



PROXIMATE COMPOSITION, MINERAL CONTENT AND SENSORY EVALUATION OF BEEF AND MUTTON MEAT PRODUCTS

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ABSTRACT

This study evaluated the proximate composition, mineral content and sensory characteristics of beef and mutton products. Fresh beef and mutton were sourced from Muda Lawal Market, Bauchi State and processed into fried and *dambu* products using standard preparation procedures. Samples were analyzed for proximate and mineral composition using standard analytical methods, while sensory evaluation was conducted by twenty (20) panelists using a 9-point hedonic scale. Data obtained were analyzed using a factorial arrangement with meat type and processing method as the main factors, and means were separated at 5% level of significance using Duncan's Multiple Range Test. The results showed that, beef had significantly ($P<0.001$) higher dry matter (95.63%), calcium (1749.70 mg/kg), zinc (76.40 mg/kg), chlorine (198.76 mg/kg), and sulphur (38.87 mg/kg) than mutton. Mutton contained higher moisture (6.02%), protein (49.08%), ash (5.47%), nitrogen-free extract (27.12%), and silicon (4.10 mg/kg). Processing method significantly influenced most quality parameters. Fried products had higher protein (53.52%), calcium (1780.90 mg/kg), iron (91.95 mg/kg), zinc (67.01 mg/kg), and sulphur (38.59 mg/kg), while *dambu* products contained lower moisture (4.63%), higher nitrogen-free extract (28.18%), and superior tenderness (8.37) and texture (8.40) scores. Interaction effects were significant only for ether extract ($P<0.01$), iron ($P<0.05$), and sulphur ($P<0.01$), while most other proximate, mineral, and sensory parameters were not significantly affected by the interaction between meat type and processing method. Sensory evaluation revealed a high consumer acceptance for all products, with overall acceptability values ranging from 8.50 to 8.65 on the 9-point hedonic scale. The study concluded that processing methods exerted a greater influence on product quality than meat type, particularly for protein, mineral composition, tenderness and texture. It was recommended that fried and *dambu* meat products be promoted as nutritious value-added meat products for improving dietary protein intake. Standardization of processing techniques should be encouraged to ensure consistent nutritional quality and consumer acceptability as well as increasing its shelf life.

Keywords: Beef, Mutton, Sensory, Evaluation, *Dambu*, Fried-meat

INTRODUCTION

Meat and meat products constitute an essential component of human diets across the globe, providing a dense source of nutrients required for growth, development, and maintenance of body functions. In recent years, increasing attention has been directed toward understanding the nutritional composition and quality attributes of meat, particularly in developing countries where protein deficiency remains a public health concern. Meat is widely recognized for high biological value of it protein, essential amino acids, vitamins (especially B-complex), and minerals such as iron, zinc, and selenium, which are highly bioavailable compared to plant sources (Stadnik, 2024). This underscores the importance of evaluating meat products not only for their proximate composition but also for their mineral content and sensory qualities. Proximate composition analysis is a fundamental approach used to determine the nutritional value of food materials by quantifying major components such as moisture, crude protein, fat, ash, and carbohydrates. These parameters provide insight into the energy value, storage stability, and overall quality of meat products.

According to Datti *et al.* (2020), proximate composition serves as a reliable indicator of meat quality and is essential for assessing compliance with nutritional standards as well as consumer expectations. In meat science, variations in proximate composition are influenced by factors such as animal species, age, feeding regime, and processing methods. Beef and mutton are among the most widely consumed red meats globally and are particularly important in Nigeria due to their availability



and cultural acceptance. Beef, obtained from cattle, is known for its tenderness and relatively lower fat variability, while mutton, derived from sheep, is valued for its distinctive flavor and higher fat content. Studies have shown that both beef and mutton are rich in essential nutrients, though their composition differs significantly depending on physiological and environmental factors (Ding *et al.*, 2024). These differences make comparative evaluation necessary, especially when processed into various traditional and modern meat products. Processing of meat into value-added products such as *dambu* and fried meat forms is an important strategy for improving shelf life, enhancing palatability, and increasing consumer acceptability.

Meat processing also contributes to food security by reducing post-harvest losses and enabling diversification of meat-based diets. Iyiola and Obialigwe (2025) reported that processing methods such as roasting and frying significantly influence both the proximate composition and sensory attributes of meat products, thereby affecting their nutritional and market value. Consequently, understanding how different processing techniques affect meat quality is critical for optimizing product development. *Dambu*, a traditional Nigerian shredded meat product, is gaining increasing attention due to its convenience, extended shelf life, and unique sensory characteristics. It is typically prepared by cooking, shredding, spicing, and drying meat, resulting in a product that is rich in flavor and suitable for storage under ambient conditions. Variants such as beef *dambu* and mutton *dambu*, as well as fried forms, provide diverse options for consumers. However, limited scientific data exist on the comparative nutritional composition and sensory properties of these products, necessitating further research.

