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Proximate Composition and Concentrations of Some Essential Heavy Metals in Liver, Kidney and Tissue Muscle of Cow, Ram, and Goat in Lokoja, Kogi State, Nigeria

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ABSTRACT: Nutritional qualities of consumer foods particularly, meat is of great importance in improving health of an individual. Hence, the objective of this study was to determine the proximate composition and concentrations of some essential heavy metals (Co, Se and B) in the liver, kidney and tissue muscle of cow, ram, and goat in Lokoja, Kogi State. Proximate analysis was done according to AOAC procedure. After sampling, the tissues were prepared for metal analysis by acid digestion method and read by inductively coupled plasma mass spectrometry. The result showed that moisture content ranged from 70.1% to 74.8%, ash content ranged from 1.1% to 3.8%, protein content 16.2 to 19.9%, fat content 4.7 to 8.8%, organic matter ranged from 96.2% to 99.1%, carbohydrate contents ranged from 0.2% to 0.9%, and dry matter content 25.5% to 29.8 %. Selenium ranged from 5.2 to 6.0 mg/kg, boron ranged from 0.1 to 0.3 mg/kg, and cobalt ranged from 1.5 to 6.0 mg/kg. The mean concentration of selenium and cobalt unlike boron exceeded permitted recommended level. Excessive level of essential elements can pose a threat to human health. Therefore, regular consumption of offal from the studied animals consumed in Lokoja may poses a health risk with respect to Se and Co. Sources of Se and Co need to be investigated to safeguard consumers from possible exposure to health hazards.

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Meat is rated highly among the most significant, nutritious, and preferred food items available to the masses. In human development history, meat has always played a significant role in human nutrition as part of a well-balanced diet (Cabrera and Saadoun, 2014). Meat is composed of mainly proteins, fat, and a lot of essential elements such as, zinc, iron, selenium, and phosphorus including important vitamins like vitamin A and B-complex (Cabrera and Saadoun, 2014). Meat is essential for body building and maintenance of good health. In the last few decades, there have been a drastic demand for meat and dairy products globally. This could be attributed to factors such as increasing world population, rising life expectancy, and increase in people's income, especially in the developing world (Salter, 2017). Offal refers to those edible organs and entrails inside an animal such as the brain, the heart, liver, gizzard, lungs, intestine, and kidney usually eaten as food (Mariam *et al*., 2004). Research have shown that they contain significant quantity of all the important nutrients required for growth and development of the human being, comprising protein, vitamins, macro and trace elements (Florek *et al*., 2012). Worldwide, different cultures include livestock offal in their diet either as a delicacy or for their nutritive value (Mwirigi and Waweru, 2011; Tomovic *et al*., 2015). The quality features of meat and the amount of nutrients it contains is determined by several factors. These include the breed of the animal, feeds (grains, pasture, grass, and

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water), genetic makeup of the livestock, and preparation techniques during and after slaughter (Ahmad *et al*., 2018, Mwangi *et al.*, 2019). In Nigeria where livestock are reared mainly on natural pastures and weeds that grow wildly, shortage of grazing land due to population growth coupled with farmers and herdsmen conflicts have resulted in suboptimal feeding of livestock (Dimelu *et al.*,2017). The productivity of ruminant livestock is considered low due to inadequate quantity and poor-quality feed. Present-day ruminant feeding in a developing country like Nigeria is partly targeted at searching for cheap readily available feed resources, which can partly or completely replace the scarce and expensive feed stuffs and inadequate forages (Okoruwa and Omoragbon, 2017). Summarily, pollution and poor diet for live stocks negatively impact the nutritional quality of meat (Mwangi *et al*., 2019; Sebezhko *et al*., 2017). Even though most of these animals consumed in Lokoja are deemed suitable for human consumption, our knowledge of their nutritive value is fragmentary. This study will provide comparative information to the consumer about mineral contents of kidney, liver, and meat of goat, ram, and cow. The information obtained will guide consumers on the choice of meat to take between cow, goat, and ram. Therefore, the objective of this study was to determine the proximate composition and concentrations of some essential heavy metals (Co, Se and B) in the liver, kidney and tissue muscle of cow, ram, and goat in Lokoja, Kogi State, Nigeria.

