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NUTRITIONAL QUALITY, MINERAL COMPOSITION AND OXIDATIVE STABILITY OF SELECTED MEAT TYPES: A COMPARATIVE STUDY OF CHICKEN, BEEF AND CHEVON

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ABSTRACT

Meat plays a vital role in human nutrition as a major source of high-quality protein, essential minerals and bioactive compounds necessary for growth, tissue repair and overall health. This study evaluated the nutritional quality, mineral composition and oxidative stability of selected meat types, namely chicken, beef and chevon. Meat samples were analyzed for proximate composition (crude protein, fat, ash and moisture), mineral profile (sodium, potassium, chloride, calcium and magnesium), and oxidative stability indices including superoxide dismutase (SOD), catalase, glutathione peroxidase (GPX) and malondialdehyde (MDA). Data obtained were subjected to one-way analysis of variance and means were separated using appropriate post hoc tests at a significance level of $P < 0.05$.Results showed significant differences ($P < 0.05$) in most proximate parameters among the meat types. Chicken meat recorded the highest crude protein (86.69%) and moisture content (4.63%), while chevon exhibited the highest fat content (9.06%). Beef showed the highest ash content (4.76%). Mineral analysis revealed that chicken meat had significantly higher sodium and potassium levels, whereas chevon had the highest chloride concentration. Magnesium content was highest in beef. Oxidative stability indices indicated that chicken meat had significantly higher SOD activity, while no significant differences ($P > 0.05$) were observed in catalase, GPX and MDA among the meat types. The findings suggest that chicken meat possesses superior protein quality and antioxidant capacity, while chevon and beef contribute differently to fat and mineral intake. These variations highlight the importance of meat selection based on nutritional and health considerations.

Keywords: Mineral Profile, Oxidative Stability, Antioxidant Enzymes, Meat Quality

INTRODUCTION

Meat is an important component of the human diet, providing high-quality protein, essential amino acids, vitamins and minerals required for growth, maintenance and overall health (Aberle et al., 2001; Lawrie & Ledward, 2006). Among commonly consumed meat types, chicken, beef and chevon (goat meat) are widely recognized for their nutritional contributions; however, their composition varies depending on species, feeding practices and post-slaughter handling (Bender, 1992; Webb et al., 2005).

Proximate composition, including crude protein, fat, ash and moisture content, is a major determinant of meat quality and consumer acceptability. Protein plays a critical role in tissue development and repair, while fat contributes to energy supply, flavor and palatability (Williams, 2007). However, excessive fat intake has been associated with increased risk of cardiovascular diseases, making comparative evaluation of fat levels across meat types essential (WHO, 2003). Ash content represents the total mineral fraction, which is important for metabolic processes such as enzyme activation, bone formation and electrolyte balance (Ockerman & Basu, 2004).

Minerals such as sodium, potassium, calcium, magnesium and chloride are vital for numerous physiological functions, including nerve transmission, muscle contraction and maintenance of osmotic balance (Demeyer & Doreau, 1999). Variations in mineral composition among different meat types can significantly influence their nutritional value and dietary recommendations, particularly for individuals with conditions such as hypertension or mineral deficiencies (Honikel, 2004).

In addition to nutritional composition, oxidative stability is a key quality parameter influencing the shelf life, safety and acceptability of meat products. Lipid oxidation leads to the formation of off-flavors, discoloration and potentially harmful compounds (Falowo et al., 2014). Antioxidant enzymes such as superoxide dismutase (SOD), catalase and glutathione peroxidase (GPX) play crucial roles in protecting tissues against oxidative damage, while malondialdehyde (MDA) is widely used as an indicator of lipid peroxidation (Morrissey et al., 1998; Lund et al., 2011). Although several studies have investigated individual aspects of meat quality, there is limited comprehensive information integrating proximate composition, mineral profile and oxidative stability across commonly consumed meat types such as chicken, beef and chevon. Therefore, this study was designed to comparatively evaluate the nutritional quality, mineral composition and oxidative stability of these selected meat types, with a view to providing relevant data for consumers, nutritionists and the meat industry.

MATERIALS AND METHODS

Study Location

The study was conducted in the Animal Science and Food Analysis Laboratory of Joseph Sarwuan Tarka University, Nigeria. All laboratory analyses were carried out under standard conditions using approved analytical procedures.