Mineral content is another aspect of meat quality that contributes significantly to human nutrition. Minerals such as iron, zinc, calcium, phosphorus, and potassium play crucial roles in physiological processes including oxygen transport, bone formation, enzyme function, and immune response. Meat is particularly valued as a source of heme iron, which is more readily absorbed by the human body than non-heme iron from plant sources (Stadnik, 2024). Evaluating the mineral composition of meat products is therefore essential for determining their contribution to dietary requirements. In addition to chemical composition, sensory evaluation is a critical component in assessing the quality and acceptability of meat products. Sensory attributes such as color, flavor, tenderness, juiciness, and overall acceptability influence consumer preference and purchasing decisions. Sensory analysis involves trained panelists who evaluate products using standardized scales. According to Murlykina (2025), sensory evaluation provides valuable information on the functional and organoleptic properties of meat products, complementing laboratory-based nutritional analyses. The integration of proximate composition, mineral analysis, and sensory evaluation provides a comprehensive assessment of meat product quality. The study was therefore carried out to evaluate the proximate composition, mineral content, and sensory characteristics of beef and mutton meat products.

MATERIALS AND METHODS

Study Area

The study was conducted in Bauchi metropolis, Bauchi State, Nigeria, located between latitudes 9°30'–12°30'N and longitudes 8°50'–11°00'E. Bauchi State lies within the Sudan savannah ecological zone and experiences distinct wet (May–October) and dry (November–April) seasons, with annual rainfall ranging from 800 to 1,300 mm and temperatures between 25 and 40°C (NiMet, 2023). The metropolis is a major commercial centre with active livestock markets, abattoirs, and meat processing activities, making it suitable for studies involving beef and mutton products.

Source of Experimental Materials

Fresh beef and mutton were purchased from Muda Lawal Market, Bauchi State. Ten (10) kg of meat (5 kg each of beef and mutton) was obtained from freshly slaughtered, healthy animals. The samples were transported in insulated containers under hygienic conditions. Other ingredients, including vegetable oil, onions, salt, and spices, were also purchased from the same market.

Sample Preparation and Processing

Visible fat, bones, and connective tissues were removed from the meat samples before washing with potable water and draining. The samples were divided into four treatment groups: A – Beef *dambu*, B – Fried beef, C – Mutton *dambu* and D – Fried mutton



Preparation of Meat Products

Dambu

The meat was cut into small pieces, boiled until tender, manually shredded into fine fibres, and dried under controlled conditions until the characteristic dry, fibrous texture of dambu was achieved.

Fried Meat

The meat was cut into uniform pieces, lightly seasoned, and deep-fried in preheated vegetable oil at approximately 150°C until golden brown. The fried samples were drained to remove excess oil.

Laboratory Analysis

Proximate and mineral analyses were carried out at the Soil, Water and Plant Analytical Laboratory (SWAPAL), Abubakar Tafawa Balewa University, Bauchi, following standard procedures of AOAC (2019) and AOAC (2016) respectively.

Proximate Analysis

The following parameters were determined: Dry matter and moisture by oven drying at 105°C, crude protein using the Kjeldahl method ($N \times 6.25$), ether extract using Soxhlet extraction, ash by incineration in a muffle furnace at 550°C and nitrogen-free extract (NFE) was calculated by difference.

Mineral Analysis

Calcium, magnesium, iron, zinc, potassium, and sodium were determined using Atomic Absorption Spectrophotometry (AAS). Phosphorus was determined by the vanadomolybdate colorimetric method, sulphur by the turbidimetric method, chlorine by argentometric titration, and silicon by the colorimetric method. Mineral concentrations were expressed as mg/kg.

Sensory Evaluation

Sensory evaluation was conducted using 20 semi-trained panelists comprising staff and students of Bauchi State College of Agriculture. The coded meat samples were presented in a randomized order, and clean drinking water was provided between samples to minimize carry-over effects. The samples were evaluated for: Colour, flavour, tenderness, juiciness, texture and overall acceptability. A 9-point hedonic scale was used, where 9 = Like extremely and 1 = Dislike extremely.

Experimental Design and Statistical Analysis

The experiment was arranged in a 2×2 factorial design consisting of two meat types (beef and mutton) and two processing methods (fried meat and dambu). Data were analyzed using Analysis of Variance (ANOVA) in SPSS version 29. Where significant differences occurred, means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

RESULTS AND DISCUSSION

Effect of Meat Types and Products on Proximate Composition

The results of the effect of meat type and processing methods on proximate composition of meat products showed a significant variation in most of the evaluated parameters. Differences observed between mutton and beef could be attributed to species variation, muscle characteristics, breed, feeding conditions, age, and differences in fat deposition patterns. According to Lawrie and Ledward (2014), the chemical composition of meat is influenced by several biological factors including species and muscle physiology, which ultimately affect the nutritional quality of meat. The dry matter content was significantly ($P < 0.001$) higher in beef (95.63%) as compared to mutton (92.97%). The higher dry matter content in beef indicates a relatively greater concentration of nutrients due to reduced moisture proportion. This observation agrees with the findings of Datti *et al.* (2020), who reported variations in proximate composition of beef samples due to differences in animal characteristics and processing conditions. Moisture content differed significantly ($P < 0.05$) between the meat types, with mutton recording a higher value (7.03%) compared with beef (4.37%). Moisture is a quality attribute of meat because it affects storage stability, texture, and microbial growth. This observation may be due to variation in muscle structure and water-holding capacity between sheep and cattle meat.

