Fjrs.futa.edu.ng

FUTA Journal of Research in Sciences

ISSN: 2315 – 8239 (Print); E-ISSN: 2489 - 0413

FUTA Journal of Research in Sciences, Vol. 15(1), April, 2019: 124-133

Dietary Contributions of Cu, Fe and Zn from *Gallus gallus domesticus* and *Numida meleagris*

Tomori, Wasiu Bolaji

Department of Chemistry, The Federal University of Technology, Akure, Nigeria
Corresponding Author: wbtomori@futa.edu.ng; +2348138639740

ABSTRACT

Metal ions can regulate a lot of physiological processes with extensive specificity and selectivity in living organisms but they could pose health problem when their concentration is elevated in the food chain. The present study therefore seeks to determine dietary contributions of Cu, Fe and Zn from *Gallus domesticus* and *Numida meleagris* by determining the metal concentrations in gizzard, kidney, liver and muscle using standard procedures. The results obtained showed that female caged *Gallus domesticus* has the highest copper concentration (2.91 mg/kg) in its gizzard while its male counterpart has the least (0.03 mg/kg). The female *Numida meleagris* has highest concentration of iron (8.76 mg) in the liver and the lowest concentration (0.06 mg/kg) in the gizzard of the two birds. The highest concentration of zinc is found in the muscle of free ranged female and male *Gallus domesticus* (3.74 mg/kg; 3.18 mg/kg) respectively. The estimated daily dietary intake of these metals in various organs and tissues of the different birds was found to be generally higher in liver; however, it could not be said to be of any adverse effect as the values were less than the Recommended Daily Allowance (RDA). Hence, their consumption is deemed safe and of no environmental and/or dietary health risk to the population.

Keywords: Heavy metals; Dietary; Birds, Daily Allowance; Health Risk.

INTRODUCTION

Trace elements present in foods are utilized to varying extents depending on the presence of several ‘antagonizing’ factors. The differential availability of trace elements in foods thus limits the use of data on the trace element content of foods for determining the nutritional adequacy of diets (Skalnaya and Skalny, 2018). Human copper deficiency was considered impossible for many years because of its small nutritional requirement until not long ago when cases of Cu deficiency were reported (Bonham *et al.,* 2002). Early manifestations of the Cu deficiency are neutropaenia and hypochromic anemia, a condition where an individual does not respond to oral iron therapy (Hantaweepant and Chinthammir, 2016). The earlier estimate of 50 mg/kg body weight for the requirement of Cu for infants and young children provides an inadequate margin of safety; an intake of 80 mg/kg body weight was said to be a realistic allowance that allows for safety margin. Moreover, 40 mg/kg body weight for older children and 30 mg/kg body weight for an adult were said to be adequate (Bost *et al.*, 2016).

The incidence of Cu deficiency is probably smaller and limited to special circumstances when compared to Zn deficiency (Prasad, 2013). The essentiality of Zn for human nutrition has long been recognized and a variety of effects of Zn supplementation to human diets has been described (Lokuruka, 2012). Dietary Zn deficiency is associated with 'nutritional dwarfism', this is characterized by retarded growth and delayed sexual maturation (Brown *et al.*, 2001; Yanagisawa, 2004). Zinc-responsive growth failure has been observed in young children who consume relatively little meat, less than 30 g/day. Dietary requirements for Zn are related to the needs for growth, tissue repair and obligatory excretion of the trace element. Thus, the requirement for zinc for an adult is 2.2 mg/day. The requirement for the trace element increases to 3.0 and 5.5 mg/day during pregnancy and lactation respectively (Skalnaya and Skalny, 2018). Dietary human deficiencies of Zn could cause serious health problems such as anaemia, poor pregnancy outcomes, increased risk of morbidity and mortality, stunted growth and impaired physical and cognitive development (Bailey *et al.*, 2015). Zinc is found in meat, liver, kidney, fish, pork lamb, beef, shell fish, Oysters, lobster and organ meats, poultry, dairy products, cereals, fruits, whole grains and cereals, leafy grains, root vegetables, (Deshpande *et al.*, 2013) to mention a few. Despite this widespread occurrence, there is worldwide prevalence of zinc deficiencies (Bailey *et al.*, 2015).

