Bio-accumulation of some heavy metals in bushmeat around Epe, Southwest Nigeria.

Ogungbile, P.O..[1] ✉Ajibare, A.O.,[2] Ekanade C.T.,[1] Akinola, O.M.,[1] Akande, J.A.[3] and M.K.C. Sridhard[4]

[1]*Environmental Management and Toxicology Unit, Lead City University, Ibadan, Nigeria.*
[2]*Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria.*
[3]*Environmental Management and Crop Production Unit, College of Agricultural Engineering and Science, Bowen University, Iwo, Nigeria.*
[4]*Department of Environmental Health Sciences, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.*
✉Corresponding Author: mrajifem@yahoo.com

Accepted on March 02, 2023

Abstract

This study measured the concentration of heavy metals in bushmeat in Epe and its environs in Southwestern Nigeria. Ten bushmeat varieties viz:- Antelope (*Antilope servicapra*), Alligator (*Alligator mississippiensis*), Roan antelope (*Hippotragus equinus*), Grasscutter *(Thryonomys swinderianus*), Hedgehog (*Atelerix albiventris*), Squirrel *(Xerus erythropus*), Bushbuck *(Tragelophus scriptas*), Porcupine (*Atherurus africanus*), Phython (*Python sebae*) and Duicker (*Sylvicapra grimmia*) were sourced from the study area. Concentrations of Iron (Fe), Manganese (Mn), Copper (Cu), Lead (Pb), Cadmium (Cd), Nickel (Ni) and Zinc (Zn) in the meat samples were determined using Atomic Absorption Spectrophotometer and the mean values were used to study their accumulation patterns in the bushmeat. Among all the bushmeat studied heavy metal concentration in Alligator was the highest for Fe (5801.47 mg/kg), Cu (11.03mg/kg and Ni (10.08 mg/kg), Mn level in Alligator was 21.70 mg/kg, while in Grasscutter, Zn was 145.46 mg/kg. These concentrations were compared to FAO/WHO (2011) standards only to find that the amounts of Fe, Cu and Zn exceeded the permissible limits in all the bushmeat samples. Likewise, Ni concentrations in Alligator, Roan antelope and Squirrel exceeded the FAO/ WHO (2011) limits. The mean concentrations of Cd, and Pb in all the bushmeat samples fell below detectable limits, also Ni concentrations in Hedgehog, Squirrel, Bushbuck Porcupine, Python, and Duicker were equally below detection. The bioaccumulation sequence of the heavy metals was similar for Roan antelope and Squirrel where Fe > Zn > Ni > Cu > Mn. Hedgehog, Bushbuck and Python also showed comparable bioaccumulation sequence where Fe > Zn > Mn > Cu. Furthermore, Grasscutter, Porcupine and Duicker exhibited identical bioaccumulation sequence of Fe >Zn > Cu > Mn. Traced bioaccumulation sequence was unique for Antelope (Fe > Zn > Mn > Ni > Cu) and Alligator (Fe > Zn > Mn > Cu > Ni). Of the essential heavy metals required in various quantities by humans, the mean values for Fe, Cu and Zn in the bushmeat samples were above the FAO/WHO (2011) permissible limits. This could signal negative health implications. Also, Cd and Pb often associated with human poisoning were not detected in the bushmeat samples, making the consumption of bushmeat from the study area permissible.

Keywords: Contamination, Bushmeat/Wild animals, Heavy metals, bioaccumulation, Health implications.