The crude protein content was significantly higher ($P < 0.001$) in mutton (49.08%) compared with beef (47.99%). The higher protein concentration in mutton suggests greater deposition of muscle protein relative to other components. Ahmad *et al.* (2018) stated that meat is a source of high-quality protein, and variations in protein content among meat species are related to differences in muscle



composition, animal maturity and nutritional status. Similarly, Tanko *et al.* (2024) reported differences in proximate composition among traditional shredded meat products prepared from different meat sources, indicating the influence of meat type on protein composition. Ether extract content was significantly different ($P<0.001$) between mutton (13.97%) and beef (14.01%), although the difference was numerically small. The slightly higher fat content in beef may be associated with species differences in fat accumulation and intramuscular lipid deposition. Wood *et al.* (2008) explained that fat deposition in meat is influenced by genetic factors, diet, age and production system, which consequently affects the nutritional composition and quality of meat. Ash content was significantly higher ($P<0.001$) in mutton (5.47%) compared with beef (5.20%), suggesting a slight variation in mineral concentration between the two meat types. Ash content represents the total inorganic mineral fraction of meat, and differences may arise from variation in mineral metabolism, dietary intake and muscle composition. Similar differences in mineral and proximate composition of meat sources have been reported by Umar (2024) in raw meat and processed meat products. Nitrogen free extract (NFE) was significantly higher ($P<0.001$) in mutton (27.12%) than beef (21.52%). Since NFE is obtained by calculation after subtracting moisture, protein, fat and ash contents from total composition, its variation reflects changes in other proximate components. The higher NFE value in mutton may therefore be associated with its lower fat and higher protein-mineral balance compared with beef.

The processing method significantly influenced most proximate parameters except dry matter and ether extract. Moisture content was significantly ($P<0.01$) higher in fried meat (6.01%) compared with *Dambu* (5.39%). The lower moisture content observed in *Dambu* may be due to the prolonged drying and shredding process involved in its preparation, which promotes moisture reduction. Eke *et al.* (2012) reported that the production process of *Dambu*-nama involves dehydration, which contributes to changes in moisture and nutrient concentration. Crude protein content differed significantly ($P<0.001$) between processing methods, with fried meat recording a higher value (53.52%) compared with *Dambu* (52.43%). The increased protein concentration in fried meat may be related to moisture loss during heating, resulting in nutrient concentration. Tornberg (2005) explained that heat treatment alters meat protein structure and can influence the chemical composition and quality attributes of meat products. Ether extract was not significantly affected by processing method, although *Dambu* recorded a slightly higher value (14.01%) than fried meat (13.97%). This indicates that both processing methods had similar effects on fat retention. However, changes in fat content during cooking may depend on processing temperature, duration and fat migration. Olanihun *et al.* (2023) reported that different cooking methods influence nutrient retention and quality attributes of meat products. Ash content was significantly higher ($P<0.001$) in fried meat (5.82%) compared with *Dambu* (5.20%). The higher ash content in fried meat may be due to concentration of mineral components following moisture reduction during frying. Similar effects of processing methods on nutrient concentration have been reported by Wang *et al.* (2023), who noted that processing conditions affect protein, lipid and other nutritional components of meat products. The NFE content was significantly higher in *Dambu* (28.18%) compared with fried meat (20.46%). This difference may be due to variations in moisture loss and changes in other proximate fractions during processing. Since NFE is calculated by difference, any increase or reduction in protein, fat, moisture or ash directly affects its value.

Table 1: Effect of Meat Type and Processing Method on Proximate Composition

Parameters (%)	Meat types			Processing Method		LOS
	Mutton	Beef	LOS	Fried	<i>Dambu</i>	
DM	92.97	95.63	***	93.99	94.61	NS
Moisture	7.03	4.37	*	6.01	5.39	**
Protein	49.08	47.99	***	53.52	52.43	***
Ether extract	13.97	14.01	***	13.97	14.01	NS
Ash	5.47	5.20	***	5.82	5.20	***
NFE	27.12	21.52	***	20.46	28.18	***

* $P<0.05$, ** $P<0.01$, *** $P<0.001$, NS = Not significant ($P>0.05$)