The fraction of iron absorbed from the amount ingested is typically low, but may range from 5% to 35% depending on circumstances and type of iron (Abbaspour *et al.*, 2014). Dietary iron occurs in two forms: heme and non-heme. Heme iron is highly bioavailable (15%-35%) whereas non-heme iron absorption is much lower (2%-20%). Non-heme iron generally contributes more to iron nutrition than heme-iron despite its lower bioavailability because the quantity of non-heme iron in the diet is many fold greater than that of heme-iron (Abbaspour *et al.*, 2014). The Recommended Dietary Allowance (RDA) for iron for all age groups of men and postmenopausal women is 8 mg/day, and for premenopausal women it is 18 mg/ day (Blanck *et al*., 2005). Pregnant women require 27 mg/day while for children of both sexes between the ages of 6 months and 11 years, their RDA is 11 mg/day (Skalnaya and Skalny, 2018). Despite the high prevalence of iron deficiency, excessive iron intake is also a source of adverse effects. Iron overload occurs when excess iron is stored in the tissues and is most often due to genetic causes such as hemochromatosis (Oh and Moon, 2019). Adverse effects are usually seen with intakes between 20 and 60 mg/kg, and depending on the quantity of iron ingested, the cardiovascular system, central nervous system, kidneys, liver, and hematologic system can be affected (Abbaspour *et al.*, 2014).

Knowledge gap exist on the trace element content of foods because those currently available were said to be unsatisfactory despite the compendium of their elemental composition; this will therefore limits the usage of the data available (Soetan *et al., 2010*). Living organisms have the ability to concentrate preferentially certain elements from the environment and variation from normal values will occur if the organism is exposed to environmental contamination or possesses ability to accumulate certain elements which are normally excluded by same living organisms (Tchounwou *et al.*, 2012). Domesticated birds are cheap sources of protein and are becoming a growing protein source in Nigeria. It is therefore expedient to consider food/animal nutritional composition most especially those involving essential minerals in other to i) provide an estimate of their dietary availability to Nigerian nutrition and 2) monitor their environmental concentration to avoid passing toxic levels of these minerals into the food chain.

MATERIALS AND METHOD

Sampling, Sample Treatments and Analysis

The male and female samples of *Gallus gallus domesticus* (chicken-free ranged and caged) and *Numida meleagris* (guinea fowl) were purchased (in triplicate) from three commercial markets in Akure metropolis and each bird was slaughtered using a stainless steel knife, dissected to remove the target organs and muscle (chest and wing) samples after removal of their feathers with boiled distilled water. The digestion mixture (HNO_3:H_2O_2:$HClO_4$ (10:2:1)) was added to 2 g of homogenised sample in an acid washed Teflon beaker and the content was allowed to stand overnight for complete digestion. The digest were quantitatively transferred to a 50 ml volumetric flask (with several wash of the Teflon beaker) through a filter paper (Wattman No 42) and the content was made up to mark with distilled water. The digested sample was then labeled and stored for analysis (Deng *et al*, 2007). Determination of the selected heavy metals was made directly on each of the final solutions using Atomic Absorption Spectrophotometer (AAS) (Buck Scientific 200A).

Estimated daily dietary intakes (EDI)

The estimated daily intakes (EDI) for the analyzed metals were calculated by multiplying the respective mean concentration of the metal determined in the targeted chicken samples by the weight of chicken consumed by an average individual in Nigeria. EDI per kg is thus calculated by using the formula (Atique-Ullah *et al.*, 2017)

$$EDI = \text{DFC X MC}$$

where, DFC = daily food consumption and MC =mean metal concentration in the sample The daily chicken consumption rate for an adult (60 kg) was an average of 350 g on fresh weight basis as consumed in the various eatery across Nigeria.

RESULTS AND DISCUSSION

Metals such as arsenic, cobalt, copper, iron, manganese, selenium and zinc are added to feeds as a means to prevent disease, improve weight gain and increase egg production (Bolan *et al*., 2004). Food contamination with heavy metal could pose serious threat to the population because of their toxicity, bioaccumulation and biomagnifications in the food chain. They often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently (Iwegbue *et al.,* 2008). The results of copper, iron and zinc determination in the selected samples and organs are presented in Tables 1-3.

