Comparative Analysis of Mineral and Proximate Compositions of Two Major Meats Sold in Makurdi, Benue State, Nigeria

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ABSTRACT

This study was carried out on the comparative analysis of minerals and proximate composition of goat meat and pork meat purchased from Wurukum market, Makurdi, Benue State. The samples were carefully trimmed, oven dried and then pounded to powdery form. The proximate parameters were determined using standard method as described by AOAC, whereas the minerals were determined using atomic absorption spectrophotometer (AAS). The results for proximate analysis revealed that the moisture content of pork meat and goat meat were 11.18% and 9.80%; crude protein, 26.38% and 34.24%; crude fat, 14.80% and 10.20%; crude fibre, 6.19% and 7.60%; and ash content, 6.09% and 7.40% respectively. The results of mineral analysis revealed the composition of calcium in pork meat and goat meat to be 14.67 and 12.67 mg/kg; copper, 0.16 and 0.13 mg/kg; magnesium, 1.26 and 1.53 mg/kg; iron, 1.35 and 2.08 mg/kg; zinc, 0.08 and 0.09 mg/kg respectively. Goat meat showed a higher crude protein content (34.24%) compared to pork (26.38%). Pork meat, however, contained more fat (14.80%) than goat (10.20%), giving it a richer flavor and higher caloric density, suitable for those needing increased energy intake

Keywords; Atomic absorption spectrophotometer, goat meat, pork meat, minerals, proximate composition

INTRODUCTION

Meat is an excellent source of protein and several vital elements of high biologic value, as well as lipids rich in vitamin B_{12} and linoleic acid [1, 2]. Non-pristine protein food, such as meat obtained from the poultry and livestock sectors, are very important for human diets in many parts of the world because they provide essential trace elements, vitamins, minerals, amino acids, and a rich amount of dietary proteins for safe human health [1]. Twenty different amino acids serve as the building blocks of proteins. Human body can synthesize ten of these amino acids in sufficient quantity, but the other ten called essential amino acids, must be obtained from human diet. The essential amino acids are isoleucine, leucine, methionine, phenylalanine, threonine, tryptophan, valine, arginine, histidine, and lysine. These amino acids are obtained from digesting foods containing proteins. Complete proteins which are protein that contains all ten essential amino acids are very important as they provide the body with all of the building block that the body needs. Examples of complete proteins include meat, fish, milk, and eggs. [2]. Generally, meat is a suitable carrier of several essential micro nutrients, such as Fe, Se, folic acid and vitamins in an easily absorbable form. The intake of meat can be an excellent approach to addressing the optimum necessities of these micronutrients [2]. The optimal intake of elements such as se, Zn, ca, Cu, Fe, and Mn is critical since they are necessary for the effective performance of nearly all enzymatic and biochemical activities in the human body. Meat intake ensures adequate distribution of essential amino acids and micronutrients.

Minerals are chemical elements required as an essential micronutrient by organisms (livestock and humans) to maintain sound health throughout life. [3; 4]. Minerals are needed for the regulation of cellular function, growth, mechanisms of neuromodulation and other biochemical and physiological functions in the body therefore, the lack of essential minerals in the human diet can cause metabolic disorders, organ damage, chronic diseases and ultimately death [3]. at least twenty mineral elements are needed to support human biochemical processes by serving structural and functional roles as well as electrolytes [5]. Some of these elements such as Ca, P, K are required in large amounts, while others, like Fe, Zn, Cu, I and Se, are required in trace amounts because higher concentrations can be harmful [6]. Minerals such as iron and zinc are low in plant based diets (cereal, legume and tuber) and can only be provided through consumption of muscle foods such as beef, pork, chicken etc. to meet the daily recommended level for a healthy life. [6] indicated that the daily intake of about 50 g of either meat, poultry, or fish in a staple-based diet will increase the total iron content as well as the amount of bio-available iron in the body. Red meat such as beef, pork and goat meat is an important source of minerals (mainly Fe, Zn and Mn) in the human diet, as it provides highly bioavailable elements required for normal development and health [6].

Generally proximate composition refers of the major components of a food sample such as moisture, protein, fat, carbohybrate and ash [7]. These component are often referred to as the "proximate principles" of a food and their analysis which is carried out using a fundamental technique used by chemist and scientist in various fields characterize the composition of various food product including meats, milk, vegetable, fruits and grains.

The aim of this study is to conduct a comparative analysis of the mineral and proximate composition of pork meat and goat meat sold in Makurdi, Benue State, Nigeria, in order to provide insight into their nutritional profiles.

Study Area

Makurdi town is located at latitude 7°47′ and 10° 00 North and Longitude 6° 25' and 8° 8' East of the Equator. It is bounded by Guma Local Government Area to the North, Gwer Local Government to the South, Gwer-West Local Government to the South-West and Doma Local Government Area of Nassarawa State to North-west.

It is situated in the Benue valley on the bank of river Benue. The town is located on the north-south transportation network by road and by rail, between Nassarawa and Enugu State with the total land area of about 810 square kilometers [8]. Makurdi has been in existence since 1912. In 1976 following the creation of Benue State out of the Benue plateau, Makurdi doubles as the State capital as well as the headquarter of Makurdi Local Government Area.