Interaction of Meat Types and Processing Method on Proximate Composition

The interaction effect of meat types and processing methods on the proximate composition of meat products is presented in Table 2. The results revealed that, the interaction between meat type and processing method was not significant ($P>0.05$) for dry matter, moisture, crude protein, ash and nitrogen free extract, while ether extract was significantly affected ($P<0.01$). This indicated that although both meat type and processing method independently influenced some proximate parameters, their combined effect was only pronounced on fat content. The dry matter content was also not significantly affected by the interaction between meat type and processing method, although numerically higher values were observed in mutton *Dambu* (95.86%) and mutton fried meat (95.40%) compared with beef *Dambu* (93.36%) and beef fried meat (92.58%). The higher dry matter values in mutton products suggest a relatively greater concentration of nutrients, possibly due to lower moisture retention and differences in muscle composition. According to Lawrie and Ledward (2014), variations in meat composition among species are associated with differences in muscle structure, physiological characteristics and nutrient deposition. Moisture content was not significantly affected by the interaction effect, but fried beef recorded the highest value (7.42%), while mutton *Dambu* had the lowest moisture content (3.80%). The lower moisture content observed in mutton *Dambu* may be attributed to the dehydration effect associated with *Dambu* preparation, which involves shredding and drying of meat. Eke *et al.* (2012) reported that *Dambu*-nama production reduces moisture content through drying processes, thereby improving storage stability. Similarly, Honikel (2004) noted that water retention characteristics of muscles influence the final moisture content and quality of processed meat products.

Crude protein content was not significantly affected by the interaction between meat type and processing method. However, mutton fried meat recorded the highest protein value (55.49%), followed by beef fried meat (51.54%), while beef *Dambu* recorded the lowest value (46.51%). The higher protein concentration in fried products may be related to moisture reduction during heating, resulting in apparent concentration of nutrients. Tornberg (2005) explained that heat processing affects meat protein structure and influences the nutritional characteristics of meat products. The higher protein content observed in mutton products may also reflect species differences in muscle protein composition. Ether extract was significantly influenced ($P<0.01$) by the interaction between meat type and processing method. Mutton *Dambu* (15.92%) and mutton fried meat (14.89%) recorded significantly higher fat contents compared with fried beef (13.07%) and beef *Dambu* (12.10%). The higher lipid concentration in mutton products may be associated with differences in fat deposition patterns between sheep and cattle. Wood *et al.* (2008) reported that species, breed, feeding system and age influence intramuscular fat accumulation and consequently affect the lipid composition of meat. The lower ether extract values observed in beef *Dambu* may also be related to fat loss during processing.

Ash content was not significantly affected by the interaction effect, although fried mutton recorded the highest value (6.17%), while beef *Dambu* recorded the lowest (4.94%). The slightly higher ash content in mutton products suggests possible differences in mineral deposition between species. Umar (2024) reported that variations in mineral composition among meat sources may occur due to differences in animal species and processing conditions. Nitrogen free extract was not significantly affected by the interaction between meat type and processing method. However, beef *Dambu* recorded the highest NFE value (30.89%), followed by mutton *Dambu* (25.46%), while fried mutton had the lowest value (17.58%). Since NFE is estimated by difference, variations in protein, fat, moisture and ash contents influence its final value. The higher NFE observed in *Dambu* products may be related to greater changes in other proximate components during processing. The non-significant interaction effects observed for most parameters indicate that the influence of processing method on proximate composition was relatively consistent across the two meat types. However, the significant interaction effect on ether extract demonstrates that fat content responded differently depending on the combination of meat source and processing technique. Similar findings have been reported by Olanihun *et al.* (2023), who observed that cooking and processing methods modify nutrient composition differently depending on the meat source.

Table 2: Interaction of Meat type and Processing Method on Proximate Composition

Parameters (%)	Beef		Mutton		SEM
	Fried	Dambu	Fried	Dambu	
DM	92.58	93.36	95.40	95.86	0.33 ^{NS}
Moisture	7.42	6.64	4.60	4.14	0.39 ^{NS}
Protein	51.54	46.51	55.49	49.37	0.39 ^{NS}
Ether Extract	13.07 ^b	12.10 ^c	14.89 ^a	15.92 ^a	0.22 ^{**}
Ash	5.47	4.94	6.17	5.46	0.10 ^{NS}
NFE	23.33	30.89	17.58	25.46	0.54 ^{NS}

abc: means bearing the same superscript within rows are similar; ** P<0.01; SEM-standard error of means; NS= Not significant (P>0.05)