MATERIALS AND METHODS

Description of Study area: The study area is Lokoja the Kogi State Capital, located at the confluence of River Niger and River Benue. Lokoja is situated between latitude 7° 45' 27.56" - 7° 51' 04.34" N and longitude 6°41' 55.64" - 6°45' 36.58" E of the equator. It has total land coverage of about 63.82 sq. km. The built-up area of Lokoja is situated in the eastern part of River Niger, whereas, in the western part of the city is Mount Patti. The increase in population growth in the town over the years has resulted in an acute shortage of decent accommodation for inhabitants and a high cost of living in the city. The increase has also led to increase in demand for meat products. Hence more animals such as cattle, sheep, and goats are slaughtered on daily basis for consumers. Some of these are brought in from different places within and outside Kogi State. Lokoja has six major areas namely, Felele, Adankolo, Lokongoma, Ganaja, Otokiti, and Sarkin Noma. A study by Alabi, M. O. (2009) of the spatial patterns of the urban sprawl of Lokoja identified three areas outside the core city area with significant sprawl to be Felele, Adankolo, and Lokongoma. Of these three, Felele with a population density of 66923.96 in 2007 has the highest sprawl. The abattoir located in Felele on latitude N7º51'643932" and longitude E6º43'4839168" was selected for this study.

Sample Collection: The samples were collected within a duration of six weeks commencing from 24th of June to 5th of August 2021. The whole kidney, liver, and 100g each of meat samples of fresh meat tissue of cattle, sheep, and goats respectively were procured using convenience sampling. The meat samples were taken from one animal stock. The samples were packed in Ziplock bags and labeled appropriately. The zip lock bags containing the samples were properly placed in a cooler [GeostyleTM] containing ice packs and then transported to the laboratory for analysis.

Sample Preparation: At the laboratory, each of the sample was washed with distilled deionized water. Each portion was sliced with a stainless-steel knife and spread out in the laboratory to dry at ambient temperature except the portion used for moisture content. Dry samples were ground and sieve using a < 2mm mesh and kept in labelled polyethylene prior to analysis.

Proximate analysis: Determination of moisture content, ash, crude protein, crude lipid, crude fiber, and nitrogen-free extracts was performed according to the methods described by the AOAC (2016).

Determination of moisture content: Moisture content is determined through a thermogravimetric approach; that is by loss on drying (Sun *et al*., 2020). Here, the sample is heated and the weight loss due to evaporation of moisture is recorded. The weight loss due to moisture was calculated using the formula:

$$Moisture\ (\%) = \frac{(w_1 - w_2)}{(w_1 - w_0)} \times 100 \qquad (1)$$

Where: Wo= Weight of the empty crucible; W1= weight of the powder sample + empty crucible; W2= weight of dried sample + empty crucible

Determination of ash: Percentage ash was calculated according to equation 2:

$$\text{Ash}\ (\%) = \frac{w2 - w0}{w1 - w0} x100 \qquad (2)$$

Where: Wo = weight of the empty crucible; W_1 = weight of crucible + powdered sample

Determination of crude protein: Kjeldahl Method was used to determine protein content - based on the standard procedure in AOAC Official Method 973.48 (AOAC 2016).

$$\text{Nitrogen content (\%)} = \frac{(t-b) x\ 0.2\ x\ 14}{1000\ x\ W(sample)} x100 \quad \ldots (3)$$

Where: t = titration volume for sample (mL), b = titration volume for blank (mL), 0.2 = normality of titrant, HCl (mol/l) (Sigma-Aldrich Munich, Germany), 14 = atomic mass of nitrogen, Wsample = weight of sample taken (g).