Makurdi has a population of 226,198 a density of 323 persons per square kilometer as of 1991.

the national population census data [8] figure has a population of 300,377 with a density of over 400 people per square kilometer as of the 2006 National population census data figures and highest on the State [3]

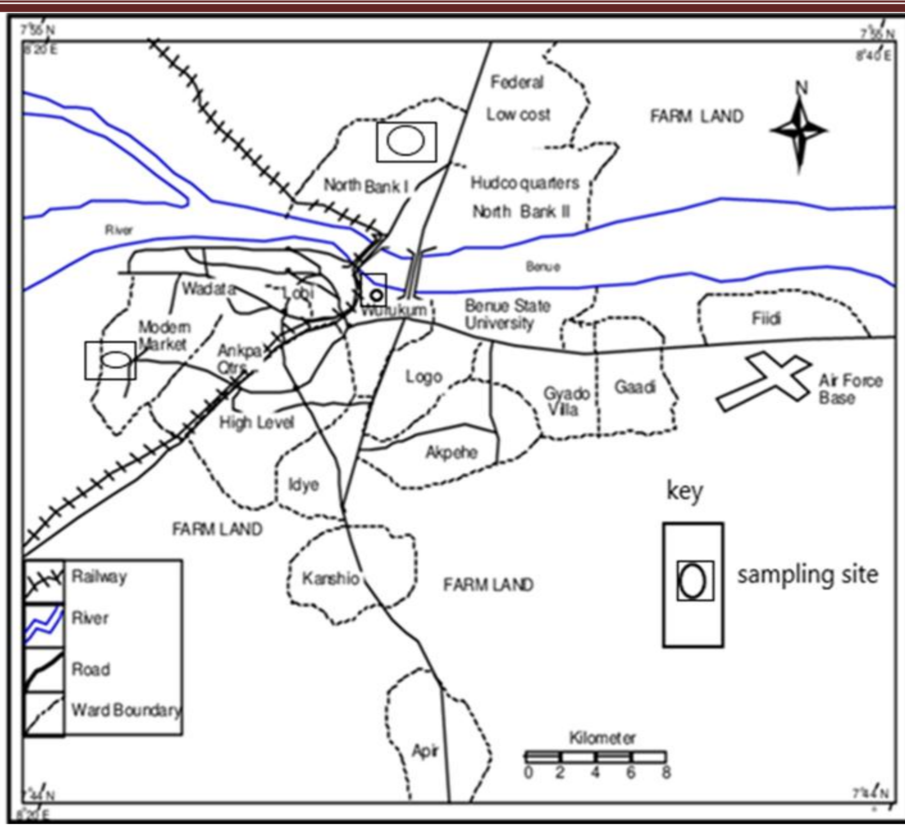

Figure 1: Map of Makurdi town showing the study area [8]

MATERIALS AND METHODS

Sample Collection

The goat meat and pork meat samples were obtained from Wurukum market in Markurdi Local Government of Benue State.The samples were collected in a freezer bag also known as a zip-lock bag which is an airtight bag which prevent air from entering or escaping in order to preserve the samples and maintain its freshness. They were transported to the laboratory for chemical analysis.

Apparatus

The materials include the following apparatus: analytical balance, desiccator, oven, muffle furnace, kjeldahl apparatus, Soxhlet extractor, and rotary evaporator.

Chemicals

The various reagents include: H_2SO_4, petroleum ether, NaOH, $CuSO_4$, 40% boric acid (H_3BO_3), HNO_3, H_2O_2, and HCl.

Sample Preparation

The meat samples were carefully trimmed to remove any visible fat using a sharp knife to remove lean meat content, connective tissues, tendons and bones. The trimmed meats were then diced into small cubes (approximately 1-2 cm) for easier processing and were oven dried and then homogenized using a mortar and pestle. Then the homogenized samples were stored in an air tight container for chemical analysis

Sample Digestion

The digestion of samples was carried out by the process described by Tseggy et.al. [8]. Exactly 1.0 g dried sample was weighed into 25.0 mL of freshly prepared and aqua regia (3 mL HNO_3 + 9 mL HCl). The flask was covered with a filter paper to enable the digestion to take place under constant volume. The constant was heated for 1 h on the medium heat of a hot plate. The mixture was allowed to cool and filter paper into 50 ml standard volumetric flask. The filtrate was diluted to 50 ml with distilled water and then transferred to plastic sample bottle and covered prior to analysis

Determination of elements.

The digested sample were aspirated into (AAS 969 model, Japan) equipped with mono-elemental hollow cathode lamps and digital display read the metal concentration in mg/L from the metal concentration standard calibration curve while Na, Mg, and Ca were determined using flame photometer. Spectroscopic analysis was done for each element and values were recorded

The instrument used was first calibrated with stock solutions of the prepared standards before analysis. The final processed samples were quantitative analyzed using buck scientific VGP 210 Flame Atomic Absorption Spectrophotometer. After every five sample analyzed using AAS, the first sample was repeated for quality check. Only when the results were within 10% earlier readings did the analyses proceed further.