Copper, Cu

Copper is an essential trace element for human body and is an indispensable component of many enzyme systems; however a number of pathogenic characteristics are attributed to this element. It is involved in absorption, storage and metabolism of iron but in high doses it can cause anemia, liver and kidney damages as well as stomach and intestinal irritation (Stern *et al*., 2007; Scheers, 2013). The results from Table 1 indicated that female caged *Gallus domesticus* has the highest copper concentration (2.91 mg/kg) in its gizzard while its male counterpart has the least (0.03 mg/kg). There is therefore the possibility that feeding with layer mash for egg production is the source of the copper in the animal. Various metals (Cu, Mn, Zn) are added to poultry diets (premix) to enhance their weight gain and disease prevention (Avitech, 2002). It is an established fact that copper is added to poultry to enhance certain advantages. Copper from Cu sulfate used in poultry diet supplementation has been found to increase the egg production of laying hens and higher values were found to cause gizzard erosion and decreased feed intake (Skrivan *et al.*, 2006; Pekel and Alp, 2011). This corroborated the presence of copper in highest concentration in the gizzard that was found in this study, an indication of possible copper storage in the gizzard of caged female *Gallus domesticus.*

Table 1: Copper (Cu) Concentration in Muscle, Liver, Kidney and Gizzard of *Gallus gallus domesticus* (Chicken) and *Numida Meleagris* (Guinea Fowl)

Birds	n	Sex	Muscle	Liver	Kidney	Gizzard
Chicken	18	Female	1.81±0.10	1.09±0.01	ND	2.57±0.06
(Free Ranged)		Male	1.89±0.07	2.40±0.00	2.11±0.11	1.78±0.03
Chicken (Caged)	18	Female	1.20±0.04	1.29±0.03	ND	1.32±1.29
		Male	1.21±0.05	2.16±0.01	1.28±0.04	0.03±0.02
Guinea fowl	18	Female	1.66±0.20	2.74±0.14	ND	2.91±0.05
		Male	2.62±0.11	2.85±0.09	2.16±0.05	2.03±0.04

Note: values shown are Means ± SD of eighteen samples expressed as mg/kg fresh weight basis.

Table 2: Iron (Fe) Concentration in Muscle, Liver, Kidney and Gizzard of *Gallus gallus domesticus* (Chicken) and *Numida Meleagris* (Guinea Fowl)

Birds	n	Sex	Muscle	Liver	Kidney	Gizzard
Chicken	18	Female	3.93±0.11	2.88±0.17	ND	0.06±0.00
(Free Ranged)		Male	4.02±0.21	2.85±0.08	3.29±0.02	0.06±0.00
Chicken (Caged)	18	Female	2.79±0.15	2.10±0.02	ND	0.06±0.00
		Male	2.23±0.04	3.23±0.15	3.24±0.07	0.06±0.00
Guinea fowl	18	Female	5.10±0.09	8.76±0.25	ND	0.06±0.00
		Male	5.07±0.23	3.97±0.08	4.81±0.14	0.06±0.00

Note: values shown are Means ± SD of eighteen samples expressed as mg/kg fresh weight basis.

Table 3: Zinc (Zn) Concentration in Muscle, Liver, Kidney and Gizzard of *Gallus gallus domesticus* (Chicken) and *Numida Meleagris* (Guinea Fowl)

Birds	n	Sex	Muscle	Liver	Kidney	Gizzard
Chicken	18	Female	3.74±0.15	2.02±0.26	ND	2.19±0.05
(Free Ranged)		Male	3.18±0.03	1.68±0.05	1.30±0.01	2.16±0.01
Chicken (Caged)	18	Female	2.13±0.05	1.36±0.07	ND	1.27±0.09
		Male	2.69±0.03	2.03±0.22	2.24±0.11	0.02±0.03
Guinea fowl	18	Female	2.09±0.16	2.14±0.10	ND	3.11±0.05
		Male	2.65±0.02	2.29±0.06	3.66±0.10	2.77±0.02

Note: values shown are Means ± SD of eighteen samples expressed as mg/kg fresh weight basis.