Introduction

The term 'bushmeat' is originally an African term for wildlife species that are hunted for human consumption and usually refers specifically to the meat of African wildlife (Costa and Pittia, 2018). The meat of wild animals has formed a part of staple diet of rural/forest and urban dwelling people and remains a primary source of animal protein, micro-nutrients and fat (Kehinde *et al.,* 2020; Soriano and Sanchez–Garcia, 2021). Bushmeat is also important source of income for many families (Cawthorn and Hoffman, 2015; Soewu *et al.*, 2020). Consumers often consider bushmeat as wholesome and safe alternative to commercially produced meat in the market. It is preferred to industrial meats that often contain chemicals and additives (van Vliet *et al.,* 2017). Furthermore, bushmeat plays important roles including cultural and spiritual roles (Chaussen *et al.,* 2019). Bushmeat hunting is a common human practice of seeking, pursuing and capturing or killing animal wildlife. Typical reasons are to harvest food and useful animal products; for recreation and to remove pests that may be dangerous to humans or domestic animals. Wildlife hunting for food is important for the supply of dietary protein for poor people.

The bushmeat liaison group under Convention on Biological Diversity (CBD) defines bushmeat or wild meat hunting as the harvesting of wild animals in the Tropical and Sub-tropical countries for food and for non-food purposes including for medicinal use (van Vliet *et al*, 2017)· The popular animals hunted for are Antelope (*Antilope servicapra*), Alligator (*Alligator mississippiensis*), Roan antelope (*Hippotragus equinus*), Grasscutter *(Thryonomys swinderianus*), Hedgehog (*Atelerix albiventris*), Squirrel *(Xerus erythropus*), Bushbuck *(Tragelophus scriptas*), Porcupine (*Atherurus africanus*), Phython (*Python sebae*) and Duicker (*Sylvicapra grimmia*). Bushmeats can be sources of diseases of public health concerns such as zoonosis and industrial chemical toxicity. There are enough evidences that bushmeat can also be significant source of heavy metals contamination of human food. Hunting practices such as use of guns, and some chemicals as baits in killing wild animals could be a great threat to human life due to the presence of harmful chemicals of heavy metals such as Lead (Pb), Cadmium (Cd), Manganese (Mn), Iron (Fe), Zinc (Zn) and Copper (Cu) (Nkosi *et al.,* 2021).

Heavy metal contamination of the bushmeat can also occur during meat processing (Kenneth *et al.,* 2021). For instance, the use of wood mixed with engine oil or the use of plastics or tyres for burning of the animal hairs could introduce harmful substances into the animal tissues. These assorted materials also contain toxic substances such as heavy metals which can contaminate the meat and render them unfit for human consumption (Adelakun *et al.,* 2020).

Besides, other toxic substances can also be found in the bushmeat as a result of different chemicals like pesticides, herbicides and some contaminated foods being consumed or taken by the animals (Ayodele *et al.,* 2022). There is need therefore, to determine the heavy metal concentrations of some common bushmeats and their suitability for consumption.

The objective of this study was therefore to evaluate the levels of bioaccumulation of some heavy metals (Fe, Mn, Cu, Pb, Cd, Ni and Zn) in the tissues of some bushmeat in Epe in order to know their levels of contamination. Several species of wildlife animals inhabit the forest region of Epe. This encourages hunting of the wildlife animals by the neighbouring communities. This study would therefore guide and help in protecting the people of Epe from consuming contaminated bushmeat.

Materials and Methods

Study Area

The study took place in Epe, Lagos State Nigeria (Figure 1). Epe is located in the tropical humid region that is within the freshwater swamp forest vegetation of Nigeria. The forest communities composed of freshwater swamp along river banks and along the lagoon coast. Epe is located between the latitude 6° 34"59.99" N and longitude 3° 58" 59.99 E. It is about 90 km from Ibadan, Oyo state, Nigeria. According to 2006 population census, Epe has a population of 181, 409 people (Afodu *et al.*, 2016). It lies on the north bank of the coastal Lagos Lagoon. The wet and the dry seasons are partly cloudy. The mean temperature ranges between 22.8°C and 33.3°C. Epe is an agrarian economy depending on activities (such as fishing, hunting, farming among others) as major sources of livelihood. Among the small and medium enterprises in the town are fishing and hunting. Hunting is predominantly done by the young adults who hunt bushmeat for consumption. Daily harvest of animals from the hunting activity is between 1–10 animals/day. It has been reported that hunting may be significantly affected by season with the highest number of catch in the dry season (Afodu *et al.*, 2016). Measures that would ensure sustainable utilization of bushmeat species are therefore needed.