Proximate Analysis

Determination of total protein, fat ash and moisture were performed according to the methods described by Aassociation of official analytical chemist [8].

Determination of the Moisture Content

Dry matter of any sample is the content weight of the sample obtained after drying at 100 ^{o}C

Procedure

To determine the moisture content of the meat the technique reported by Tsegay [8] was adopted and modified. Here the 0.5 g of the fresh sample was placed on a flat bottom aluminum dish, which was then heated at 105 ^oC overnight in hot oven. The sample was placed in a desiccator and then allowed to cool. The dried and cooled sample was then reweighed. The weight was taken three times and average weight calculated. The moisture content was measured as a difference between the initial and final weight of the sample. It is calculated as:

Weight of sample (g)

Weight of dry matter (x)

Loss in weight (g-x)

%moisture content $(\frac{g-x}{g} \times \frac{100}{1})$

Determination of Ash Content

The residue from burning any material at 550 ^OC is called ash

Procedure

The ash content of the meat samples was determined using the dry ashing technique as reported by Tsegay *et al*. [8]. Here three slices (0.5 g each) of the fresh meat sample were taken into different silica crucibles, and were then transferred into a muffle furnace. The furnace was then operated at a temperature of 600 ^OC and maintained for 6 hours. The samples (in the crucibles) were then allowed to cool overnight. The cooled crucibles (with their contents) were then transferred to a desiccator and then weighed. Each sample was weighed and reweighed three times and then the average weight was taken. Finally, the ash content was calculated using the formula below:

Weight of sample (g)

Weight of Ash (x)

%Ash = $(\frac{x}{g} \times \frac{100}{1})$

Crude Fat Determination by Soxhlet Method

Fat and oil is determined by extraction with petroleum ether or spirit at boiling point 40 ^OC- 60 ^OC with either in a Soxhlet extractor.

Procedure

The sample fat was estimated using soxhlet extraction method as suggested by Tseggy [8]. Three samples of 0.5 grams each of the dried samples were placed on a separate filter paper and each properly tied with a string and then placed into a fat free thimble, and petroleum ether was used for the distillation. The samples were severally refluxed in the Soxhlet apparatus to ensure complete removal of the fat. The sample was then taken out of the Soxhlet apparatus and transferred to a rotary evaporator to remove the solvent (petroleum ether). The sample was then reweighed after overnight cooling and the difference between the original and final weight was calculated using the formula below.

Weight of sample (g)

Weight of fat (x)

$$\%fat = \left(\frac{x}{g} \times \frac{100}{1}\right)$$

Crude Protein Determination

The protein content of the samples was determined according to the method suggested by Tseggy et al. [8] using the Kjeldhal method. Here 0.5 grams of the sample was put into a digestion tube and 5 mL of concentrated sulphuric acid (H_2SO_4) was added. Analyses were all carried out in triplicates and two blank samples without the sample were also taken. The digestion tube with its content was then placed in boiling water for 40 minutes and then the catalysts, $CuSO_4$ and K_2SO4, were added in the ratio of 7:1, and 10 ml of concentrated, H_2SO_4 was added, and then transferred to the digestion block. The sample was then digested at 300 ^{O}C for 3 h, until when the sample turned colorless. The sample was removed from the digestion block and then allowed to cool overnight. The aliquot was then diluted with distilled water to make up the volume to 250 ml. The sample was then made alkaline by adding 10 ml of 35% NaOH, and then distilled, with the distillate collected in a flask containing 4% boric acid (H_3BO_3), with bromocresol green taken as the indicator. The distillate was then collected for 5 minutes considering that all the ammonia was collected in the boric acid solution, and then titrated with 0.1 N H_2SO_4. The nitrogen obtained in the sample was then multiplied with 6.25 to determine the percentage protein of the sample.

The percentage of nitrogen in the sample was calculated with the formula

Weight of sample (g)

Titre value (T)

$$\%N = \frac{T \times m \times 0.014 \times Df \times 100}{g}$$

%protein = %N×6.25

Determination of Crude Fibre

The method described by Tsegay [8] was modified and used in determining the crude fibre content of sample, two grams of sample was weighed into 500 mL beaker and boiled into 200 mL HCl (1%) for 30 min. The suspension was filtered using a white filter paper and rinsed using a hot water to obtain filtrate. The residue obtained was transferred into a crucible and placed in an oven for 30 min the dried residue was cooled in desiccator and weighed

Percentage of crude fiber was calculated as:

Weight of sample (g)

Weight of dry matter (T)

Weight of residue (y)

$$\%fibre = \left(\frac{x-y}{g} \times \frac{100}{1}\right)$$

Determination of Carbohydrate

The procedure outlined by Tsegay [8] was used in the determination of carbohydrate content this was calculated by difference sum total of the moisture, fat, protein, ash content were subtracted from 100.