The range of results obtained for muscle is 1.20-2.62 mg/kg, for liver 1.09-2.85 mg/kg, for kidney 1.28-2.16 and for gizzards 0.03-2.91 mg/kg. However, liver has the highest concentration (12.53 mg/kg) of copper among the organs > gizzard (10.64 mg/kg) > muscle (10.39 mg/kg) > kidney (5.55 mg/kg). It should be reported here that the kidney of female birds could not be identified and hence was not determined. This could probably account for the low total concentration of copper in the kidney, though, it is comparable to the results obtained by Al-Zuhairi *et al.*, (2015). The liver is one of the busiest organs in the body that carries out a large number of important digestive, metabolic and excretory activities including detoxification and is no wonder why liver has the highest concentration of copper considering all birds in this study. Similar observation was reported by Khan *et al.*, (2015) in Pakistan.

Numida meleagris (male) has the highest concentration (9.66 mg/kg) of total copper concentration (Figure 1) > male *Gallus domesticus* (free ranged) (8.18 mg/kg) > female *Numida meleagris* (7.31 mg/kg) > female *Gallus domesticus* (free ranged) (5.47 mg/kg) > male *Gallus domesticus* (caged) > female *Gallus domesticus* (caged) (3.81 mg/kg). Elements are introduced into poultry diets either involuntarily through contaminated feedstuffs or voluntarily, as feed additives used to supply animals' requirements or – in much greater proportions – as veterinary drugs or growth promoters (Avitech, 2002). The trend in this result shows the possibility of environmental factor as main source of copper that should be of concern because *Numida meleagris* and free ranged *Gallus domesticus* ranked highest in total concentration of copper. The concentration of copper in all samples (sex, animal type and rearing system) was found not exceeding the hygienic limit of 80 mg/kg (Skrivan *et al.*, 2011) and within the maximum copper concentration for meat and meat products that has been proposed as 0.90–30 mg d^{-1} (Alturiqi and Albedair, 2012).

Iron, Fe

Iron is an essential element because of its association with haemoglobin in the human blood. However, too much of iron may be linked to heart disease, cancer, diabetes and other diseases (Abbaspour *et al*., 2014). A more common problem for humans is iron deficiency, which leads to anaemia. A man needs an average daily intake of 7 mg of iron and a woman 11 mg; however, a normal diet will generally provide all that is needed except if there is adverse medication condition (Skalnaya and Skalny, 2018). The results of Iron content of the various animal and organs are presented in Table 2. The female *Numida meleagris* appears to have highest concentration (8.76 mg) in the liver, followed by its concentration in the female muscle (5.10 mg) and then male muscle (5.07 mg) while the lowest concentration (0.06 mg) was found in the gizzard. This is relatively constant for all the animals. Iron in all studied samples was below the recommended tolerable levels. The upper tolerable intake level of iron in children (0 months–8 years) and males/females (14–70 years) is 40 and 45 mg d^{-1}, respectively (Alturiqi and Albedair, 2012).

The range of results was 2.23-5.10 mg in the muscle, 2.10-8.76 mg in the liver, 3.24-4.81 mg in the kidney and 0.06 mg in the gizzard (relatively constant for all animals and organs). The order of results among the organs is liver (23.79) > Muscle (23.14) > Kidney > (11.34) > Gizzard (0.36). Liver is also having highest concentration of Iron depicting the fact that blood is the carrier in the detoxification of xenobiotics from the body of animals and iron is closely associated with haemoglobin in the blood. *Numida meleagris* is having the highest total concentration (13.92 mg, female; 13.91 mg male) followed by free male *Gallus domesticus* (10.22 mg) > caged male *Gallus domesticus* (8.96 mg) > free *Gallus domesticus* (6.87) > caged *Gallus domesticus* (4.95). It therefore appears that environmental factors played a key role in the accumulation of iron in the animal.

This result was in agreement with the results of Rehman *et al*., (2013) where domestic chickens were found to have higher concentration of iron than the broiler chicken. The major source of iron in the environment is indiscriminate dumping of used metal scraps. The Recommended Dietary Allowance (RDA) for iron for all age groups of men and postmenopausal women is 8 mg/day, and for premenopausal women it is 18 mg/day. Pregnant women require 27 mg/day while for children of both sexes between the ages of 6 months and 11 years is 11 mg/day (Skalnaya and Skalny, 2018).