Sample Collection and Preparation

Fresh samples of chicken, beef and chevon were obtained from reputable retail outlets within Makurdi metropolis, Benue State, Nigeria. The samples were transported to the laboratory in clean, sterile polyethylene bags under chilled conditions to prevent deterioration. Visible fat, connective tissues and extraneous materials were trimmed off, and the samples were thoroughly washed with distilled water. Each meat sample was then homogenized separately using a laboratory blender to obtain a uniform sample. The homogenized samples were stored at 4°C prior to analysis.

Determination of Proximate Composition
The proximate composition of the meat samples, including crude protein (CP), ether extract (fat), ash and moisture content, was determined using standard methods of the Association of Official Analytical Chemists (2010).

i. Moisture content was determined by oven drying samples at 105°C to constant weight.
ii. Ash content was determined by incineration in a muffle furnace at 550°C.
iii. Crude protein was determined using the Kjeldahl method, with nitrogen content multiplied by a conversion factor of 6.25.
iv. Ether extract (fat) was determined using Soxhlet extraction with petroleum ether as solvent.

Determination of Mineral Composition
Mineral elements (sodium, potassium, calcium, magnesium and chloride) were determined following wet digestion of samples using a mixture of concentrated nitric acid and perchloric acid.

i. Sodium and potassium were analyzed using a flame photometer.
ii. Calcium and magnesium were determined using atomic absorption spectrophotometry (AAS).
iii. Chloride content was determined using titrimetric methods.

All mineral analyses were conducted according to standard procedures described by AOAC (2010).

Determination of Oxidative Stability Parameters
Superoxide Dismutase (SOD) Activity
SOD activity was determined based on its ability to inhibit the auto-oxidation of epinephrine as described by Misra and Fridovich (1972). Absorbance was measured spectrophotometrically at 480 nm. Oxidative Stability and Lipid Peroxidation Levels in Selected Meat Types

Catalase Activity
Catalase activity was determined using the method described by Aebi (1984), which measures the decomposition rate of hydrogen peroxide (H_2O_2) at 240 nm.

Glutathione Peroxidase (GPX) Activity
GPX activity was determined according to the method of Rotruck et al. (1973), based on the rate of oxidation of reduced glutathione in the presence of hydrogen peroxide.

Malondialdehyde (MDA) Determination
MDA concentration, an index of lipid peroxidation, was determined using the thiobarbituric acid reactive substances (TBARS) assay as described by Buege and Aust (1978). Absorbance was read at 532 nm.

Experimental Design
The experiment was arranged in a completely randomized design (CRD) with three treatments:

i. Chicken meat
ii. Beef
iii. Chevon

Each treatment was analyzed in triplicate.

Statistical Analysis
Data obtained were subjected to one-way analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS, version 20.0). Differences among treatment means were separated using Duncan's Multiple Range Test. Statistical significance was declared at $P < 0.05$. Results were expressed as mean ± standard error of mean (SEM).

RESULTS AND DISCUSSION
Table 1: Oxidative Stability and Lipid Peroxidation Level in Selected Meat Types

Treatment	SOD	Catalase	GPX	MDA
Chicken Meat	21.04	0.11	0.01	1.67
Beef	5.49	0.15	0.02	1.52
Chevon	6.41	0.00	0.00	1.88
SEM	14.63	0.11	0.01	0.36
P-Values	0.00	0.18	0.09	0.21