%Carbohydrate content = 100-(%protein + %fat + %ash + %crude fibre + %moisture)

Statistical Analysis

Data were analyzed using least square analyses and were compared by Duncan's multiple-range test using (SPSS version 10.1, for windows, 2000. Spss Inc., Chicago, IL). Significances were established at the level of $P < 0.05$.

RESULTS AND DISCUSSION

The results of elemental contents of goat meat and pork meat samples are presented in Table 1, whereas proximate composition is presented in Table 2.

Table 1: The mineral concentration (mg/kg) of goat meat and pork meat

Parameters	GM	PM	Mean value
Ca	12.67	14.67	13.67
Mg	1.53	1.26	1.39
Fe	2.08	1.35	1.72
Zn	0.09	0.08	0.09
Cu	0.13	0.16	0.15

GM = Goat meat PM = Pork meat

Table 2: Results of the proximate analysis of goat meat and pork meat

Parameters	GM	PM	Mean value
Crude protein	34.24	26.38	30.31
Ash content	7.40	6.09	6.75
Crude fat	10.20	14.80	12.5
Moisture content	9.80	11.18	10.49
Crude fibre	7.60	6.19	6.89
Carbohydrate	30.76	35.36	33.06

Key: GM = Goat meat; PM = Pork meat

Minerals in Goat and Pork Meats

Calcium (Ca)

Calcium is the most abundant mineral in the body. The body needs it every day for vascular contraction, vasodilation, muscle functions, oocyte activation, blood clotting, nerve transmission, intracellular signalling, and hormonal secretion in the human body [9]. The result of calcium content of goat meat and pork meat are presented in Table 1. The calcium content of goat meat (12.67 mg/kg) was less than that of pork meat (14.67 mg/kg). The mean concentration of goat meat and pork meat is 13.67 mg/kg. The higher calcium content of pork meat is in agreement with finding of Pena et al.[9] and also the lower level of calcium in goat meat was noted in studies like those of Devatkal & Naveena [10]. Pork meat often contains slightly higher calcium level because pigs may have different bone density and mineral storage mechanisms compared to goats. Pigs are often fed calcium-rich feed, especially in commercial farming, which may contribute to a higher calcium deposit in their muscle tissue compared to goats, which graze on vegetation that may vary in calcium content depending on the region and vegetation type.

Magnesium (Mg)

Magnesium is widely used for metabolic processes in the body. Some of its main functions include energy production, cell growth and synthesis of biomolecules. [11]. The magnesium content of goat meat (1.53 mg/kg) was higher than that of pork meat (1.26 mg/kg). The mean concentration of goat meat and pork meat was 1.39 mg/kg. The values obtained from the samples align closely to the result reported by Bender [12]. Goat meat had an average magnesium concentration of approximately 1.5 mg/kg, compared to 1.2 mg/kg in pork. The result of this present study is slightly higher than 1.4 mg/kg for goat meat magnesium content and 1.2 mg/kg for pork meat as reported by Ozkan & Kaya [13].

The higher magnesium content of goat meat compared to pork meat is because of metabolic differences. Goats are ruminants, which means that they have a unique digestive system that may lead to different mineral absorption rates. The rumen allows for better extraction of minerals from fibrous plant materials, potentially leading to higher magnesium availability in goat muscle.

Iron (Fe)

Iron plays a crucial role in human health. It is needed for numerous metabolic processes such as synthesis of deoxyribonucleic acid (DNA), transportation of oxygen and nutrients, formation of heme enzymes and other iron-containing enzymes that are involved in electron transfer and oxidation- reduction [14]. The results of iron content of goat meat and pork meat are presented in Table 1. It shows that the level of iron varied from 2.08 mg/kg in goat meat to 1.35 mg/kg in pork meat. Goat meat had the highest iron content of 2.08 mg/kg which is significantly higher than the iron content of pork meat at 1.35 mg/kg with the mean of 1.39 mg/kg. The higher iron content of goat meat is in agreement with finding of Abbaspour et al. [14].and also the loawer level of iron in pork meat was noted in studies like those of Bender [12]. The iron content of goat meat is significantly higher due to the fact that iron is primarily stored in the muscle as part of the protein myoglobin, which gives meat its colour and helps transport oxygen within muscle tissues [15]. Goat meat, often classified as red meat, contains more myoglobin than pork, which is typically classified as white or lighter meat [16]. The higher myoglobin concentration in goat muscle cells results in a higher iron content because myoglobin has a significant amount of iron bound to it.