Zinc, Zn

Zinc has been found to be extremely toxic to birds and have severe clinical consequences which may include lethargy, shallow respiration, anorexia/reduced appetite, decreased body weight, weakness, falling of perch heamolytic anemia, kidney dysfunction, possible liver and pancreatic abnormalities etc whereas is an essential mineral in human where its deficiency could be fatal (Duruibe *et al.*, 2007). The muscle of the birds under investigation has the highest total concentration of zinc (16.48 mg/kg) when all birds are considered, followed by liver and gizzard (11.52 mg/kg). Male *Numida meleagris* has the highest zinc concentration (11.57 mg/kg) when all organs and muscle are considered. This is closely followed by male free ranged *Gallus domesticus* (8.32 mg/kg). This is an indication that environmental factors play a key role in the observed concentrations of zinc in these birds. Sources of zinc in the environment includes among others: paints, nails, nuts, padlocks, shampoos and skin preparations etc.

The highest concentration of zinc is found in the muscle of free ranged female and male *Gallus domesticus* (3.74 mg/kg; 3.18 mg/kg) respectively followed by gizzard of female and kidney of *Numida meleagris* (3.11 mg/kg; 3.66 mg/kg) respectively. It is still an evidence of environmental factor that informed the distribution of zinc in these animals. The range of values for muscle is 2.09-3.74 mg/kg, liver 1.36-2.29 mg/kg, kidney 1.30-3.66 mg/kg and gizzard 0.02-3.11 mg/kg. These results were not in line with the conclusion of Ghita *et al.*, (2009), Rehman *et al.*, (2012) and Khan *et al.*, (2015) who found higher concentrations in liver and intestines, those of Rehman *et al.*, (2013) with higher concentration in gizzard as well as Zhuang *et al.*, (2014) and Donia, (2015) that reported higher concentration in the kidney of poultry. However, this result was in line with Iwegbue *et al.*, (2008) in their study of heavy metal residues in chicken from southeastern Nigeria. Harmful effects from too much zinc generally begin at levels from 10 to 15 times higher than the recommended dietary allowances of 5, 12, and 15 mg/kg/day for infants, women and men respectively (Hussain *et al., 2012*). The first sign of zinc poisoning is usually intestinal distress which includes vomiting, stomach cramps, diarrhea and nausea.

Estimated Daily Dietary Intakes of Heavy Metals

The estimated daily dietary heavy metal intake is shown in Figures 1-3. The male birds were always contributing more dietary heavy metals than their female counterpart. It is also observed that *Numida meleagris* has the highest contributions to dietary intakes than *Gallus domesticus* irrespective of whether it is free ranged or caged. Caged *Gallus domesticus*, both male and female, has the least for all the heavy metals and hence seems to be the safest in terms of possible environmental hazard, however, it is also the least beneficial in terms of essential micronutrients like zinc. Moreover, liver is the largest contributing organ while muscle is the least considering the inability to identify kidney of female birds. None of the organs or bird contains any of the heavy metals higher than the recommended daily allowance (RDA) and hence they can be said to be safe for human consumption.

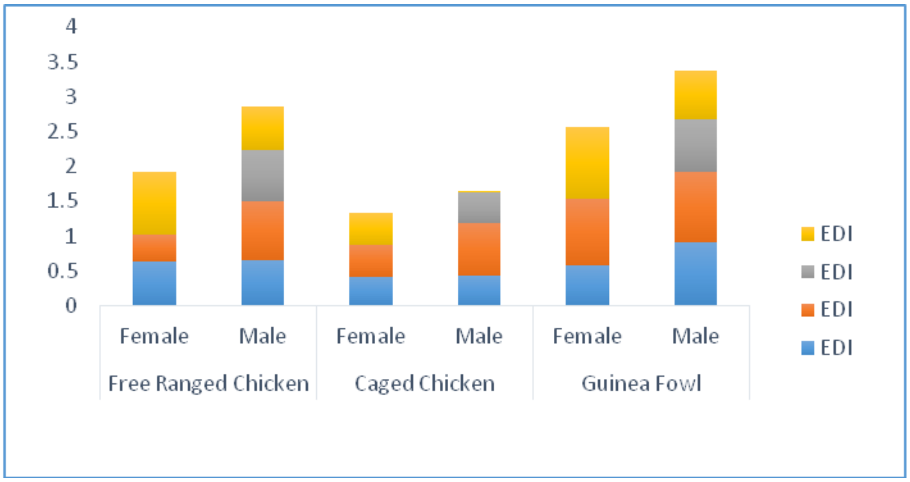

Figure 1: Estimated Daily Dietary Intake of Copper (Cu)