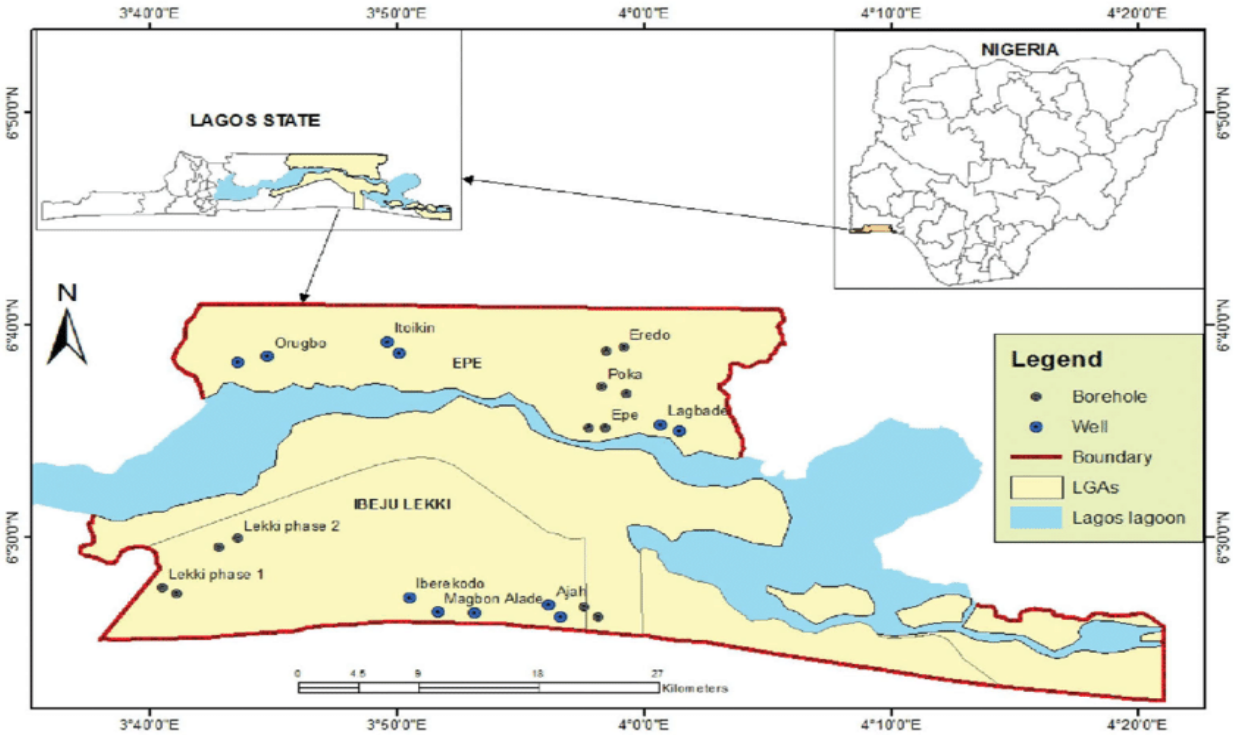

Figure 1: Map of Epe showing the freshwater swamp along river banks and lagoon coast, Lagos State Nigeria.

Collection of bushmeat samples

The samples (Bushmeat) were directly purchased from the vendors from the markets at Epe, Lagos. The common bushmeat were selected from freshly smoked Antelope (*Antilope servicapra*), Alligator (*Alligator mississippiensis*), Roan antelope (*Hippotragus equinus*), Grasscutter *(Thryonomys swinderianus*), Hedgehog (*Atelerix albiventris*), Squirrel *(Xerus erythropus*), Bushbuck *(Tragelophus scriptas*), Porcupine (*Atherurus africanus*), Phython (*Python sebae*) and Duicker (*Sylvicapra grimmia*). Muscles of different edible part of the samples were filleted into sterile plastic bags and transported to the University of Ibadan Central Laboratory for analysis.