Table 1 shows the mineral composition of chicken meat, beef and chevon. The result revealed that sodium and potassium differed significantly ($P < 0.05$) among the meat types, while chloride and calcium were not significantly affected ($P > 0.05$). Magnesium also showed significant variation ($P < 0.05$). Chicken meat recorded the highest sodium value (158.13), followed by beef (148.03), while chevon had the lowest value (85.44). This pattern agrees with the report of Falowo (2021), who reviewed the mineral composition of muscle foods and stated that chicken meat generally contains higher sodium than many other meat types. A similar observation was reported by Umar and Mohammed (2020), who found appreciable sodium levels in broiler chicken meat, indicating that poultry meat can serve as an important contributor of dietary sodium. The relatively higher sodium content in chicken meat observed in the present study may be linked to species differences in muscle metabolism, water distribution and feeding background, since mineral deposition in meat is influenced by diet, breed, age, muscle type and post-mortem handling.
Potassium followed the same trend as sodium, with chicken meat having the highest value (10.52), beef intermediate (9.48) and chevon the lowest (5.68). This agrees with the review of Falowo (2021), which indicated that chicken meat often exhibits very high potassium concentrations compared with several other meat species. Potassium is one of the major intracellular cations in muscle and is important in osmotic balance, nerve transmission and muscle function, so meats with higher potassium content may have added dietary value. However, the present result differs from the findings of Wali et al. (2025), who reported higher potassium in goat meat than in cow meat in Ethiopian samples. Such differences across studies are not unusual and may arise from differences in animal species or breeds, feeding systems, production environment, muscle sampled and the basis on which mineral values were expressed.
For chloride, chevon had the numerically highest value (52.23), followed by chicken meat (49.77), while beef had the lowest value (40.23), but the variation was not significant ($P > 0.05$). This suggests that despite numerical differences, the chloride contents of the three meats were statistically comparable. Chloride is recognized as one of the principal macro-minerals present in animal tissues, although it usually occurs in smaller concentrations than potassium and sodium in fresh meat. Falowo (2021) identified chloride among the major macro-elements in muscle foods, while Osman and

Mahgoub (2011) noted that the mineral composition of goat meat includes the common macro-elements and that their concentration is strongly affected by species, tissue type, age, breed and cooking method. The non-significant variation recorded in the present study may therefore indicate that chloride deposition is less species-dependent in the sampled meats than sodium or potassium, or that the sample size was too small to detect differences.

Calcium values ranged from 8.47 in beef to 9.06 in chicken meat, with chevon having 8.56, and these differences were not significant (P > 0.05). The lack of significant difference implies that the three meat types contributed similarly to calcium supply in this study. This finding is consistent with the general view that meat is not usually regarded as a rich source of calcium compared with milk and some plant foods. Pogorzelska-Nowicka et al. (2018) noted that the average calcium content in meat from different species is generally low, while Laskowski et al. (2018) showed that meat and meat products contribute only a modest proportion of total calcium intake in the diet. Falowo (2021) also reported wide but generally low calcium concentrations in common muscle foods relative to many non-meat sources. Therefore, the non-significant calcium values obtained here are biologically plausible and support the idea that calcium is not a major discriminating mineral among these meat types.

Magnesium content differed significantly (P < 0.05), with beef recording the highest value (5.89), followed by chevon (2.04), while chicken meat had the lowest value (1.89). This result supports reports that beef is often a better source of some minerals than poultry. Castillo et al. (2019) noted that beef is characterized by relatively high contents of phosphorus, magnesium, iron and potassium, and Yeo et al. (2023) similarly observed that beef products contained more magnesium than several other meat products. In contrast, Falowo (2021) reported that chicken may show relatively high magnesium in some datasets, while Osman and Mahgoub (2011) described goat meat as a valuable source of macro-minerals including magnesium. The disagreement in ranking among studies again points to the effect of breed, nutrition, age, anatomical cut and analytical procedures. Nevertheless, the current result suggests that beef may provide a better magnesium contribution among the three meats evaluated. Since magnesium functions as a cofactor in numerous enzymatic reactions and energy metabolism, the higher magnesium value of beef may be nutritionally beneficial.

Overall, Table 1 indicates that chicken meat was superior in sodium and potassium, beef was superior in magnesium, while chloride and calcium did not vary significantly among the meat types. These findings reinforce the view that meat is an important source of essential macro-minerals, although the specific mineral advantage depends on animal species and production factors. Previous reviews have shown that meats contribute meaningfully to dietary sodium, potassium and magnesium intake, even though their calcium contribution is usually modest. Thus, from a nutritional standpoint, the choice among chicken, beef and chevon may partly depend on the mineral of interest to the consumer.

