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Nutritional, physicochemical, and sensory evaluation of *dambu-nama*, a traditional shredded meat product, produced from camel meat, chevon, and pork

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ABSTRACT

This study evaluated the nutritional, physicochemical, and sensory qualities of *dambu-nama* produced from camel meat, chevon, and pork using three processing methods: boiled only (20 min at 100 °C), boiled then fried (soybean oil, 180 °C, ~20 min), and boiled then oven-dried (120 °C). Fresh samples (8 kg) from each meat type were analysed for proximate composition and physicochemical properties; final products were assessed for proximate, mineral, vitamin, and sensory attributes, in a completely randomized design (CRD), 3 × 3 factorial arrangement. Fresh camel meat exhibited the highest ($P < 0.05$) amount of protein (21.71 %), moisture (71.69 %), ash (2.16 %), calcium (9.70 mg/100g), potassium (274.50 mg/100g), and vitamins B_{12} (2.32 mg/100g), B_2 (0.57 mg/100g), and D (0.87 mg/100g). Boiled-then-oven-dried chevon had the highest protein overall ($P < 0.05$; 58.47 %), followed closely by boiled camel *dambu-nama* (58.12 %), while fried pork *dambu-nama* had the lowest protein (22.45 %). Generally, the boiled products obtained higher ether extract, while the fried products obtained lower protein content ($P < 0.05$). Sensory evaluation revealed that pork *dambu-nama* obtained the highest score for juiciness (6.85) and overall acceptability (7.20). Overall, chevon and pork *dambu-nama* exhibit nutritional and eating qualities comparable to camel *dambu-nama*.

Keywords: *dambu-nama*, camel, pork, chevon, processed meat

INTRODUCTION

Meat is regarded as one of the most nutrient-dense foods in the human diet, providing high-quality protein composed of essential amino acids, as well as significant quantities of minerals, iron, and vitamins. The high nutrient density of meat, combined with its high-water activity and near-neutral pH (~ 5.5), enables microbial growth, thereby limiting its shelf life in both fresh and dressed carcass forms, also resulting in off-flavours (Gonçalves et al., 2017). Without prompt preservation after slaughter, spoilage can occur rapidly, leading to significant food waste and economic loss. Hence, in order to mitigate food spoilage, meat is often processed into value-added products with extended shelf life (Comi, 2017).

The primary goal of meat processing and storage is to inhibit microbial activity, which is mainly responsible for spoilage (Comi, 2017). Studies have shown that traditional methods such as salting, smoking, and drying effectively extend the shelf life of meat (Farouk & Bekhit, 2012). Although these traditional methods of processing meat remain relevant today, consumer preferences have increasingly shifted toward modern preservation methods, particularly refrigeration, due to its convenience and effectiveness (Belman-Flores et al., 2019). Despite consumers' preference, refrigeration remains unreliable in many tropical developing countries, like Nigeria, where inconsistent power supply limits its full use. Therefore, processing meats into various intermediate moisture meats (IMM) and ready-to-eat (RTE) products happens to be an alternative since it employs low-cost and simple techniques. Examples of popular IMM and RTE meat products include *dambu-nama, kilishi, suya, and kundi,* among others.