Effect of Meat Type and Processing Method on Mineral Content Parameters

The mineral composition of mutton and beef as affected by meat type and processing method is presented in Table 3. The results showed a significant difference (P<0.001) between meat types for calcium, zinc, silicon, chlorine and sulphur, while iron was significantly different at (P<0.01). However, potassium, magnesium, phosphorus and sodium were not significantly affected by meat type. The observed differences may be attributed to species variation, muscle metabolism, age of animals, feeding system and mineral deposition patterns. According to Lawrie and Ledward (2014), mineral composition of meat varies among animal species due to differences in physiological functions and nutrient accumulation in tissues. Calcium content differed significantly (P<0.001) between meat types, with beef recording a higher value (1749.70 mg/kg) compared with mutton (1619.70 mg/kg). Calcium is an essential mineral involved in bone development, muscle contraction and cellular regulation. The higher calcium concentration observed in beef may be related to differences in mineral absorption and deposition between cattle and sheep. Similar variations in mineral contents among meat sources have been reported by Umar (2024), who observed differences in mineral composition of raw meat and processed meat products from different animal sources. Potassium content was not significantly influenced by meat type, although mutton recorded a higher value (1343 mg/kg) compared with beef (1113 mg/kg). Potassium is intracellular electrolyte involved in fluid balance, nerve transmission and muscle function. Weaver (2013) reported that meat contributes significantly to dietary potassium intake, although the concentration may vary depending on animal species and tissue composition. Magnesium content did not differ significantly between mutton (2247 mg/kg) and beef (2231 mg/kg), although mutton recorded a numerically higher value. Magnesium function in enzyme activation, energy metabolism and muscle function. The numerical differences may be associated with variation in muscle activity and mineral deposition among species. Iron concentration differed significantly (P<0.01), with beef having a higher value (84.29 mg/kg) than mutton (79.25 mg/kg).

Iron is a component of haemoglobin and myoglobin, making meat one of the major dietary sources of bioavailable iron. Hallberg and Hulthén (2000) emphasized that meat contributes significantly to iron nutrition because of the high bioavailability of haem iron. The slightly higher iron content in beef may be related to differences in muscle pigmentation and myoglobin concentration. Zinc content differed significantly (P<0.001), with beef recording a higher value (76.40 mg/kg) compared with mutton (49.27 mg/kg). Zinc is used in immune function, enzyme activity, growth and reproduction. Prasad (2013) reported that zinc is an essential micronutrient required for normal physiological functions, and animal products remain valuable sources of dietary zinc. Phosphorus content was not significantly affected by meat type, although mutton recorded a higher value (24741 mg/kg) than beef (1805 mg/kg). Phosphorus is used in energy metabolism, bone formation and cellular functions. The observed numerical differences may be influenced by variations in muscle composition and mineral distribution. Sodium content was not significantly different between mutton (1528 mg/kg) and beef (1544 mg/kg), although beef recorded a higher numerical value. Sodium concentration in meat may depend on animal diet, processing conditions and environmental factors. Greenfield and Southgate (2003) reported that mineral composition of foods is influenced by biological and environmental factors affecting nutrient accumulation. Silicon content differed significantly (P<0.001), with mutton recording

a higher value (4.10 mg/kg) compared with beef (2.10 mg/kg). Similarly, chlorine and sulphur contents were significantly higher in beef (198.76 mg/kg and 38.87 mg/kg, respectively) compared with mutton (162.62 mg/kg and 29.53 mg/kg). These variations may be related to differences in mineral metabolism and tissue composition between sheep and cattle. Regarding processing methods, significant differences were observed for calcium, iron, zinc, silicon, chlorine and sulphur contents. Fried meat recorded higher calcium (1780.9 mg/kg), iron (91.95 mg/kg), zinc (67.01 mg/kg), chlorine (191.95 mg/kg) and sulphur (38.59 mg/kg) values compared with *Dambu*. The higher mineral concentration in fried meat may be attributed to moisture reduction during frying, which increases the concentration of minerals per unit weight. Olanihun *et al.* (2023) reported that processing methods influence nutrient concentration and quality characteristics of meat products. *Dambu* recorded a higher silicon content (3.81 mg/kg) compared with fried meat (2.39 mg/kg). This may be associated with differences in processing conditions, particularly the drying and shredding process involved in *Dambu* preparation. The retention or concentration of certain minerals during processing depends on processing duration, temperature and moisture loss.

Table 3: Effect of Meat type and Processing Method on Mineral Content

Parameters (mg/kg)	Meat types			Processing		method
	Mutton	Beef	LOS	Fried	<i>Dambu</i>	LOS
Calcium	1619.70	1749.70	***	1780.9	1588.4	***
Potassium	1343	1113	NS	1415	1324	NS
Magnesium	2247	2231	NS	2010	2028	NS
Iron	79.25	84.29	**	91.95	71.22	***
Zinc	49.27	76.40	***	67.01	58.67	***
Phosphorus	1741	1805	NS	1350	1344	NS
Sodium	1528	1544	NS	1519	1510	NS
Silicon (Si)	4.10	2.10	***	2.39	3.81	***
Chlorine (Cl)	162.62	198.76	***	191.95	169.42	***
Sulphur (S)	29.53	38.87	***	38.59	29.81	***