Preparation of bushmeat Samples

In the Laboratory, each of the already filleted bushmeat samples was neatly dressed for analysis. They were first oven-dried at 60°C for 48 hour. before pulverising them into fine particles using clean acid washed mortar and pestle, sieved (with 0.8” test sieve) and stored separately in an envelope for digestion.

Digestion of bushmeat samples

One gram (1.0 g) of bushmeat sample was weighed in Teflon beaker and 10 ml of aqua regia HCl. HNO_3(3:1) was added unto it and heated on a thermostat hot plate set between 150°C and 180°C. The content of Teflon beaker was replenished as necessary with more aqua regia to avoid evaporation. After some time when light colour was observed during the digestion, the Teflon beaker with the content was allowed to cool to room temperature and then filtered using Whatman No 1 filter paper. The content was quantitatively transferred into a 25 ml volumetric flask and made up to the mark with double distilled water.

Determination of heavy metals in bushmeat samples

The digest of each bushmeat samples was analysed for Mn, Fe,Cu,Cd, Pb and Ni using Atomic Absorption Spectrophotometer (AAS). The processed samples were transferred to AAS Model 210 for readings.

Test quality assurance

The laboratory glasswares were washed with non- toxic detergents, rinsed with water, soaked in 10% HNO_3 and finally rinsed with distilled water. The mortar was thoroughly washed after grinding exercise and oven dried. During weighing, the reading was tared to zero before subsequent readings. All chemicals used were Analar grade (BDH), England to assess the precision and accuracy of result. Replicate analyses of blanks standard and samples were subsequently carried out.

Statistical analysis

The mean, standard deviation and correlation coefficient for the heavy metals in bushmeat from three replicate measurements were determined using Statistical Package for Social Scientists (SPSS 20.0).

Results

The results of heavy metal concentrations in bushmeat samples from Epe and its environ are presented in Table 1. This Table shows the mean values and FAO/WHO permissible limits for the detected heavy metals. Table 2 reveals the bioaccumulation sequence of the heavy metals in the bushmeat samples, while Table 3, shows the two-tailed correlation coefficient (r) for the heavy metals in the bushmeat samples.

Heavy metals in bushmeat samples

The mean concentration of manganese in bushmeat samples ranged between 1.49 mg/kg and 21.7 mg/kg in Porcupine and Alligator (Table1). The highest value of Mn was recorded in Alligator, while the lowest value was obtained in Porcupine.

Table 1: Mean concentrations of heavy metals in Bushmeat muscles from Epe

	Bushmeat varieties										
Heavy metals	Antelope	Alligator	Roan antelope	Grasscutter	Hodgehug	Squirrel	Bushbuck	Porcupine	Python	Duicker	FAO/WHO limits
Mn	12.8	21.7	3.41	4.27	5.89	3.80	5.00	1.49	4.48	3.08	-
Fe	237.55	5801.47	255.82	269.46	315.00	309.03	155.68	78.66	138.40	128.25	0.01
Cu	5.73	11.03	6.15	5.09	2.72	4.12	3.18	5.27	3.40	4.46	0.5
Zn	70.96	98.52	78.27	145.46	72.32	108.80	63.73	30.43	103.82	46.86	1.0
Cd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.5
Pb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1
Ni	6.82	10.8	6.25	0.00	0.00	4.95	0.00	0.00	0.00	0.00	1.0

The mean concentration of iron in bushmeat samples in mg/kg ranged between 78.66 mg/kg and 5801.47 kg/mg (Table 1). The maximum iron concentrations in the bushmeat was recorded in Alligator and the minimum value was obtained in Porcupine.The mean concentrations of iron in the bushmeat samples recorded were above 0.01mg/kg stipulated level for Fe in meat by FAO/WHO (2011). From the results presented in Table 1, the mean concentration of Copper in bushmeat samples ranges between 3.40 and 11.03 mg/kg.The highest value of Cu concentration was found in Alligator and the lowest value was recorded in Python. The permissible limit as set by FAO/WHO (2011) is 0.5 mg/kg. The mean concentrations of Cu recorded in the bushmeat samples were higher than 0.5 mg/kg stipulated level for Cu by FAO/WHO.