Zinc (Zn)

Zinc is an essential trace element and plays an important role in various cell processes including normal growth, brain development, behavioral response, bone formation, and wound healing [17]. Zinc also plays a very important role in protein and carbohydrate metabolism and also helps in metabolizing vitamin A from its storage site in the liver and facilitates the synthesis of DNA and RNA necessary for the cell production [17]. The zinc content of goat meat (0.09 mg/kg) was slightly higher than that of pork meat (0.08 mg/kg). The mean concentration of goat meat and pork meat was 0.09 mg/kg. This result aligns with findings in related research on mineral composition in meats. This difference is attributable to physiological and dietary factors unique to ruminants. Goats, as ruminants, possess a specialized digestive system that enhances mineral absorption, especially of trace elements like zinc, compared to non-ruminants like pigs. Additionally, goats are often fed forage-based diets richer in minerals, whereas pigs typically consume grain-based feeds, which can be lower in zinc. The higher metabolic demands in goats may also contribute to increased zinc retention in their muscle tissues. Supporting literature by Adeyemi et al [18], indicates similar trends. This study found zinc levels in goat meat to be 0.10 mg/kg. Hussein & Khali [19] also found higher zinc levels in goat meat (0.12 mg/kg) compared to pork, attributing this to both dietary differences and metabolic factors in ruminants. However, some studies, like that of Li *et al.* [29], report higher zinc levels in pork when pigs are pasture-fed, demonstrating that variations in diet and farming practices can significantly impact mineral composition across meat types. These findings suggest that while goat meat generally exhibits higher zinc content, dietary and environmental factors play critical roles in determining specific mineral levels across different meats.

Copper (Cu)

Copper is an essential trace element that is needed for adequate growth, cardiovascular integrity, lung elasticity, neovascularization, neuroendocrine function, and iron metabolism [20]. Copper content in goat meat and pork meat is shown in Table 1. The concentration of copper in the sample varied from 0.16 mg/kg in pork meat to 0.13 mg/kg in goat meat. The mean concentration is 0.15 mg/kg. Pork meat had the highest copper content (0.16 mg/kg) which was higher than the copper content in goat meat (0.13 mg/kg). The findings may be attributed to species-specific metabolic and dietary factors. Non-ruminants like pigs generally have diets rich in copper due to common supplementation practices in commercial feeds. Copper is crucial in pig metabolism for enzyme function, immune support, and growth, often resulting in higher tissue copper levels. In contrast, goats, as ruminants, rely on forage-based diets where copper levels are naturally variable and, due to the rumen's selective mineral absorption, often results in lower copper content in tissues. This difference reflects the varying mineral uptake mechanisms between monogastric animals (pigs) and ruminants (goats). This result appeared to be far less than the copper content of pork meat reported by Liu & Smith [21] which found copper levels in pork ranging from 0.18 to 0.25 mg/100 g, aligning with higher values due to mineral-supplemented diets.

Proximate Composition of the Goat and Pork Meats

Crude Protein

The main function of protein is growth and replacement of lost tissue in the human body. Table 2 shows the crude protein contents of pork meat and goat meat used in this study. The crude protein content in meat is a measure of the protein concentration in the tissue, calculated by quantifying nitrogen content and using a conversion factor. Proteins are fundamental for biological functions, comprising enzymes, structural components and contributing to physiological activities within the organism. Higher protein content in meat is often valued in nutritional contexts, particularly for human and animal diets. In the present analysis, the crude protein content in goat meat was 34.24%, while pork meat contained 26.38%, with a mean value of 30.31%. The higher protein content observed in goat meat compared to pork may be attributed to species-specific differences in muscle composition, dietary factors, and growth patterns. Goats, which are known for their leaner meat, typically have a higher percentage of muscle mass compared to pork, which contains more intramuscular fat. Consequently, this difference in muscle and fat distribution can lead to a higher crude protein content in goat meat, as leaner meats often show elevated protein percentages [22, 23].

The mean crude protein content of 30.31% aligns closely with findings in similar studies. Adesehinwa *et al*. [24] reported mean protein levels of approximately 29–31% in lean meats in various animal meats, reflecting similar values to those observed in this analysis. Likewise, research by Ahmad et al. [25] documented crude protein contents ranging from 25 to 33% across different meat types, further supporting the findings. These comparable results suggest that the crude protein content in goat and pork meats falls within expected ranges and reflect typical variations due to species and breed characteristics.

Ash Content

Ash content in meat is a measure of the total mineral content remaining after complete combustion of organic material. This value is important as it represents the concentration of essential minerals, including calcium, phosphorus, magnesium, and trace elements like zinc and iron, which are crucial for numerous metabolic functions [25]. In this analysis, the ash content of goat meat was 7.40%, while pork meat showed a slightly lower ash content of 6.09%, resulting in a mean value of 6.75%. The higher ash content observed in goat meat could be attributed to differences in mineral uptake and metabolism between the two species, as well as the mineral composition of their diets. Goats, particularly those grazing on mineral-rich vegetation, may accumulate higher mineral content in their tissues compared to pigs, which often consume grain-based diets [26, 27]. Additionally, goat meat is often leaner than pork, potentially leading to a higher concentration of minerals in the remaining tissue after organic components are removed.

The mean ash content of 6.75% aligns with values reported in related studies. Such as Smith & Liu [21] found mean ash contents ranging from 6.5% to 7.3% across various red meats, suggesting that the mineral concentration in goat and pork meats in this study is consistent with expected levels in animal tissues. Similarly, research by Kim et al [28] noted ash contents in the range of 5.9% to 7.6% for lean meats, further supporting these findings and indicating that the mineral content observed here reflects typical values across meat types.