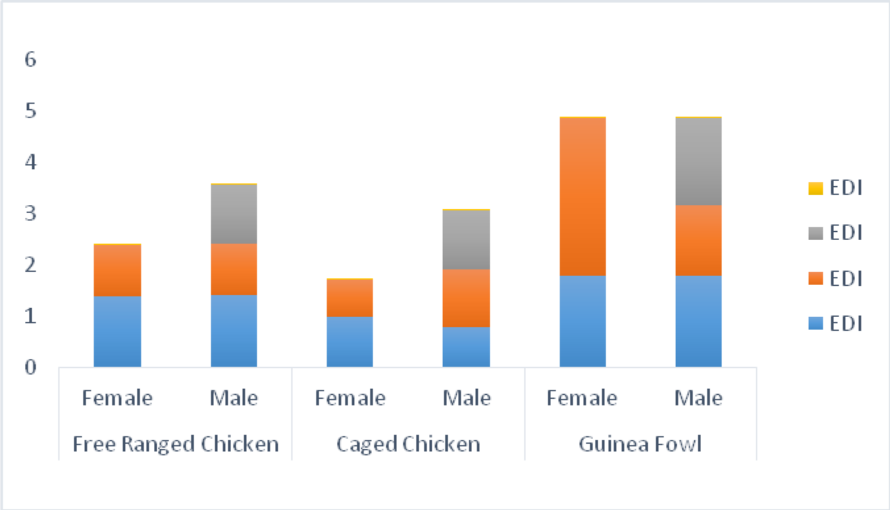

Figure 2: Estimated Daily Dietary Intake of Iron (Fe)

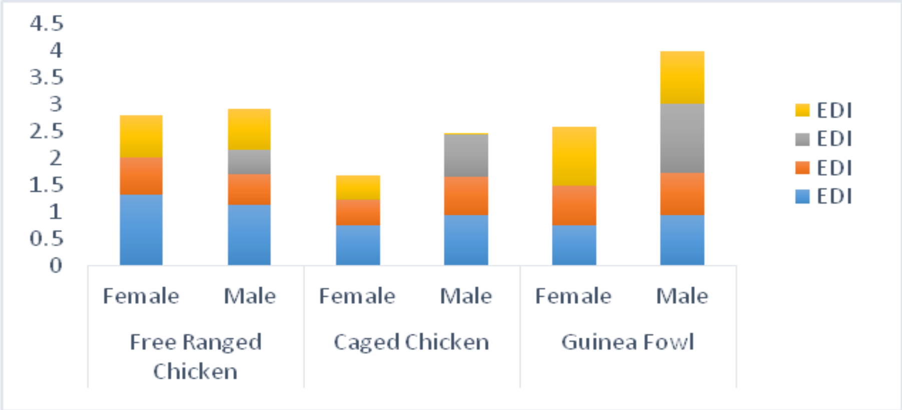

Figure 3: Estimated Daily Dietary intakes of Zinc (Zn)

CONCLUSION

Food contamination with heavy metals could pose serious threat to the population because of their toxicity and they are equally beneficial from essentiality of micronutrients. Copper was found in this study to be accumulated more in the gizzard of the female *Gallus domesticus* and this could be ascribed to the addition of this metal to poultry feed as growth promoter, egg shell improver among other things. Female *Numida meleagris* have the highest concentration of iron in its liver; liver being the centre of biochemical process of detoxification and blood being their carrier. Iron is closely related to blood being a component of haemoglobin. Zinc, an essential micronutrient, was found in the muscle of both free ranged male and female *Gallus domesticus* to be highest. There are two sides to the coin in this study, where it was found to be higher could probably pose a possible environmental threat due to bioaccumulation in the tissue while on the other could indicate more or availability of micronutrients. The estimated daily dietary intakes of these metals in various organs and tissues as well as in different birds was found to be generally higher in liver and *Numida meleagris* (both male and female); however, it could not be said to be of any adverse effect as the values were less than the Recommended Daily Allowance (RDA). Hence their consumption is deemed safe and of no environmental and/or dietary health risk to the population.