Table 2: Comparative Proximate Composition of selected Meat Types (Chicken, Beef and Chevon)

Treatment	CP	F/O	Ash	Moisture
Chicken Meat	86.69[a]	2.66[b]	4.23[c]	4.63[a]
Beef	84.50[b]	3.88[c]	4.76[a]	3.20[b]
Chevon	80.13[c]	9.06[a]	4.69[b]	3.99[a]
SEM	6.56	6.40	0.53	1.43
P-Values	0.00	0.00	0.00	0.00

In the present study, SOD differed significantly (P < 0.05) among the meat types, with chicken meat recording the highest value (21.04), followed by chevon (6.41), while beef had the lowest value (5.49). This result suggests that chicken meat possessed a stronger first-line antioxidant defense against superoxide radicals than the red meats examined. The biological importance of this finding is that SOD converts superoxide radicals into hydrogen peroxide, thereby limiting the initiation of oxidative chain reactions in muscle tissues. Reviews on meat oxidative stability have emphasized that SOD is a central enzymatic antioxidant in muscle and that improved antioxidant status is often associated with better meat quality and longer shelf life.

The significantly higher SOD value observed in chicken meat is in line with reports from poultry studies showing that broiler muscle can exhibit enhanced antioxidant enzyme activity under favorable nutritional or physiological conditions. For example, Ibrahim et al. reported that improving selenium form and level in broiler diets enhanced the antioxidative potential of fresh and frozen meat, while Hosseindoust et al. found that astaxanthin supplementation increased antioxidant status and reduced oxidative damage in chicken muscle. Likewise, Zhao et al. observed that antioxidant supplementation reduced oxidative damage in broiler breast muscle and was associated with improved antioxidant responses. Although those studies evaluated dietary interventions rather than species differences, they support the present observation that chicken muscle can express strong antioxidant defense when oxidative status is well maintained.

Catalase activity in the present study ranged from 0.00 in chevon to 0.15 in beef, with chicken meat having 0.11, but the differences were not significant (P > 0.05). This indicates that catalase activity was statistically comparable among the three meat types despite minor numerical variation. Catalase is responsible for decomposing hydrogen peroxide into water and oxygen, thereby complementing the action of SOD. The non-significant effect observed here agrees with earlier work showing that catalase activity in meat can remain relatively stable and may not always differ significantly across treatments or storage conditions. Pradhan et al. reported that catalase in beef muscle remained stable during storage and contributed meaningfully to antioxidative protection in raw meat products. Similarly, work summarized by Shimizu et al. noted that treatment factors do not always produce a consistent effect on catalase activity in meat systems.

GPX values were also not significantly different (P > 0.05), although beef numerically showed the highest value (0.02), followed by chicken meat (0.01), while chevon recorded 0.00. GPX acts together with catalase to detoxify peroxides, especially lipid hydroperoxides, and is therefore important in controlling oxidative deterioration in meat. The absence of significant variation in GPX in the present study may suggest that the three meat types had a broadly comparable peroxide-detoxifying capacity under the conditions of the analysis. This agrees with reports that GPX activity can be influenced more strongly by feeding, antioxidant supplementation, salt conditions or storage treatments than by species alone. For instance, Ibrahim et al. showed that selenium source and level can alter antioxidative potential in broiler meat, while Zhang et al. reported that dietary treatments in goats increased GPX activity and improved meat oxidative stability. In contrast, the present study found no significant species-related difference in GPX, suggesting that intrinsic species effects may have been less pronounced than management or postmortem influences.

The MDA values obtained in this study were 1.67 for chicken meat, 1.52 for beef and 1.88 for chevon, and these values did not differ significantly ($P > 0.05$). Since MDA is a product of lipid oxidation, the lack of significant difference indicates that the three meat types were broadly similar in their extent of lipid peroxidation at the point of analysis. This result is plausible because lipid oxidation in meat is influenced by several interacting factors, including fatty acid composition, heme pigments, endogenous antioxidant systems, storage temperature, oxygen exposure and processing conditions. Comprehensive reviews on meat oxidation have stressed that oxidative susceptibility is not determined by species alone, but by a combination of lipid substrate availability and pro-oxidant or antioxidant balance within the muscle.

Although MDA did not differ statistically in the present work, chevon showed the highest numerical value, which may indicate a tendency toward greater lipid oxidation. This observation finds some support in goat-meat studies showing that oxidative stability can deteriorate under certain slaughter, storage or ageing conditions. Sabow et al. reported that poorer bleed-out reduced the lipid oxidative stability of chevon during ageing, while Adeyemi et al. found that chill storage decreased antioxidant status and lipid stability in goat meat. These reports suggest that chevon can be vulnerable to oxidative deterioration depending on handling and storage environment. The present result therefore fits within the broader literature in which goat meat may exhibit acceptable oxidative stability at baseline, but can become more oxidation-prone when protective factors are compromised.