Determination of crude lipid: For crude lipid, the Soxhlet extraction method, recognized by the Association of Official Analytical Chemists (AOAC) as the standard method for crude fat analysis was employed. The determination of the crude fat content involves the extraction of the fat from the sample using an appropriate solvent, then measuring the weight of the fat recovered (Astrup *et al*., 2020).

$$Crude\ lipid\ (\%) = \frac{w1-w2}{w0} x100 \quad (4)$$

Where: Wo= weight of the sample; W1= weight of flask + oil; W2= weight of the flask

Determination of crude fiber: Crude fiber was determined by treating a sample with ether to remove fats, then boiling it alternately in a weak acid and a weak alkali (McCleary *et al*., 2019).

$$Crude\ fibre\ (\%) = \frac{w1-w2}{w0} x100 \quad (5)$$

Where: W0 = weight of the sample; W1 =weight of the dried sample; W2 =weight of ash sample

Determination of Nitrogen-Free Extracts (NFE): Nitrogen-Free Extracts (NFE) was determined by mathematical calculation. It was obtained by subtracting the sum of percentages of all the nutrients already determined from 100 (McClement et al**.,** 2021)

% NFE = % DM – OM

Where: NFE = nitrogen-free extract; DM = dry matter; Here OM = (% EE + % CP + % ash + % CF); EE = ether extract or crude lipid; CP = crude protein; CF = crude fiber

Determination of mineral elements: The digestion of the samples was done by accurately weighing 0.5g of each sample into a 100ml PTFE beaker. To the sample, 5ml of 65% HNO_3 was added, and then the mixture was boiled gently for 30 – 45min. After cooling, 2.5ml of 70 % $HClO_4$ was added, and the mixture was gently boiled until dense white fumes appeared. Later, the mixture was allowed to cool, and 10 ml of deionized water was added followed by further boiling until the fumes were totally released (Hseu 2004). Heavy metal concentrations in digests were determined using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Lehel et al., 2016).

Quality assurance: Appropriate safety measures and quality control methods were used to verify the accuracy and veracity of the results acquired. Adequate precaution was used when handling samples to prevent cross-contamination. All the used glassware was thoroughly cleaned. All phases of sample preservation, preparation, and metal analysis was conducted using double distilled water and analytical grade reagents. A blank and combined standards was run with each batch of samples to detect background contamination and to check consistency across batches to assess the reliability of the analytical method used for metal determination. The analysis's findings were verified by digesting and examining common reference materials using the same process. To establish with confidence, the accuracy of the approach, the certified reference values and the metals' analyzed values was compared.

RESULTS AND DISCUSSION

The mean values ± standard deviation of moisture content, ash content, protein, fat, organic matter, carbohydrate, and dry matter percentage measurements of the kidney, liver, and muscle tissue from cow, goat, and ram are given in Table 1. Results of analysis of variance (ANOVA) show significant variation at $p < 0.05$ in the proximate composition parameters of the various internal organs of the animals. The analysis revealed that moisture content ranged from 70.1% - 74.8%, the highest value obtained was in goat kidney (74.8±0.6%) and least value in cow muscle tissue (70.1±5.1 %). The differences among the various internal organs studied were statistically significant at $p < 0.05$. The percentage of ash contents of the internal organs of the various livestock were not significantly different from one another ($p > 0.05$). The values ranged from 1.1% to 3.8%. The highest value of 3.8±4.3% was found in cow muscle tissue whereas, ram muscle tissue has the least (1.1±0.3%). Protein content is highest in goat liver (19.9±0.4%) and lowest in goat kidney at 16.2±0.4% ($p < 0.05$). Ram muscle tissue (8.8±0.6%) contains the highest fat content among the various samples and cow liver has the least (4.7±1.6 %). The value for the measurement of organic matter ranged between 96.2% - 99.1% with the highest value in ram muscle tissue (99.1±0.5%) and least value in cow muscle tissue (96.2±4.3%). The percentage carbohydrate contents of the internal organs of the various livestock vary from one another and the variation is statistically significant ($p < 0.05$). The values ranged from 0.2% to 0.9%. The highest value of 0.9±0.5 % was found in ram liver whereas, goat liver has the least (0.2±0.1 %). Dry matter content is highest in cow muscle tissue (29.8±5.2 %) and lowest in goat kidneys at 25.5±1.4 % (p = 0.007).