ACKNOWLEDGEMENT

I wish to thank Messers Okondo, Owoso and Fesobi, for their individual and collective assistance in the course of this work most especially preparation of samples for analysis.

REFERENCES

Abbaspour, N.; Hurrell, R. and Kelishadi, R. (2014). Review on Iron and its Importance for Human Health. *Journal of Research in Medical Sciences*, 19(2), 164-174.

Alturiqi, A. S. and Albedair, L. A. (2012). Evaluation of Some Heavy Metals in Certain Fish, Meat and Meat Products in Saudi Arabian Markets. *Egyptian Journal of Aquatic Research,* 38, 45-49.

Al-Zuhairi, W. Sh.; Farhan, M. A. and Ahmed, M. A. (2015). Determination of Heavy Metals in the Heart, Kidney and Meat of Beef, Mutton and Chicken from Baguda and Howaydir Market in Baquda, Diyala Province, IRAQ. *International Journal of Recent Scientific Research,* 6(8), 5965-5967.

Atique-Ullah, A. K. M.; Maksud, M. A.; Khan, S. R.; Lufta, L. N. and Quraish, S. B. (2017). Dietary Intake of Heavy Metals from Eight Highly Consumed Species of Cultured Fish and Possible Human Health Risk Implications in Bangladesh. *Toxicology Reports,* 4, 574-579.

Avitech, (2002). Trace Minerals in Poultry Nutrition. Avitech Scientific Bulletin, May, 2002, Avitech Animal Health PVT LTD, Gurgeon, India, 6pp.

Bailey, R. L.; West K. P. and Black, R. E., (2015). The Epidemiology of Global Micronutrient Deficiencies. *Annals of Nutrition and Metabolism*, 66(2), 22–33.

Bolan, N. S., Adriano, D. C. and Mahimairaja, S. (2004). Distribution and bioavailability of trace elements in livestock and poultry manure by-products. *Critical Reviews in Environmental Science and Technology,* 34, 291–338.

Bonham, M.; O'Connor, M. J.; Hannigan, B. M. and Strain, J. J. (2002). The Immune System As A Physiological Indicator Of Marginal Copper Status. *British Journal of Nutrition*, 87, 393–403.

Bost, M.; Houdart, S.; Oberli, N.; Kalouji, E.; Huneau, J-F. and Margaritis, I. (2016). Dietary Copper and Human Health: Current Evidence and Unresolved Issues. *Journal of Trace Elements in Medicine and Biology*, 35, 107-115.

Brown, K. H.; Wuehler, S. E. and Peerson, J. M. (2001). The Importance of Zinc in Human Nutrition and Estimation of the Global Prevalence of Zinc Deficiency. *Food and Nutrition Bulletin*, 22(2), 113-125.

Deng H., Zhang Z., Chang C., Wang Y. (2007). Trace Metal Concentration in Great Tit (*Parus major*) And Greenfinch (*Carduelis sinica*) at The Western Mountains of Beijing, China. *Environmental Pollution*. 148: 620-626.

Deshpande, J. D.; Joshi, M. M. and Giri, P. A. (2013). Zinc: The Trace Element of Major Importance in Human Nutrition and Health. *International Journal of Medical Science and Public Health*, 2, 1-6.

Donia, G. R. (2015). Determination of Some Heavy Elements Residues in some Organs of Migratory Quail in Relation to Public Health. *International Journal of Science and Research*, 4(10), 2048-2059.

Duruibe, J. O.; Ogwuegbu, M. O. and Egwurugwu, J. N. (2007). Heavy Metal Pollution and Human Biotoxic Effects. *International Journal of Physical Sciences*, 2 (5), 112-118.

Ghita, M.; Stanescu, V.; Tudor, L.; Llie, L.I. and Gallis, A. M. (2009). Determination of Heavy Metals Content of Meat and Meat by Products by Using Neutron Activation Analysis and Atomic Absorption Spectrometry. *Scientific Works-University of Agronomical Sciences and Veterinary Medicine, Bucharest Series C., Veterinary Medicine*, 55(3), 140-146.

Hantaweepant, C. and Chithammir, Y. (2016). Anemia and Neutropenia in Copper-Deficient Patients: A Report of Two Cases and Literature Review. *J Med Assoc Thai*, 99(6), 732-736.