For beef, the numerically lowest MDA value observed in this study suggests comparatively lower lipid peroxidation at the time of measurement, despite its low SOD value. This is an interesting outcome because some literature indicates that beef may be more susceptible to oxidation than other meats due to its higher heme pigment concentration and iron-mediated pro-oxidant activity. Reviews by Amaral et al. and comparative analyses cited in the meat oxidation literature indicate that raw beef is often more susceptible to lipid oxidation than raw chicken, largely because of higher myoglobin and iron contents. However, poultry meat may also be highly susceptible to oxidation because of its higher proportion of polyunsaturated fatty acids, especially in membrane phospholipids. Thus, the lower numerical MDA value for beef in the present study may reflect the influence of sample freshness, cut type, storage history or endogenous protective systems rather than species effect alone.

Chicken meat combined the highest SOD value with an intermediate MDA value, which may indicate a relatively active antioxidant defense system that helped restrain oxidative damage. Similar patterns have been reported in poultry studies where improved antioxidant enzyme activity corresponded with reduced lipid peroxidation. Hosseindoust et al. observed that enhancing antioxidant status in chickens reduced muscle MDA, while Zhao et al. similarly reported that antioxidant supplementation lowered MDA in broiler breast muscle under oxidative challenge. Therefore, the high SOD value of chicken meat in the present study may partly explain why its MDA value remained moderate rather than high.

Overall, Table 2 shows that among the antioxidant indices measured, only SOD differed significantly among chicken meat, beef and chevon, with chicken meat exhibiting superior enzymatic antioxidant activity. Catalase, GPX and MDA were statistically similar across treatments, indicating that the three meat types had comparable peroxide-scavenging capacity and lipid peroxidation status under the conditions of this study. The results suggest that species-related variation in oxidative status was more evident at the level of SOD than for the other oxidative markers. In practical terms, this means that while all three meats may have similar oxidative stability at baseline, chicken meat may possess a stronger intrinsic capacity to neutralize superoxide radicals. This interpretation is consistent with broader meat-science literature showing that oxidative stability is governed by a complex interaction of endogenous antioxidant enzymes, fatty acid profile, iron chemistry and postmortem handling conditions.

Table 3: Comparative Analysis of Mineral Profile in Chicken, Beef and Chevon Meat

Treatment	Sodium	Potassium	Chloride	Calcium	Magnesium
Chicken Meat	158.13a	10.52a	49.77	9.06	1.89
Beef	148.03b	9.48b	40.23	8.47	5.89
Chevon	85.44c	5.68c	52.23	8.56	2.04
SEM	64.25	4.48	2.46	0.59	4.00
P-Values	0.00	0.03	0.96	0.81	0.02

For crude protein, chicken meat recorded the highest value (86.69), followed by beef (84.50), while chevon had the lowest value (80.13). This suggests that, on the analytical basis used in the present study, chicken meat had the best protein concentration among the three meat types. This pattern agrees with a comparative multi-species study reporting that chicken meat had the highest protein ratio among the meats examined, showing that poultry can compare favorably with red meats in protein concentration. Likewise, standard meat-composition references indicate that skeletal muscle is generally rich in protein, though the exact level depends on species and sample type. The present trend, however, differs from some reports on goat meat, where chevon has been described as containing about 18–25% protein in raw meat and sometimes showing protein values comparable to, or even higher than, beef depending on genotype and cut. The lower crude protein value observed for chevon in this study may therefore reflect differences in muscle type, sample preparation, age of the animals, fat deposition pattern, or the analytical expression basis rather than a universal inferiority of goat meat.