Table 1: Proximate composition of internal organs and muscle tissue of selected livestock

Parameter	Offal	Cow		Goat		Ram	
		Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Moisture content	Kidney	74.8±1.4	73.0-76.1	74.8±0.6	73.8-75.4	73.3±1.1	71.3-74.1
	Liver	74.1±1.2	72.1-75.4	72.2±1.8	70.3-74.3	71.9±1.9	70.1-74.1
	Muscle tissues	70.1±5.1	63.6-73.9	70.5±0.6	70.0-71.1	71.2±0.7	70.1-71.9
% Ash	Kidney	1.2±0.3	0.9-1.7	1.3±0.2	1.2-1.7	1.3±0.2	1.2-1.6
	Liver	1.3±0.3	0.9-1.7	1.6±0.1	1.5-1.6	1.4±0.2	1.0-1.7
	Muscle tissues	3.8±4.3	0.9-9.3	1.4±0.4	0.9-1.8	1.1±0.3	0.9-1.7
% Protein	Kidney	16.4±0.5	16.0-17.1	16.2±0.4	16.0-17.0	17.1±1.1	16.0-19.0
	Liver	19.7±0.8	18.0-20.0	19.9±0.4	19.1-20.2	19.4±0.8	18.1-20.1
	Muscle tissues	18.2±1.2	16.9-19.3	19.3±0.7	18.4-20.1	18.7±0.6	18.0-19.3
% Fat	Kidney	7.4±0.5	7.0-8.0	7.3±0.4	7.0-8.0	7.8±0.4	7.0-8.1
	Liver	4.7±1.6	4.0-8.1	6.4±1.9	4.0-8.1	6.4±1.9	4.0-8.1
	Muscle tissues	7.5±0.4	7.0-8.1	8.2±0.5	7.9-9.3	8.8±0.6	8.0-9.2
Organic matter	Kidney	98.8±0.3	98.3-99.1	98.6±0.3	98.1-98.8	98.6±0.2	98.4-98.8
	Liver	98.6±0.4	98.1-99.1	98.4±0.1	98.4-98.5	98.6±0.2	98.4-99.0
	Muscle tissues	96.2±4.3	90.7-99.1	98.7±0.4	98.2-99.1	99.1±0.5	98.3-99.8
Carbohydrate	Kidney	0.2±0.3	0.01-0.6	0.4±0.04	0.3-0.4	0.5±0.4	0.02-0.9
	Liver	0.6±0.5	0.01-0.9	0.2±0.1	0.1-0.2	0.9±0.5	0.4-1.5
	Muscle tissues	0.3±0.2	0.03-0.5	0.6±0.3	0.2-0.8	0.3±0.3	0.1-0.6
Dry matter	Kidney	25.9±2.2	23.9-29.1	25.5±1.4	24.6-28.2	26.7±1.6	25.0-29.7
	Liver	26.2±0.9	25.3-27.9	27.6±1.9	25.1-29.7	28.2±1.9	25.9-30.0
	Muscle tissues	29.8±5.2	26.1-36.5	29.5±0.5	29.0-30.0	29.0±1.2	28.1-31.3

Essential metals concentrations in meat and offal of livestock: The mean values of the heavy metals (HMs) – boron (B), cobalt (Co), and selenium (Se) concentrations in the kidney, liver and muscle tissue from cow, ram and goat studied are given in Figures 1-3. The concentrations of cobalt ranged from 1.5±0.7 to 6.0±1.4 mg/kg, Selenium ranged from 5.2±0.3 to 6.0±0.3 mg/kg while Boron range from 0.1±0.03 to 0.3±0.3. Figure 1 shows that the concentrations of selenium among all the internal organs studied occurred in the following order cow kidney (6.0±0.3) followed by the ram liver (5.8±0.2) and least in the ram kidney (5.2±0.3). The muscle tissue (0.3±0.3) of the goat contains the highest concentration of boron among all the internal organs studied while the goat liver (0.1±0.3) has the lowest (Figure 2). It was noticed that the quantity of boron in muscle tissues of all livestock studied is higher than their respective internal organs. Cobalt was observed to have the highest mean concentration in goat kidneys (6.0±0.4) and lowest in goat muscle tissue (1.5±0.7) (Figure 3). Cow muscle tissue (4.9±1.3), cow liver (4.5±1.9), and cow kidney (3.2±2.4) all contain a substantial amount of cobalt. The goat kidney was observed to have the highest mean percentage of moisture content followed by the cow kidney and the cow muscle tissue was the lowest. These values are higher than that obtained by Bristone et al., (2018) in goat kidneys and cow kidneys which were 21.71% and 38.95% respectively. Also, the result demonstrates that the kidneys have more moisture content when compared with other tissues, irrespective of the animal species.