Dambu-nama (from the Hausa language, meaning "meat floss") is a traditional ready-to-eat meat product predominantly produced in northern Nigeria. *Dambu-nama* is typically made from camel meat or beef, and it is highly valued for its unique taste and cultural significance, often served during special ceremonial occasions (Farouk & Bekhit, 2012; Tanko et al., 2024). *Dambu-nama* is prepared using meat from the hindquarters, specifically, the semitendinosus muscle. The semitendinosus muscle is considered premium and contributes to the high cost of the final product, making *dambu-nama* less accessible to low-income populations (Eke et al., 2012). Furthermore, the production of *dambu-nama* is concentrated in the northern parts of Nigeria, where there is a relatively abundant population and supply of camels, commonly used for *dambu-nama* production. Given the growing need for affordable and nutritious meat products across diverse regions of Nigeria, it is predicted that *dambu-nama* can also be produced from smaller livestock such as goats (chevon) and pigs (pork), which are more abundant and well-distributed in the southern regions of Nigeria and would probably give comparable nutritional and eating quality to those produced from camel meat. By exploring alternative meat sources, this study seeks to provide a cost-effective alternative production of *dambu-nama*, thereby contributing to improved protein intake for the general populace, particularly in resource-limited settings. Currently, a few studies have investigated pork and camel *dambu-nama* in terms of nutritional and eating qualities, and there is limited data on chevon *dambu-nama* (Balarabe et al., 2016, 2018; Eke et al., 2012; Gandi et al., 2020; Omojola et al., 2014; Talabi et al., 2022; Tanko et al., 2024). Therefore, this study aimed to evaluate and compare the nutritional and quality characteristics of *dambu-nama* prepared from camel meat with those produced from chevon and pork.

MATERIALS AND METHODS

Ethical statement

An approval from the Institutional Care and Use Committee (IACUC) was not required; treatments were not applied to live animals.

Experimental site

This study was conducted at the Osun State University, Meat Science Laboratory, Department of Animal Science, College of Agriculture and Renewable Resources, Ejigbo, Osun State, Nigeria (7° 52' 28.37" N and 4° 18' 13.76" E).

Meat Procurement

An already-deboned hindquarter of a camel carcass was sourced from a commercial abattoir in Lagos State and transported in an insulated cooler with ice to the Meat Science Laboratory of the Osun State University, Ejigbo. A live boar (Large White breed) was obtained from a commercial farm in Lagos State, while a live buck (West African Dwarf breed) was purchased from a livestock market in Oko, Oyo State. Both animals were slaughtered and manually deboned by an experienced butcher following standard ethical procedures. Following slaughter, the buck carcass was dressed using the singeing method, while the boar carcass was dressed by scalding. To maintain consistency across meat types, the hindquarters of the carcasses, the semitendinosus muscles, were used for the preparation of *dambu-nama* (approximately 8 kg for each meat type).

Meat Preparation

All meat samples were thoroughly trimmed to remove visible dirt, external fat, connective tissues, and ligaments. The cleaned cuts were rinsed with water and then portioned into uniform chunks weighing 50 g each. Meat chunks from each meat type (camel meat, chevon, and pork) were randomly assigned to heat treatment groups based on the different processing methods employed, with each treatment replicated three times. Additionally, 100 g of meat from each meat type was excised and used for the analysis of physicochemical properties and proximate chemical composition of the fresh meat samples.

Physicochemical Analysis

a.) Water Holding Capacity (WHC)

Following the press method described by Suzuki et al., (1991), the water holding capacity of meat samples was determined as follows:

$$\text{WHC} = \frac{100 - (Aw - Am) \times 9.47}{(Wm \times Mo)}$$

Aw = Area of water released from meat (cm^2)
Am = Area of meat sample (cm^2)
Wm = Weight of meat (mg)
Mo = Moisture content of meat %
9.47 is a constant factor

b.) Cold shortening

Meat samples were chilled at 4 °C for 24 hours. Pre- and post-chilling lengths were measured, and cold shortening was calculated as the percentage difference in length. Cold shortening was computed as follows, according to Fakolade et al., (2016).

$$\text{Cold shortening} = \frac{(L1 - L2) \times 100}{L2}$$

L1 = Initial length of meat sample (cm)
L2 = Final length of meat sample (cm)

c.) Thermal shortening

Thermal shortening was assessed by oven-heating meat samples at 175 °C for 20 minutes. After equilibrating to room temperature, the lengths were re-measured, and the percentage change in length was recorded as thermal shortening and computed as follows, according to Fakolade & Fatola (2021).

$$\text{Thermal shortening} = \frac{(L1 - L2) \times 100}{L2}$$

L1 = Initial length of meat sample (cm)
L2 = Final length of meat sample (cm)

d.) Thaw rigour

Meat samples of predetermined weight and length were chilled at 4 °C for 24 hours. After storage, weights were measured, and the percentage reduction was recorded as thaw rigour following Fakolade et al., (2016).