** P<0.01, *** P<0.001, NS = Not significant; LOS-Level of significant

Interaction of Meat Type and Processing Method on Mineral Content Parameters

The interaction effect of meat types and processing methods on the mineral composition of meat products is presented in Table 4. The results showed that, interaction between meat type and processing method significantly influenced iron (P<0.05) and sulphur (P<0.01), while calcium, potassium, magnesium, zinc, phosphorus, sodium, silicon and chlorine were not significantly affected (P>0.05). The observed differences indicated that, influence of processing method on mineral composition depends on the type of meat used. Calcium content was not significantly affected by the interaction effect, although fried mutton recorded the highest value (1843.3 mg/kg), followed by fried beef (1718.6 mg/kg), while beef *Dambu* recorded the lowest value (1520.9 mg/kg). The higher calcium values observed in fried products may be associated with moisture loss during frying, which results in concentration of minerals in the final product. Calcium plays essential roles in skeletal development, muscle contraction and physiological regulation. Variations in calcium concentration among meat products may arise from differences in animal species, muscle characteristics and processing conditions (Lawrie and Ledward, 2014). Potassium content was not significantly influenced by the interaction between meat type and processing method. However, fried mutton recorded a notably higher value (1086 mg/kg) compared with beef fried meat (1419 mg/kg), beef *Dambu* (1267 mg/kg) and mutton *Dambu* (1382 mg/kg). Potassium is an intracellular mineral involved in fluid balance and muscle activity. Weaver (2013) reported that meat contributes to dietary potassium supply, although the concentration varies according to animal source and tissue composition.

Magnesium content was not significantly affected by the interaction effect, but fried mutton recorded the highest value (2367 mg/kg), followed by mutton *Dambu* (2095 mg/kg), while fried beef had the lowest value (1862 mg/kg). Magnesium is involved in energy metabolism, enzyme activity and

muscle function. The numerical variation observed may be due to differences in mineral deposition between sheep and cattle muscles. Iron content was significantly affected ($P < 0.05$) by the interaction between meat type and processing method. Fried mutton (92.37 mg/kg) and fried beef (91.33 mg/kg) recorded significantly higher values compared with mutton *Dambu* (76.22 mg/kg), while beef *Dambu* recorded an intermediate value (89.16 mg/kg). The higher iron content in fried products may be attributed to concentration effects resulting from moisture reduction during frying. Iron is a component of haemoglobin and myoglobin, and meat remains one of the major sources of highly available haem iron (Hallberg and Hulthén, 2000). The reduction observed in *Dambu* products may be related to processing losses or redistribution of minerals during drying. Zinc content was not significantly influenced by the interaction effect, although fried beef recorded the highest value (83.08 mg/kg), followed by fried mutton (80.93 mg/kg). Zinc works in immune response, growth, reproduction and enzyme functions. Prasad (2013) reported that animal-derived foods are contributors of zinc in human diets, with variation occurring due to animal species and production factors. Phosphorus content was not significantly affected by the interaction between meat type and processing method. However, fried mutton recorded the highest value (1605 mg/kg), while beef *Dambu* had the lowest value (1284 mg/kg). Phosphorus is essential for energy metabolism, cellular function and bone development. Differences observed among treatments may be associated with variations in mineral deposition and processing-related changes. Sodium content was not significantly affected by the interaction effect. Beef *Dambu* recorded the highest sodium content (1743 mg/kg), while fried beef had the lowest value (1406 mg/kg). Sodium concentration in meat products may be influenced by animal diet, processing procedures and possible addition of ingredients during preparation. Greenfield and Southgate (2003) noted that mineral composition of foods is affected by both biological and processing factors. Silicon content was not significantly influenced by the interaction, although beef *Dambu* recorded the highest value (4.78 mg/kg), while mutton fried meat had the lowest value (1.36 mg/kg). The variation may be related to differences in mineral accumulation and processing conditions. Chlorine content was not significantly affected by the interaction effect, although fried mutton recorded the highest value (211.98 mg/kg), followed by mutton *Dambu* (168.53 mg/kg), fried beef (171.92 mg/kg) and beef *Dambu* (153.31 mg/kg). The observed differences may be linked to species variation and processing effects on mineral concentration. Sulphur content was significantly affected ($P < 0.01$) by the interaction effect. Fried mutton recorded the highest value (45.27 mg/kg), followed by mutton *Dambu* (32.47 mg/kg), fried beef (31.92 mg/kg), while beef *Dambu* had the lowest value (27.14 mg/kg). Sulphur is associated with sulphur-containing amino acids such as methionine and cysteine, which contribute to protein structure and biological functions. The higher sulphur content observed in fried mutton may be related to its higher protein concentration and differences in amino acid composition.