The mean concentrations of zinc in the bushmeat samples from Epe and its environ was between 30.43 mg/kg and 145 mg/kg. The highest mean value of zinc was recorded in Grasscutter and the lowest zinc value was observed in Porcupine. The permissible limits set by FAO/WHO is 1.0 mg/kg. It was observed the concentrations of Zn in all the bushmeat samples were higher than the above stated FAO/WHO limit. From the results presented in Table 1 shows that concentration of Cd is below detectable level. The concentration of lead in the bushmeat samples was below detectable level (Table 1).

Mean concentration of Ni on bushmeat samples ranges between 4.95 mg/kg and 10.8 mg/kg. The highest value of Ni 10.80 mg/kg was recorded in Alligator and the lowest 4.95 mg/kg was observed in Squirrel (Table 1). The permissible limit as set by FAO/WHO heavy metal concentrations for Ni is 1.0 mg/kg. The values of Ni recorded in Alligator 10.8 mg/kg and 4.95 mg/kg were higher than the FAO/WHO recommended limits for meat. Also, Table 2 revealed that sequential levels of accumulation in Bushbuck and Python were similar, likewise Roan antelope and Squirrel also have similar sequence. Bushbuck and Hedgehog also have the same pattern of accumulation from the study (Table 2). The Pearson's correlation co-efficient in table 3 showed the relationship among the heavy metals in all samples. The Table revealed that Fe is directly correlated to Cu ($p>0.01$) and Cu showed significant positive relationship with Ni ($p< 0.05$).

Table 2: Bioaccumulation sequence of the heavy metals in the Bushmeat

Samples	Heavy Metals
Antelope	Fe>Zn>Mn>Ni>Cu
Alligator	Fe>Zn>Mn>Cu>Ni
Roan antelope	Fe>Zn>Ni>Cu>Mn
Grasscutter	Fe> Zn> Cu >Mn
Hedgehog	Fe>Zn>Mn> Cu
Squirrel	Fe>Zn>Ni>Cu>Mn
Bushbuck	Fe>Zn> Mn>Cu
Porcupine	Fe>Zn>Cu>Mn
Python	Fe>Zn> Mn >Cu
Duicker	Fe> Zn> Cu> Mn

Table 3: Correlations analysis for heavy metals in the bushmeat samples

	mg/kg Mn	mg/kg Fe	mg/kg Cu	mg/kg Zn	mg/kg Cd	mg/kg Pb	mg/kg Ni
mg/kg Mn	1						
mg/kg Fe	0.636	1					
mg/kg Cu	0.565	.891**	1				
mg/kg Zn	0.302	0.012	0.043	1			
mg/kg Cd	.a	.a	.a	.a	1		
mg/kg Pb	.a	.a	.a	.a	.a	1	
mg/kg Ni	0.634	0.684	.832*	-0.024	.a	.a	1

**. Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)
.a = Below detectable level

Discussion

Heavy metal concentrations in bushmeat indicated that Fe had the highest mean value in all the samples followed by Zn while Cd and Pb were below the detectable levels. The average concentrations of iron, zinc and copper were above the values recommended by FAO/WHO (2011). Similarly, the mean values of Nickel were above the FAO/WHO (2011) permissible limits in Antelope, Alligator, Roan antelope, and Squirrel. Nickel was below detectable limits in Grasscutter, Hedgehog, Bushbuck, Porcupine, Python and Duicker. The differences in the heavy metals in samples of the bushmeat may be attributed to probable variation in the harvesting locations, the size, age and physiological status of the bushmeat. The high levels of Fe and Zn recorded in this study is similar to the observation by Oladunjoye *et al.* (2015) and Adelakun *et al.*, (2020).