Moisture Content

Moisture content in meat refers to the amount of water present within the tissue, which plays a significant role in meat quality, texture, and shelf life. Water content affects the juiciness and tenderness of meat and is influenced by various factors such as the animal's species, age, diet, and fat content [29].

Moisture content determination is an integral part of the proximate composition analysis of food. The result of moisture content of pork meat and goat meat is presented in Table 2. In this analysis, the moisture content in pork meat was measured at 11.18% with the mean concentration obtained to be 10.49%, while goat meat showed slightly lower moisture content of 9.80%, with a mean value of 10.49%. The higher moisture content in pork compared to goat meat can be attributed to differences in fat composition and muscle structure between these species. Pork, generally known for its higher intramuscular fat, tends to retain more water within muscle fibers due to the water-holding capacity associated with fat content. Conversely, goat meat is leaner, with less intramuscular fat, and therefore tends to have a slightly lower moisture content, which is consistent with its denser, leaner muscle structure [30, 35]. The mean moisture content of 10.49% aligns closely with values reported in other studies on red meat. Such as, Brown *et al* [32] observed moisture content values ranging from 9.5% to 11.5% across different cuts of lean meats, reflecting similar levels to those observed here. Additionally, research by William&Chen [31] documented moisture contents between 10% and 12% in pork and other meats with moderate fat content, which supports the values found in this study.

Crude Fibre

Crude fiber content in meat measures the indigestible portion of plant-based material and connective tissues present in the meat. Although typically low in animal tissues compared to plant-based foods, crude fiber in meat originates from small amounts of connective tissue and the residual fibers associated with the animal's diet. While fiber is generally absent in muscle, small amounts can be detected in meats due to factors such as animal diet and muscle type [32]. Crude fibre provide bulk to the gut which stimulates peristalsis and results in shorter passage time and more frequent defecation.

In this analysis, the crude fiber content of pork meat was 6.19%, while goat meat had a higher crude fiber content of 7.60%, with an overall mean of 6.89%. The higher crude fiber content observed in goat meat compared to pork may be attributed to differences in their feeding habits and muscle composition. Goats are primarily grazers, often consuming fibrous plant material, which can contribute to a slightly higher fiber concentration within muscle tissue. Additionally, goat muscle is denser and leaner, which may contain more structural fibrous tissues compared to pork, which tends to have more intramuscular fat [33, 34].

The mean fiber content of 6.89% in this study is somewhat higher than values reported in similar research. Roberts &Yang [35] found crude fiber contents ranging from 2% to 5% in red meats, noting that such values vary based on factors such as animal diet, muscle type, and meat processing methods. Similarly, a study by Allen *et al*. [36] reported that crude fiber in meat generally ranges from 3% to 5% in lean cuts, reflecting lower levels than those observed in the present analysis.

Crude Fat

Crude fat content in meat refers to the overall fat present in the tissue, including both intramuscular fat and fat within the connective tissue. The fat content plays a crucial role in the meat's nutritional profile, taste, tenderness, and energy density. The amount of fat in meat varies across species, breeds, diets, and muscle types, all of which influence the meat's texture and flavor [37].

In the present analysis, pork meat exhibited a crude fat content of 14.80%, while goat meat contained 10.20%, resulting in a mean fat content of 12.5%. The higher fat content in pork compared to goat meat can be explained by differences in the animals' biology and diet. Pigs, typically fed grain-rich diets, accumulate higher levels of intramuscular fat. On the other hand, goats are leaner animals that feed on fibrous plants, resulting in a lower fat accumulation in their muscles [21, 38]. The mean fat content of 12.5% observed in this study is consistent with findings from similar research. Zhao *et al*. [40] found that pork cuts usually contain between 12-15% fat, reflecting a substantial amount of intramuscular fat, while goat meat typically falls within a range of 8-11%, which is in line with the current results. Likewise, Jones & Smith [39] reported that pork generally contains more fat than leaner meats such as goat and lamb, further supporting the observed fat differences between these meats.

Carbohydrate Content

Carbohydrate content in meat represents the residual non-protein, non-fat component, often including glycogen, glucose, and some indigestible fibers. Although carbohydrates in meat are generally low compared to plant foods, they still play a role in energy provision, particularly as stored glycogen in muscle tissue, which can vary depending on factors such as the animal's diet, activity level, and muscle type [39].

In this analysis, the carbohydrate content in pork meat was 35.36%, while goat meat showed a slightly lower carbohydrate content of 30.76%, with an overall mean of 33.06%. The higher carbohydrate content in pork may result from species-specific differences in glycogen storage and muscle composition. Pigs, particularly those raised on carbohydrate-rich feed, may have higher glycogen reserves in their muscles, contributing to a greater carbohydrate content in pork compared to goat meat. Goats, being grazers with a natural diet of fibrous plants, may store relatively lower levels of glycogen, resulting in a slightly lower carbohydrate concentration in their meat [40, 41].