Table 4: Interaction of Meat Type and Processing Method on Mineral Content

Parameter (mg/kg)	Beef		Mutton		SEM
	Fried	<i>Dambu</i>	Fried	<i>Dambu</i>	
Calcium	1718.6	1520.9	1843.3	1536.0	15.72 NS
Potassium	1419	1267	1086	1382	11.11 NS
Magnesium	1862	1961	2367	2095	17.86 NS
Iron	91.33 ^a	89.16 ^b	92.37 ^a	76.22 ^b	1.48 *
Zinc	83.08	45.47	80.93	71.87	0.95 NS
Phosphorus	1419	1284	1605	1404	12.94 NS
Sodium	1406	1743	1632	1684	20.28 NS
Silicon	3.41	4.78	1.36	2.84	0.10 NS
Chlorine	171.92	153.31	211.98	168.53	2.01 NS
Sulphur	31.92 ^b	27.14 ^c	45.27 ^a	32.47 ^b	0.74 **

abc: means bearing the same superscript within rows are similar; * $P < 0.05$; ** $P < 0.01$, SEM-standard error of means; NS-Not significant



Effects of Meat Types and Processing on Sensory Evaluation Parameters

The sensory evaluation results of meat types and products as presented in Table 5 showed that, meat type did not significantly influence ($P>0.05$) tenderness, juiciness, colour, palatability, flavour, acceptability and texture. However, processing method significantly affected tenderness and texture ($P<0.001$). The absence of significant differences among meat types suggests that both mutton and beef products were generally comparable in sensory quality and were accepted similarly by the panelists. Tenderness is one of the sensory attributes determining consumer preference for meat products. The result showed that, beef (8.12) had a slightly higher tenderness score compared with mutton (7.85), although the difference was not significant. This slight variation may be associated with differences in muscle fibre characteristics, connective tissue content, animal age and post-processing changes. According to Mörlin (2019), tenderness perception is influenced by structural changes in muscle proteins, connective tissue breakdown and processing conditions. The high tenderness scores recorded for both meat types indicate that the processing techniques used were effective in improving eating quality. Juiciness scores were not significantly different between mutton (8.45) and beef (8.42). The similarity shows that both meat types retained comparable moisture levels and water-holding properties after processing. Juiciness is affected by moisture retention, intramuscular fat and cooking method. Iwe (2010) reported that sensory characteristics such as juiciness are influenced by both physical properties of food and the perception of consumers during evaluation. Colour evaluation showed no significant difference between mutton (8.63) and beef (8.20). Although mutton recorded a slightly higher score, both values indicate good colour acceptance by the panelists. Meat colour is influenced by myoglobin concentration, oxidation reactions and processing conditions. Font-i-Furnols and Guerrero (2014) reported that colour is one of the major visual attributes influencing consumer acceptance and purchasing decisions for meat products.

Palatability scores were not significantly affected by meat type, with mutton recording 8.58 and beef 8.43. The similar scores indicate that both products had comparable overall eating quality. Palatability is a combined perception influenced by tenderness, flavour, juiciness and texture. Meilgaard *et al.* (2016) explained that sensory acceptability represents the interaction of several sensory attributes rather than a single characteristic. Flavour scores were also not significantly different between mutton (8.55) and beef (8.50). The close values suggest that the processing methods produced acceptable flavour characteristics in both meat types. Meat flavour develops from interactions between proteins, fats and heat-induced chemical reactions during cooking. Mottram (1998) reported that flavour formation in meat products results from complex reactions involving lipid oxidation and Maillard reactions during heating. Acceptability was not significantly influenced by meat type, with beef recording a slightly higher value (8.58) than mutton (8.55). This indicates that panelists had similar preference for both meat products. Similar observations have been reported by Gambo *et al.* (2010), who noted that consumer preference for different ruminant meat types is influenced by sensory perception, cultural preference and product quality. Regarding processing methods, tenderness was significantly higher ($P<0.001$) in *Dambu* (8.37) compared with fried meat (7.60). The improved tenderness observed in *Dambu* may be due to the prolonged heating, shredding and drying process, which may reduce muscle fibre toughness and improve ease of chewing. Bashir *et al.* (2016) reported that *Dambu* processing influences sensory characteristics, including tenderness and overall acceptance. Juiciness, colour, palatability, flavour and acceptability were not significantly affected by processing method. However, *Dambu* recorded slightly higher scores for most parameters, suggesting better sensory preference. The higher acceptance of *Dambu* may be associated with its traditional preparation method, which enhances flavour development and improves product characteristics. Yusuf and Gambo (2024) reported that standardization of *Dambu* preparation influences sensory quality and consumer acceptability. Texture was significantly affected ($P<0.001$) by processing method, with *Dambu* recording a higher value (8.40) compared with fried meat (7.30). The improved texture of *Dambu* may be attributed to shredding and drying processes that modify meat structure and create a desirable mouthfeel. Omojola (2008) reported that processing techniques used in traditional meat products influence texture and sensory characteristics.