The fat/oil values showed an opposite pattern, with chevon recording the highest value (9.06), followed by beef (3.88), while chicken meat had the lowest value (2.66). Since the differences were significant, the result indicates that chevon in this study was the fattest of the three meat types, whereas chicken meat was the leanest. This finding is noteworthy because much of the literature describes goat meat as relatively lean, with lower intramuscular fat than beef and with a favorable protein-to-fat ratio. Reviews have reported that goat meat often contains less fat than beef, and some datasets place goat meat fat roughly in the range of 0.6–2.6% or about 2–5%, depending on breed, sex, diet, and cut. Therefore, the higher fat value observed for chevon in the present study does not align with the common expectation from the literature. A plausible explanation is that the goat samples analyzed here may have originated from fatter carcasses, older animals, or cuts with more visible or intermuscular fat, since goat carcasses can sometimes appear lean externally while still showing appreciable intermuscular fat. In addition, sample trimming procedures and the anatomical location of the tissue analyzed can markedly alter measured fat values.

The relatively low fat content of chicken meat obtained in this study is in agreement with reports that some chicken muscles, especially depending on breed and cut, can be comparatively low in fat. Nigerian data comparing livestock meats also showed variability in fat content among species and cuts, with lower fat values reported in some chicken samples than in red meats. However, the present result does not agree with every study, because other comparative work on meat products has shown beef and chicken samples with relatively higher fat values than goat-based samples. This inconsistency confirms that fat content is one of the most variable proximate traits in meat and is highly influenced by breed, feeding intensity, slaughter age, and whether breast, thigh, loin, or mixed muscle was used for analysis.

Ash content was highest in beef (4.76), slightly lower in chevon (4.69), and lowest in chicken meat (4.23), and the differences were significant ($P < 0.05$). Because ash represents the total mineral residue following incineration, the result suggests that beef contained the greatest overall mineral matter among the meat types studied. This is biologically reasonable and is broadly consistent with the view that ash content varies among species and muscles depending on mineral deposition and tissue characteristics. Some previous studies have likewise found significant differences in ash among meat types and breeds, while reviews of goat meat composition report that ash content usually varies with genotype and feeding background. In contrast, other studies have shown only small differences in ash content across species, especially when similar cuts are analyzed. The present finding that beef exceeded chicken and chevon in ash therefore supports the idea that red meat may provide a stronger total mineral contribution in certain contexts, even though the specific minerals responsible may differ Moisture content also differed significantly among treatments. Chicken meat had the highest value (4.63), beef had the lowest (3.20), while chevon was intermediate (3.99). Based on the superscripts shown in the table, chicken meat and chevon appear not to differ significantly from each other, whereas beef was lower. In general, moisture and fat are often inversely related in meat, such that tissues with lower fat tend to have higher moisture. This inverse relationship fits the current data reasonably well, since chicken meat had the lowest fat value and the highest moisture value, whereas beef had lower moisture than chicken. Published meat-composition studies consistently show that moisture is one of the principal constituents of muscle and that differences among species are expected. For example, comparative reports have found higher moisture in some beef samples than in other meats, while other studies have shown goat meat moisture commonly ranging from about 73–79% depending on sex, diet, and cut. The fact that the present ranking does not fully match every published result further emphasizes that moisture is strongly affected by muscle type, water-holding capacity, fat level, and sample handling. Taken together, the results of Table 3 indicate that chicken meat in this study was characterized by superior crude protein and moisture values and the lowest fat content, suggesting a nutritionally favorable profile. Beef was distinguished by the highest ash content, indicating a comparatively stronger total mineral residue, while chevon recorded the highest fat value, which contrasts with the common literature description of goat meat as lean. This discrepancy does not invalidate the result; rather, it highlights the extent to which proximate composition depends on the origin of the samples, carcass characteristics, and analytical procedures. Overall, the table confirms that proximate composition differs significantly among meat types and that these differences can influence both nutritional interpretation and consumer preference.

CONCLUSION

This study showed that chicken, beef and chevon differ significantly in their proximate composition, mineral content and oxidative stability. Chicken meat had the highest protein and antioxidant activity, beef was richer in minerals, while chevon recorded higher fat content. These variations highlight that each meat type offers distinct nutritional advantages and can contribute differently to human dietary needs.

RECOMMENDATIONS

i. Consumers should choose meat based on nutritional needs (e.g., chicken for high protein, beef for minerals).
ii. Further studies should investigate factors influencing fat content in chevon.
iii. Improved handling and storage practices are recommended to maintain meat quality and oxidative stability.

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