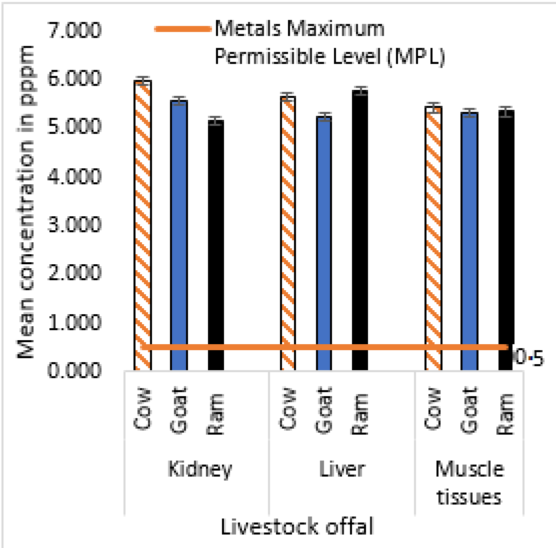

Fig 1: Mean concentration of selenium in the offal of animals

The quantity of moisture in a food material affects its texture, shelf life, and ease of processing (Ma et al., 2020). This result indicates that goat kidneys and cow kidneys are prone to quick spoilage, as they are vulnerable to an increase in the rate of microbial growth. Cow muscle tissues contain the highest mean percentage of ash content followed by goat liver and the lowest in ram muscle tissues. This value agrees with that obtained by Bristone et al. (2018) for goat liver. Besides the cow muscle tissue, the ash content in all the samples studied is within the same range of 1.1±0.3% to 3.8±0.3%. Ash content is an important quality attribute for food, as it represents the total mineral content in foods. This correlates with the values of dry matter observed in cow muscle tissue in the studied sample. This shows that cow muscle tissue contains the richest mineral content. The maximum protein concentration was found in goat liver, followed by cow liver, and ram liver. The lowest concentration of protein was found in goat kidney compared to all the tissues studied.

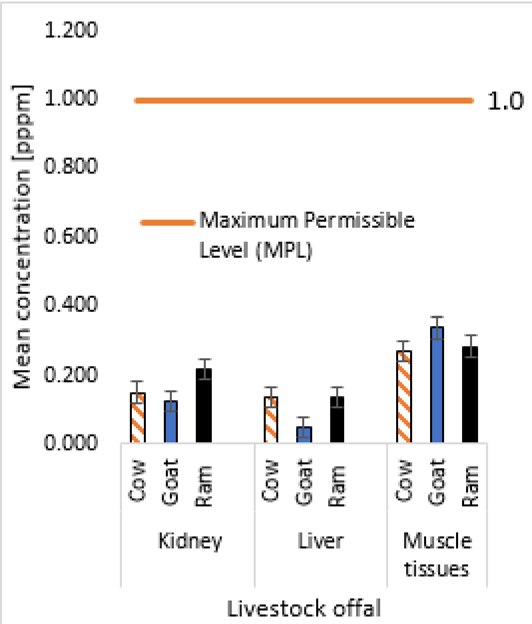

Fig 2: Mean concentration of boron in the offal of animals.

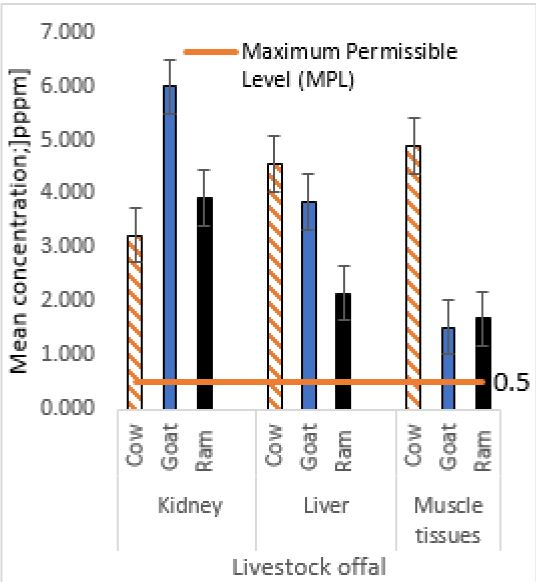

Fig 3: Mean concentration of cobalt in the offal of animals.