Hussain, R. Th.; Ebraheem, M. Kh. And Moker, H. M. (2012). Assessment of Heavy Metals (Cd, Pb and Zn) contents in Liversof Chicken available in the Local Markets of Basrah City, IRAQ. *Bas. J. Vet. Res.*, 11(1), 43-51.

Iwegbue, M. A.; Nwajei, G. E. and Iyoha, E. H. (2008). Heavy Metal Residues of Chicken Meat and Gizzard and Turkey Meat Consumed in Southern Nigeria. *Bulgarian Journal of Veterinary Medicine*, 11(4), 275−280.

Khan, M. Z.; Perween, S.; Gabol, K.; Khan, I. S. and Baig, N. (2015). Concentration of Heavy Metals in Liver, Meat and Blood of Poultry Chicken *Gallus domesticus* in three Selected Cities of Pakistan. *Canadian Journal of Pure and Applied Sciences*, 9(1), 3314-3324.

Lokuruka M., (2012). Role of Zinc in Human Health with Reference to African Elderly. *African Journal of Food, Agriculture, Nutrition and Development*, 12(6), 6646-6664.

Oh, C. and Moon, Y. (2019). Dietary and Sentinel Factors Leading to Hemochromatosis. *Mdpi Nutrients*, 11, 1047; doi:10.3390/nu11051047.

Pekel, A. Y. and Alp, M. (2011). Effects of Different Dietary Copper Sources on Laying Hen Perfomance and Egg Yolk Cholesterol. *The Journal of Applied Poultry Research*, 20(4), 506-513. Prasad, A. S. (2013). Discovery of Human Zinc Deficiency: Its Impact on Human Health and Disease. *Adv. Nutr.*, 4(2), 176-190.

Rehman, H.; 2, Rehman, A.; Ullah, F.; Ullah, N.; Zeb, S.; Iqbal, T.; Rohullah; Azeem, T.; Rehman N. and Farhan, (2013). Comparative Study of Heavy Metals in different Parts of Domestic and Broiler Chickens. *Int. J. Pharm. Sci. Rev. Res.*, 23(2), 151-154.

Rehman, K. Ur.; Andleeb, S. and Mahmood, A. (2012). Assessment of Heavy Metals in Different Tissues of Broilers and Domestic Layers. *Global Veterinaria*, 9(1), 32-37.

Scheers, N. (2013). Regulatory Effects of Cu, Zn, and Ca on Fe Absorption: The Intricate Play between Nutrient Transporters. Nutrients, 5, 957-970.

Skalnaya, M. G. and Skalny, A. V. (2018). Essential Trace Elements in Human Health: A Physician's View. Tomsk State University Publishers, Tomsk, 224pp.

Skrivan, M.; Skrivanova, V. and Maroune, K. (2006). Effect of Various Copper Supplements to Feed of Laying Hens on Cu Content in Eggs, Liver, Excreta, Soil and Herbage. *Arch Environ Contam Toxicol*, 30(2), 280-283.

Soetan, K. O.; Olaiya, C. O. and Oyewole, O. E. (2010). The Importance of Mineral Elements for Human Domestic Animals and Plants: A Review. *African Journal of Food Sciences*, 4(5), 200-222.

Stern, B. R.; Solioz, M.; Krewski, D.; Aggett, Aw. T-C.; Baker, S.; Crump, K.; Dourson, M.; Haber, L.; Hertzberg, R.; Keen, C.; Meek, B.; Rudenko, L.; Schoeny, R.; Slob, W. and Starr, T. (2007). Copper and Human Health: Biochemistry, Genetics and Strategies for Modelling Dose-Response Relationships. *Journal of Toxicology and Environmental Health, Part B.*, 10, 157-222.

Tchounwou, P. B.; Yedjou, C. G.; Patlolla, A. K. and Sutton, D. J. (2012). Heavy Metals Toxicity and the Environment. *EXS*, 101, 133-164.

Yanagisawa, H. (2004). Zinc Deficiency and Clinical Practice. *JMAJ*, 47(8), 359-364.

Zhuang, P.; Zou, B.; Lu H. and Li, Z. (2014). Heavy Metal Concentrations in Five Tissues of Chickens from a Mining Area. *Pol. J. Environ. Stud., 23(6),* 2375-2379.