirements. Iron was found in all sampled feeds though lower than the permissible concentration level of 45-80 mg/kg stipulated by SON and FAO. Efforts are required to increase supplementation of all the micro-elements that were lower than the permissible minimum level in poultry feeds.

CONCLUSION

This study detected the presenceof the selected heavy metal elements in all the sampled company brand feeds. Some, for example, Fe, Cu and Ni, were found to be below the permissible limit level while others like Zn, Pb and Mn, were found to be higher than the permissible limit level concentration. Those at the lower permissible limit acceptance level are considered as non-toxic while those above are considered toxic in poultry feeds. Efforts is needed to increasesupplementation of those micro-nutrientsthat were found to be below the permissible limit and those found to be far above the maximum permissible limit level to reduced their inputs during poultry feed preparation. Also, the chicken feed producers must always observe and maintain the maximum permissible level of heavy metals in poultry feeds. Activities that allowed heavy metals to gain access into food chain beyond those limits of regulatory agencies must be reduced to minimum.

Adefinite standard should be provided for heavy metal acceptable limit in poultry feeds,beyond which it should be regarded as pollutants so as to maintain the safety of food chain from heavy metals and its further consequences.

Commercial feeds sold should be regularlymonitored by the regulatory bodies to ensure that the concentration of heavy metals may be present at the maximum and below the permissible limit acceptance level and enforcement of good manufacturing practices to be encouraged at all times. Available poultry feeds in the open market need to be analyzed for heavy metal percentage contamination. Further studyis recommended to cover other animal feeds and more locations in the various geographical parts of the country.

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