Levels of iron were found to be highest (5801.49 mg/kg) in Alligator samples and were lowest in Duicker 182.25 mg/kg. Iron is regarded as one of the essential elements for humans. Approximately 3000 to 5000 mg of iron exist in the human body. Therefore, as long as the quantity of iron in the environment is not too large, it may not be harmful to humans.

The highest concentration of Zn was found in the meat of Grasscutter while the lowest was found in Porcupine. Linnik and Zubenko (2000) stated that Zn is an essential cofactor element for several enzymatic reactions in human body; hence it is required in the human diet. Zinc deficiency after birth may result to dwarfism, poor appetite and mental lethargy, while excess amount of Zn can cause stomach cramps, nausea, vomiting central nervous system disorder (Orebiyi *et al.,* 2010).

The amount of Cu observed in the various meat samples were above the FAO/WHO limits. The highest value of Cu was recorded in Alligator and the lowest value was observed in Hedgehog. Cu is an essential trace mineral for the human body, involved in several metabolic activities (Hassan *et al.*, 2020). It is needed for the terminal oxidation, the elimination of free medicals, the efficient performance of iron metabolism, the synthesis of hormones, neurotransmitters and the stabilization of the extracellular matrix (Vetlenyi and Raez, 2020).

This study has revealed that Cd and Pb are below detectable levels in all the meat samples collected in the Epe area. This implies that the meat samples were free of carcinogenic risk. Cadmium and Pb are toxic metals that have no known vital or beneficial effect on organisms and its accumulation over time in the bodies of animals and humans can cause serious ailments (Binkowski, 2012). The concentration pattern of heavy metals in bushmeat in the study area revealed Roan antelope and Squirrel had the same pattern of Fe > Zn > Ni > Cu > Mn. Hedgehog, Bushbuck and Python show similar accumulation pattern of Fe > Zn > Mn > Cu. Similarly, Grasscutter, Porcupine and Duicker show a similar pattern of Fe > Zn > Cu > Mn. These patterns of accumulation are similar to documentations ascribed to Oladunjoye *et al.* (2015) and Adelakun *et al.* (2020).

Conclusion

Consumption of bushmeat procured from Epe, Lagos State and its environs may not be harmful to consumers as the observed values of contaminants (heavy metals, toxic and non-essential cations) such as Cd and Pb were below detectable limits of FAO/WHO Standard. A critical analysis of other essential heavy metals such as Fe, Zn and Cu appeared to exceed recommended permissible limits for human consumption. The quantity of Fe, Zn and Cu in the bushmeat was, however, not excessive, and may be tolerable in human diet since the quantity of bushmeat in the diet is low.

References

Adelakun, K.M., Kehinde, A.S., Joshua, D.A., Ibrahim, A.O., and T.G. Akinade (2020). Heavy metals in Bushmeat from New-Bussa and its environs, Nigeria. *J. Appl. Sci. Environ. Manage*. 24(4): 667-671.

Afodu, O.J., Makinde, Y.O., Bello, A.T., Ndubusi-Ogbonna L.C., and O.E. Akintoye (2016). Gender Analysis of Culture Fish Enterprises in Epe Local Area of Lagos State, Nigeria. *International Journal of Sciences: Basic and Applied Research.* (IJSBAR); 26(1): 292-303.

Ayodele E., Akinsanya B., Akeredolu E., Fatsuma O., Amos L. and P.O. Isibor (2022). Impacts of trace metals on Roan Antelope, *Hippotragus equines* and its Endoparasites *Trongyloides* spp, sampled in the tropical rainforests of Odo Onakekere, Ibadan, Oyo State Nigeria *Scientific African* 16:1-13.