Table 5: Main Effects of Meat Type and Processing Method on Sensory Evaluation Parameters

Parameter	Meat types			Processing		Method
	Mutton	Beef	LOS	Fried	Dambu	LOS
Tenderness	7.85	8.12	NS	7.60	8.37	***
Juiciness	8.45	8.42	NS	8.35	8.52	NS
Colour	8.63	8.20	NS	8.55	8.27	NS
Palatability	8.58	8.43	NS	8.53	8.48	NS
Flavour	8.55	8.50	NS	8.70	8.35	NS
Acceptability	8.55	8.58	NS	8.55	8.58	NS
Texture	7.93	7.78	NS	7.30	8.40	***

*** $P < 0.001$, NS = Not significant ($P > 0.05$); LOS-Level of significance

Interaction of Meat Type and Processing Method on Sensory Evaluation Parameters

The interaction effect of meat type and processing methods on sensory parameters is presented in Table 6. The results showed that, interaction between meat type and processing method did not significantly influenced ($P > 0.05$) tenderness, juiciness, colour, palatability, flavour, acceptability and texture. This indicates that the sensory characteristics of the meat products were generally similar regardless of the combined effect of meat source and processing method. The absence of significant interaction suggests that the processing techniques applied produced consistent sensory qualities across both beef and mutton products. Tenderness scores were not significantly affected by the interaction effect, although mutton *Dambu* recorded the highest value (8.65), followed by beef *Dambu* (8.10), while both fried products recorded lower values (7.60). The higher tenderness observed in *Dambu* products may be attributed to the shredding and prolonged heating process, which may reduce muscle fibre resistance and improve ease of chewing. Mörlein (2019) reported that tenderness perception in meat products is influenced by muscle structure, connective tissue properties and processing conditions. The similar tenderness scores between beef and fried mutton indicate that frying produced comparable effects on meat texture. Juiciness was not significantly influenced by the interaction between meat type and processing method. Beef *Dambu* recorded the highest score (8.55), while both fried products recorded similar values (8.35). The slightly higher juiciness observed in *Dambu* may be associated with moisture retention and processing conditions that limit excessive drying. According to Iwe (2010), juiciness is a sensory attribute influenced by moisture content, fat composition and the ability of meat proteins to retain water during processing. Colour scores were not significantly different among treatments, although fried beef recorded the highest value (8.80), followed by beef *Dambu* (8.45), fried mutton (8.30) and mutton *Dambu* (8.10). The higher colour score in fried beef suggests better visual appeal, which may be related to differences in pigment concentration and heat-induced colour changes. Font-i-Furnols and Guerrero (2014) stated that colour is one of the primary sensory characteristics influencing consumer perception and acceptance of meat products. Palatability was not significantly affected by the interaction effect. Fried beef had the highest score (8.65), while fried mutton had the lowest (8.40). The close scores among treatments indicate that both meat types and products had acceptable eating quality. Palatability represents the overall sensory impression resulting from the combination of flavour, tenderness, juiciness and texture. Meilgaard *et al.* (2016) explained that overall acceptance of food products depends on the interaction of multiple sensory attributes. Flavour scores were also not significantly affected by the interaction, although fried beef recorded the highest value (8.75), followed by fried mutton (8.65), while both *Dambu* products recorded similar values (8.35). The higher flavour scores observed in fried products may be related to flavour compounds produced during heating, including those formed through Maillard reactions and lipid-related reactions. Pateiro *et al.* (2022) noted that processing conditions contribute significantly to flavour development and sensory quality of meat products. Acceptability was not significantly influenced by the interaction effect, with mutton *Dambu* recording the highest value (8.65), followed by fried beef (8.60). The high acceptability scores across treatments indicate that all products were favourably perceived by panelists. Similar findings have been reported by Yusuf and Gambo (2024), who observed that traditional meat products can achieve high consumer acceptance when processing conditions enhance desirable sensory



attributes. Texture scores were also not significantly affected by the interaction effect, although *Dambu* products recorded higher values (beef *Dambu* = 8.35; mutton *Dambu* = 8.45) compared with fried products. The improved texture of *Dambu* may be associated with its shredding process, which alters muscle fibre arrangement and produces a softer product. Bashir *et al.* (2016) reported that processing methods influence texture and sensory quality of shredded meat products.

Table 6: Interaction of Meat Type and Processing Method on Sensory Parameters

Parameter	Beef		Mutton		SEM
	Fried	<i>Dambu</i>	Fried	<i>Dambu</i>	
Tenderness	7.60	8.10	7.60	8.65	NS
Juiciness	8.35	8.55	8.35	8.50	NS
Colour	8.80	8.45	8.30	8.10	NS
Palatability	8.65	8.50	8.40	8.45	NS
Flavour	8.75	8.35	8.65	8.35	NS
Acceptability	8.60	8.50	8.50	8.65	NS
Texture	7.50	8.35	7.10	8.45	NS

NS = Not significant ($P>0.05$); SEM-standard error of means

CONCLUSION AND RECOMMENDATIONS

The study concluded that both meat type and processing method significantly influenced the nutritional composition and sensory quality of processed meat products. Beef and mutton produced nutritionally rich and highly acceptable products, while fried processing enhanced some nutrient concentrations and *dambu* processing improved tenderness and texture. It was recommended that, both beef and mutton should be promoted for processed meat production using standardized processing methods to ensure consistent nutritional quality, product safety, and consumer acceptability. Further studies should investigate the effects of breed, age, feeding system, and muscle type on the nutritional and sensory qualities of processed meat products.

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