$$\text{Thaw rigour} = \frac{(W1 - W2) \times 100}{W2}$$

W1 = Initial weight of fresh meat sample (g)
W2 = Final weight of chilled meat sample (g)

g.) Cooking loss

Samples were enclosed in airtight polythene bags and subjected to boiling at 100 °C for 20 minutes. Upon chilling, final weights were documented, and cooking loss was determined as the percentage difference between pre- and post-cooking weights, as follows, according to Fakolade & Fatola (2021).

$$\text{Cooking loss} = \frac{(W1 - W2) \times 100}{W2}$$

W1 = Initial weight of fresh meat sample (g)
W2 = Final weight of cooked meat sample (g)

Spice and Ingredient

The ingredients utilized for recipe formulation included table salt, seasoning (monosodium glutamate) cubes, thyme, curry powder, onions, red pepper, African nutmeg, ginger, garlic, soybean oil, and cloves. All ingredients were locally sourced from markets within the study area.

Preparation of Spice Mixtures

Spice mixtures are prepared in two phases for the cooking and shredding stages of the *dambu-nama* production. All spices used were well-ground and dried. The spice powders were stored at room temperature and in air-tight containers until use. Each mixture was formulated to ensure consistency in flavour and aroma in accordance with the procedures described by Omojola et al., (2014).

The Preparation of Dambu-nama

Meat floss preparation is described as follows:

Cooking

Each meat type (camel, chevon, and pork) was cooked using an adjustable cylinder gas cooker. A standardized cooking recipe was applied at a ratio of 1 g of spice mixture per 100 g of meat. Water was added at a ratio of 0.15 litres (L) per 1.0 kg of meat. After cooking, the residual broth was allowed to evaporate completely. The cooked meat samples were then equilibrated at room temperature; the meat samples were removed from the pot prior to being measured to determine the post-cooking weight using a manual weighing scale.

Shredding

The cooked meat samples were shredded individually by manually pounding them in a traditionally made mortar and pestle. A second spice blend (shredding recipe) was added at a ratio of 50 g of spice per 1000 g (1:20) of meat. Following the addition of spices, the meat samples were pounded further until fine, fluffy shreds of meat were obtained. The shredded samples were reweighed to assess the weight changes after processing.

Frying and Oven-drying

The shredded meat was divided for further processing. A portion of each meat type was deep-fried in a preheated soybean oil at 180 °C, using an oil-to-meat ratio of 1 L to 500 g. Frying lasted approximately 20 minutes, with frequent stirring until a uniform golden-brown colour (Maillard reaction) was achieved. Another portion of the shredded meat was oven-dried (without frying) at 120 °C. A third portion was kept as a fresh control (boiled only, not fried or oven-dried). Each processing method: fresh, fried, and oven-dried, was performed in triplicate per meat type.

Oil Removal (Manual pressing)

After frying, the meat floss was transferred to a sieve. Manual pressure was applied to remove excess oil and to prevent clumping. Light and spongy shreds of final products were obtained and stored in separate, airtight containers for subsequent analyses.

Proximate, Vitamin, and Mineral Composition

The proximate composition (moisture, crude protein, fat, ash, and fibre) as well as the vitamin and mineral contents of the fresh and processed meat products were analysed using the standard procedures outlined by the Association of Official Analytical Chemists (A.O.A.C., 2005).

Sensory Evaluation

Semi-trained panellists (n = 15), consisting of 70 % males and 30 % females, participated in the sensory evaluation. The semi-trained panellists had some familiarity with food product characteristics and sensory evaluation, and they were trained on assessment procedures before the evaluation began. *Dambu-nama* samples from each meat type were presented on coded white plates in random order. Bread and water were provided for palate cleansing between tastings. Panellists evaluated each sample using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely), assessing colour, flavour, juiciness, tenderness, and overall acceptability. The scores for each attribute were averaged across panellists to obtain a mean sensory score for each characteristic per *dambu-nama* product.