A crucial requirement for muscle protein synthesis, maintaining skeletal muscle mass, and maintaining physical function is an adequate protein intake (Grasso et al., 2021). Researchers suggest that high protein consumption could cause or aggravate chronic kidney disease (Ko et al., 2017) while protein deficiency has been implicated in various health disorders such as Kwashiorkor, marasmus, impaired mental health, edema, organ failure, wasting and shrinkage of muscle tissues, and weakness of immune system (Khan et al., 2017). There is a need therefore to balance the intake of protein. This study result is comparable to that of Bristone et al., (2018) except for goat kidney. The author reported the protein composition of the cow's liver to be 20.81%, the goat liver 18.54%, the goat kidney 20.38%, and the sheep liver 18.19%. The study shows that the liver is a higher source of protein followed by the tissue muscle than the kidney. This observation is noticeable in all three species of animal studied. The highest percentage of fat was observed in ram muscle tissue followed by goat muscle tissue and the lowest in cow liver. These results are lower than those reported by Bristone et al., (2018) where crude fat content ranged from 2.13 to 9.09. Fat is a major source of energy and provides essential lipid nutrients. Over-consumption of certain fat components such as cholesterol and saturated fats has been associated with health conditions such as atherosclerosis**.** In many foods, the lipid component plays a major role in determining the overall physical characteristics, such as flavor, texture, mouth feel, and appearance. The data suggests that crude fat content is higher in the muscle tissues of the livestock compared to the selected internal organs. This suggests that muscle tissues are particularly susceptible to lipid oxidation, which can lead to the formation of undesirable off-flavors and aromas, as well as potentially toxic compounds in line with the observations (Amaral et al., 2018). Similarly, the consumption of muscle tissue of the studied animals could pose a serious health challenge. Ram muscle tissue was observed to have the highest mean percentage of organic matter (99.1±0.5) followed by cow kidney (98.8±0.3) and the lowest in cow muscle tissues (96.2±4.3). Organic matter in meat represents complex compounds of carbon(C), hydrogen (O) and oxygen such as carbohydrates, lipids, proteins, and nucleic acids. The result shows that the carcass of the livestock studied are of high nutritive quality and will be suitable to be used in the production of manure. The highest amount of carbohydrates was found in ram liver (0.9±0.5) followed by goat muscle tissue (0.6±0.3) and the lowest in goat liver (0.2±0.1). However, recent studies by Bristone et al. (2018) show a wide variation in the findings. The study found carbohydrate content to be between 38.81and 65.82 in the offal of goat, cow and sheep reared in Maiduguri, Bornu State of Nigeria. However, the result of this study agrees with the observation of Kanungo et al. (2018) and Wang et al. (2020) that the liver is the principal storage organ for carbohydrates as glycogen except for the goat liver which has the lowest quantity. The low carbohydrate in the goat liver along with relatively high carbohydrates in the kidney suggests a disorder in the goat studied. Carbohydrates serve as energy sources and as essential structural components in living things. Cow muscle tissue was observed to have the highest mean percentage of dry matter followed by goat muscle tissue and the lowest in goat kidney. These findings are in close agreement with those reported by Rahman et al. (2020) in a study to determine the quality attributes of beef which ranged from 21.22 to 28.98 and 29.17 -31.56 obtained by Lamanov et al. (2020). Dry matter is what remains after all the water is evaporated out of food material, and it contains all the nutrients in the food material. Its determination provides a measure of the amount of a particular food material that is required to supply a set amount of nutrients. Selenium (Se) is an essential element that plays a significant role in human health. Se plays a role in the functioning of cellular immunity and humoral immunity however, its deficiency has been associated with cardiovascular diseases, infertility, muscle degenerative diseases, and retardation in cognitive activities (Shreenath et al., 2022). Supplementation with Se must be done with caution and in a