The mean carbohydrate content of 33.06% observed in this study is somewhat higher than levels reported in similar study by Roberts and Yang [35] in which they found carbohydrate levels in raw pork and goat meats to be below 1%, as most of the non-protein and non-fat content comprises water and trace amounts of glycogen. Similarly, findings by Martinez *et al*. [6] reported carbohydrate levels in various meats generally under 1%, which may indicate that the values observed here reflect additional components or processing differences.

CONCLUSION

This study was carried out on proximate and mineral analysis of pork meat and goat meat in Benue state Nigeria. Pork meat and goat meat were purchased in Wurukum market, Makurdi, Benue State. The proximate parameters were determined using standard method as described by Tseggy et al. [8], while the mineral element using atomic absorption spectrophotometer (AAS). The mineral analysis revealed that pork meat contains higher levels of calcium (14.67 mg/kg) and copper (0.16 mg/kg), which are essential for bone health and metabolic functions. Goat meat, on the other hand, showed a higher concentration of iron (2.08 mg/kg), magnesium (1.53 mg/kg), and zinc (0.09 mg/kg). These minerals are crucial for oxygen transport, energy production, and immune support, particularly beneficial for populations with anemia or magnesium deficiencies. The variation in mineral content can be attributed to species-specific digestive efficiencies, dietary habits, and rearing practices. Also,goat meat showed a higher crude protein content (34.24%) compared to pork (26.38%), indicating that goat meat is a richer source of protein, which is beneficial for muscle development and tissue repair. Pork meat, however, contained more fat (14.80%) than goat (10.20%), giving it a richer flavor and higher caloric density, suitable for those needing increased energy intakes. Additionally, the higher moisture content in pork (11.18%) enhances its juiciness and tenderness, whereas goat's lower moisture and fat content contribute to its leaner, firmer texture. Goat meat, with its higher protein, iron, and magnesium levels, is ideal for health-conscious individuals seeking lean protein sources and those at risk for mineral deficiencies, such as iron. Also, pork meat, with its higher calcium and fat content, provides beneficial minerals for bone health and a higher energy density for individuals needing additional caloric intake.

REFERENCES

[1] Alturiqi, A. S., & Albedair, L. A. (2012). Evaluation of some heavy metals in certain fish, meat and meat products in Saudi Arabian markets. *The Egyptian Journal of Aquatic Research,* 38(1), 45-49.

[2] Williamson, C. S., Foster, R. K., Stanner, S. A., & Buttriss, J. L. (2005). Red meat in the diet. *Nutrition Bulletin*, 30(4), 323-355.

[3] Awuchi, C.G., Igwe, V.S., AmagwulaI, Echeta, C.K. (2020). Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: a systematic review. *Int J Food Sci* 3(1):1– 32

[4] Djinovic-Stojanovic, J. M., Nikolic, D. M., Vranic, D. V., Babic, J. A., Milijasevic, M. P., Pezo, L. L., & Jankovic, S. D. (2017). Zinc and magnesium in different types of meat and meat products from the Serbian market. *Journal of Food Composition and Analysis*, 59, 50-54.

[5] Zoroddu, M. A., Aaseth, J., Crisponi, G., Medici, S., Peana, M., & Nurchi, V. M. (2019). The essential metals for humans: a brief overview. *Journal of inorganic biochemistry*, 195, 120-129.

[6] Martínez-Ballesta, M. C., Dominguez-Perles, R., Moreno, D. A., Muries, B., Alcaraz-López, C., Bastías, E., ... & Carvajal, M. J. A. F. S. D. (2010). Minerals in plant food: effect of agricultural practices and role in human health. A review. *Agronomy for sustainable development,* 30(2), 295-309.

[7] Parimelazhagan Thangaraj, P. (2016). Proximate composition analysis. Pharmacological assays of plant-based natural products, Progress in Drug Research, 21-31.

[8] Tsegay L.., Mohammed, B. & Sandip, B. (2015). Quality of Beef, Chevon and African. *Journal Of Food Science* 9(50), 301-306

[9] Peña, F., Bonvillani, A., Freire, B., Juárez, M., Perea, J. & Gómez, G.(2009).. Effects of genotype and slaughter weight on the meat quality of Criollo Cordobes and Anglonubian kids produced under extensive feeding conditions. Meat Sci., 83, 417–422.

[10] Devatkal, S. K., & Naveena, B. M. (2010). Mineral content in goat meat and its implications for nutrition. *Food Chemistry*, 120(3), 873-878.

[11] Zhang, Y., Xun, P., Wang, R., Mao, L. & He, K. (2017). Can magnesium enhance exercise performance?. *Nutrients*, *9*(9), 946.

[12]Bender, A. (2012). *Meat and Meat Products in Human Nutrition in Developing Countries*. FAO.

[13] Özkan, M. & Kaya, A. (2008). "Comparative mineral content analysis of meat from different animal sources. *Journal of Food Composition and Analysis*, 21(2), 215-221.

[14] Abbaspour, N., Hurrell, R. & Kelishadi, R. (2014). Review on iron and its importance for human health. *Journal of research in medical sciences: The Official Journal of Isfahan University of Medical Sciences*, *19*(2), 164.