Binkowski N.N. (2012). Preliminary results of cadmium and lead concentration in pectoral muscles of mallards and coots shot in 2006 in Southern Poland. *J. Microbiol. Biotech. Food Sci.* 1:1120-1128.

Cawthorn D.M. and L.C. Hoffman (2015). The bushmeat and food security nexus; A global account of the contributions, conundrums and ethical collisions. *Food Research International* 76(4): 906-925.

Chaussen, A.M., Rowcliffe, J.M., Escouflaire L., Wieland M. and J.H. Wright (2019). Understanding the Sociocultural Drivers of Urban Bushmeat Consumption for Behaviour change Interventions in Pointe Noire, Republic of Congo *Human Ecology* 47: 179-191.

FAO/WHO (2011). Working document for information use in discussion related to contaminants toxins in the GSCTFF. In: Joint FAO/WHO Food Standards Programme Codex Committee in Foods 1-90. Available from ftp://ftp.fao.org/codex/meetings/cccf/cccf5/cf05 INF.pdf.

Hassan S., Hassan F. and M.S. Rehman (2020). Nano-particles of Trace Minerals in Poultry Nutrition: Potential Applications and future Prospects. *Biol. Trace Elements Research.* 195(2): 591-612.

Kehinde, A.S, Adelakun, K.M., Halidu, S.K., Bobadoye, A.O., Babatunde, T.O. and B.O. Fadimu (2020). Nutrient Qualities of selected Bushmeat in New Bussa and its Environs, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 13(5): 579-587.

Kenneth I.K., Yunusa H.G., Zirintunda K.F., Farag M.A., Altalbawy, J.E., Andrew T., Kevin M., Fred S., Robert M., Francis K., Theophilus P., Hellen K., Paul B. and M. Henry (2021). Descriptive Analysis of Heavy Metals content of Beef from Eastern Uganda and their safety for Public Consumption. *Frontiers in Nutrition*. 8; 1-10.

Linnik, P.M. and Zubenko, I.B. (2000) Role of Bottom Sediments in the Secondary Pollution of Aquatic Environments by Heavy-Metal Compounds. *Lakes Reservoirs and Resources Management,* 5, 11-21. https://doi.org/10.1046/j.1440-1770.2000.00094.x

Nkosi, D.V., Bekker, J.L. and L.C. Hoffman (2021). Toxic Metals in Wild Ungulates and Domestic Meat Animals Slaughtered for Food Purposes: A Systemic Review. *Foods* 10(11) doi 3390/foods 10112853.

Oladunjoye, R.Y., Asiru, R.A. and D.A. Shokoya (2015). Heavy metals (Cd, Pb, Cu, Fe, Cr, Mn, Zn) contents in ungulates of Ogun State Agricultural Farm Settlement, Ago-Iwoye, Nigeria. *J. Biol. Life Sci.* 6(2): 119-129.

Orebiyi, E.O.; Awomeso, J.A., Idowu, O.A., Martins, O., and A.M. Taiwo (2010). Assessment of Pollution Hazards of Shallow well in Abeokuta and Environs, South West, Nigeria. *American J. Environ. Sci.* 6(1): 50-56.

Siren A. (2012). Festival hunting by the kickwa people in the Ecuadorion amazon. *Journal of Ethnobiology* 32(1): 30-50.

Soewu, D., Ingram, D.J. Jansen, R., Sodeinde O. and D.W. Pietersen (2020). Chapter 15 – Bushmeat and Beyod: historic and contemporary use in Africa. Science, Society and conservation. Biodiversity of World, Conservation from genes to Landscapes Academic Press pp. 241-258.

Soriano, A. and C. Sanchez–Garcia (2021). Nutritional Composition of Game Meat from Wild Species Harvested in Europe *Meat and Nutrition* Doi 10. 5772/int.echopen 97363.

Vetlenyi, E. and G. Raez (2020). The physiological function of copper, the etiology role of copper and deficiency. *O.V. Hetil.* 161(35): 1488-1496.