controlled manner to prevent serious impacts that are the opposite of the anticipated effect, since the difference between the required quantity and the toxic dose is very small (Gouveia et al., 2020). Excess dietary Se commonly causes food poisoning complications such as diarrhea, nausea, and vomiting (Kieliszek et al., 2022). The highest mean concentrations of selenium among all the internal organs studied occurred in the cow kidney followed by the ram liver and least in the ram kidney (Figure 1). Selenium was observed to be high in all the samples studied. The concentrations of Se reported in this study were higher than the values found in the liver, kidney, and flesh of cattle from Sivas-Turkey which is 4.38 mg/kg in cow kidney, 1.38 mg/kg in cow liver, and 0.60 mg/kg in muscle tissue (Oymak et al., 2017). Selenium was detected in an amount above the MPL (0.5) in all the internal organs as set by various regulatory bodies. Boron (B) is an important micronutrient with well-established biological functions in plants and essential for human and animal health. At low doses, boron has a wide range of physiological impacts on biological systems; nevertheless, at excessive quantities, boron is poisonous (Uluisik *et al.,* 2018)**.** It enhances bone density, wound healing, and embryonic development and has a potential impact on the metabolism of numerous minerals and enzymes. Boron deficiency has been associated with decreased immunity and an increased rate of osteoporosis. Extraordinary boron levels cause cell damage and toxicity in human and different animal species (Abdelnour *et al.,* 2018). The muscle tissue of the goat contains the highest concentration of boron among all the internal organs studied, while the goat liver has the lowest (Figure 2). This study shows that boron accumulates primarily in the muscle tissues and not in the internal organs. The presence of boron could be a result of the ingestion of contaminated drinking water (Lin *et al.,* 2021). However, in this study boron concentration is within the acceptable limit as such, poses no danger through consumption of the meat tissues from these animals. Cobalt (Co) is a trace element essential for the formation of vitamin B12 which is required for the development and function of various tissues and organs, including the brain, nerves and is a component of two enzymatic systems involved in the metabolism of carbohydrates, lipids, some amino acids, and DNA (González-Montaña et al., 2020). Emerging evidence indicates that cobalt toxicity can result in visual changes, peripheral neuropathy, hearing loss, and hypothyroidism, and induce respiratory tumors locally (Lison et al., 2018)**.** It has been reported that chronic Co exposure is associated with kidney disease, osteoporosis, cardiovascular diseases, and cancer (Fatima et al., 2019). Co was observed to have the highest mean concentration in goat kidneys and lowest in goat muscle tissue (Figure 3). Cow muscle tissue, cow liver, and cow kidneys all contain substantial amounts of cobalt. The high concentration of Co observed in all the internal organs of the selected livestock studied indicates that the soil and forages where the livestock was reared are rich in cobalt (Khan *et al.,* 2020; Walker *et al.,* 2022). The concentrations of Co reported in this study were higher than the values found in the liver, kidney, and flesh of cattle, sheep, and goats from Anka and Bukkuyum in Zamfara, Nigeria which ranged from 0.00 to 2.71 $\mu g \cdot g^{-1}$ (Birnin-Yauri *et al.,* 2018) and 0.030 ± 0.003 mg/ kg in the kidneys of sheep found in Calabar, Cross River State (Birnin-Yauri *et al.,* 2018). Cobalt was detected in an amount above the MPL (0.5) in all the internal organs as set by various regulatory bodies. The findings showed that Co was present as an environmental pollutant in the area that was being studied.

Conclusion: The study outcome demonstrates that internal organs (kidney, liver) and muscle tissues of cow, goat, and ram sold within the Lokoja metropolis have significant nutritional value. This food material is an important proportion of a balanced diet required for the growth and building of body tissues. However, due to the high-fat content of meat, there is a need to be concerned about the consumption of meat. Furthermore, the meat from the livestock studied poses a significant health risk to its consumers due to the high content of toxic heavy metals.

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