[15] Wei, Y., Li, X., Zhang, D. & Liu, Y. (2019). Comparison of protein differences between high-and low-quality goat and bovine parts based on iTRAQ technology. *Food Chemistry*, *289*, 240-249.

. [16] Sebsibe, A. (2008). Sheep and goat meat characteristics and quality. *Sheep and Goat Production Handbook for Ethiopia. Ethiopian Sheep and Goats Productivity Improvement Program (ESGPIP), Addis Ababa, Ethiopia. pp323-328*.

[17] Jahnen-Dechent, W. & Ketteler, M. (2012). Magnesium basics. *Clinical kidney Journal*, *5*(Suppl_1), i3-i14.

[18] Adeyemi, K. D., Sani O. M. & Sandra G. O. (2015). Comparative analysis of mineral composition in ruminant and non-ruminant meats.*Journal of Animal Science*, 23(2), 198-205.

[19] Hussein, M. A., & Khalil, I. M. (2018). Zinc levels in meat from different species and dietary implications. *Nutrition Science*, 12(3), 154-162.

[20] Khayat, S., Fanaei, H. & Ghanbarzehi, A. (2017). Minerals in pregnancy and lactation: a review article. *Journal of Clinical and Ddiagnostic Research: JCDR*, *11*(9), QE01.

[21] Liu, Z. & Smith, T., (2018). Copper accumulation in pork from mineral-supplemented diets. *International Journal of Food Science and Nutrition*, 30(1), 89-97.

[22] Murray, S.M., Blair, H.T. & Sinclair, R. (2021). Muscle composition and protein levels in livestock. *Journal of Nutritional Biochemistry*, 32(3), 193-199

[23] Ayisi, C.L., Zhao, J., & Deng, Y. (2018). Nutritional quality of meat: Differences across species and cuts. *Food Chemistry*, 245, 315-320.

[24] Adesehinwa, A.O.K., Oladele, I.B., & Omojola, A.B. (2020). Comparative study of the proximate composition of different meat types. *Journal of Animal Science Research*, 15(2), 54-63.

[25] Ahmad, I., Shah, M.A. & Shafi, M. (2019). Protein content variations in meat of different animal species. *Meat Science*, 123, 67-72.

[26] Martinez, S. & Garcia, P. (2020). The mineral profile of meats: Impact of species and feeding practices. *Journal of Animal Nutrition*, 25(4), 98-10

[27] Chang, H., Kim, S.J., & Lee, Y. (2018). Comparative mineral analysis in animal meats: Implications for nutrition. *Meat Science Journal*, 138, 85-93

[28] Kim, J.H., Park, W. & Yoon, H.J. (2022). Variability of ash content in lean and fatty meats. *Food and Nutrient Composition Research*, 19(3), 305-312..

[29] Li, J., Zhao, F. & Kim, Y. (2020). The role of water content in meat quality and preservation. *Food Chemistry Research,* 28(3), 214-222

[30] Park, S., Kim, J. & Hwang, J. (2019). Water-holding capacity and moisture content in pork and other meats. *International Journal of Food Properties*, 22(6), 745-755..

[31] Williams, C. & Chen, L. (2021). Fat and moisture dynamics in various meats. *Food Science Journal,* 47(5), 200-207.

[32] Brown, H. & Lee, K. (2021). Proximate composition and fiber content in different meats: Pork and goat comparison. *International Journal of Meat Science*, 15(3), 188-194.

[33] Chen, S., Liu, P. & Zhao, W. (2020). The impact of diet and grazing on crude fiber content in meat tissues. *Food Chemistry Research*, 38(2), 301-307.

[34] Park, S. & Williams, A. (2019). Crude fiber content and its role in animal muscle tissues across species. *Meat Composition Journal*, 25(1), 57-64.

[35] Roberts, L. & Yang, T. (2022). Comparative study of dietary fiber in meats: Species and cut differences. *Journal of Meat Science and Nutrition*, 45(2), 66-72.

[36] Allen, R., Garcia, M., & Liu, J. (2021). Crude fiber and its dietary sources in animal meats. *Journal of Animal Nutrition and Food Science*, 34(4), 245-253

[37] Kim, Y. & Park, H. (2020). Fat composition in livestock meats and its impact on meat quality. *Journal of Animal Nutrition*, 15(1), 90-97.

[38] Nguyen, M., Zhao, Y. & Chen, L. (2021). Comparative fat content in meats: Species and dietary influences. *Meat Science Review*, 38(2), 233-240.

[39] Jones, M., & Smith, P. (2021). Non-protein, non-fat components in meat tissue: A review on carbohydrates. *Journal of Food Science*, 56(2), 78-85.

[40] Chen, L., Zhao, F. & Wang, H. (2019). Glycogen storage and carbohydrate content in meat: Species differences. *Meat Science Journal*, 145, 120-128.

[[41] Patel, A., & Green, S. (2020). Diet and muscle glycogen variations across livestock species. *Journal of Animal Nutrition*, 48(3), 199-207.