Experimental Design and Statistical Analysis

The study employed a completely randomized design (CRD) in a 3 × 3 factorial arrangement (meat type × processing method) comprising three meat types (camel meat, chevon, and pork), three processing methods, and three replicates per meat type and processing method. Data were analysed using IBM SPSS Statistics software (IBM. Corp, 2012). One-way analysis of variance (ANOVA) was used to assess the effects of meat type on proximate composition, physicochemical properties, and sensory attributes at a significance level of $\alpha = 0.05$. For the analysis of the proximate, vitamin, and mineral composition of *dambu-nama* products, two-way ANOVA was conducted considering meat type and processing method as fixed factors. Duncan's Multiple Range Test was performed to compare the mean values.

RESULTS AND DISCUSSION

The Physicochemical Properties of Fresh Meat Samples

Figure 1 presents the mean values of the physicochemical properties of fresh meat samples from camel meat, chevon, and pork. Significant differences ($P < 0.05$) were observed in cold shortening among the meat types across all measured parameters. Chevon recorded the highest value (12.35 %), followed by pork, while camel meat exhibited the lowest value. The lower cold shortening observed in camel meat is consistent with the previous finding of Fakolade & Fatola (2021) who reported 5.15 %. In this present study, 10 % appeared to be the cut-off value for cold shortening, with higher values indicating higher cold shortening and vice versa. In practice, values exceeding this threshold probably indicate excessive muscle contraction during rapid chilling, which could negatively affect meat tenderness (King et al., 2003; Marsh, 1977). Both chevon and pork exceed the 10 % cut-off, indicating that they exhibit high cold shortening. The higher cold shortening values in pork and chevon suggest faster postmortem chilling, which promotes sarcomere contraction before rigor mortis is complete (Dransfield & Lockyer, 1985; Iversen et al., 1995). Camel meat, on the other hand, is well below this threshold, indicating minimal cold shortening effects. The reduced cold shortening in camel meat may be attributed to a slower rate of postmortem glycolysis, limiting muscle contraction during chilling.

Camel meat exhibits reduced cold shortening due to a slower rate of postmortem glycolysis, particularly in muscles with a high proportion of type I fibres (slow-twitch), such as the psoas major and semitendinosus, which are more tender compared to muscles like the longissimus thoracis that are rich in type IIb fibres (fast-twitch) and exhibit an increased rate of glycolysis and higher shear force. The slower glycolytic rate in type I fibre-rich muscles is associated with lower activities of key glycolytic enzymes within the first hours after slaughter, which limits ATP depletion and muscle contraction during chilling, thereby reducing the risk of cold shortening and improving meat tenderness. In contrast, muscles with a higher percentage of type IIb fibres experience accelerated glycolysis, leading to increased muscle contraction and poorer sensory qualities (Lyu et al., 2024; Thompson et al., 2006).

Thermal shortening also differed significantly ($P < 0.05$) among the meat types. Chevon exhibited the highest thermal shortening (42.11 %), followed by camel meat and pork (14.67 % and 13.69 %, respectively). The marked difference suggests that chevon may be more susceptible to structural changes during high-temperature cooking. The high thermal shortening recorded in chevon could be traced to the length of the heat treatment on the sarcomere length of buck carcasses during dressing; this result is consistent with Apata et al., (2023) and Ugochukwu et al., (2018), who both reported that singed buck carcasses exhibit high thermal shortening. Camel meat exhibited the highest cooking loss (45.34 %), which was significantly greater ($P < 0.05$) than in chevon. However, no significant difference was observed between pork and chevon ($P > 0.05$). The cooking loss values observed in this study exceed those reported by Yam et al., (2015) and Fakolade (2007), who documented 32 % and 37.75 %, respectively, for camel meat. Cooking loss, defined as the combined loss of water and soluble substances during thermal processing (Brugiapaglia, 2012), is an important quality influencing juiciness and product yield.

Camel meat obtained the highest water holding capacity (WHC), 41.53 %, followed by chevon and pork, with significant differences among all three meat types ($P < 0.05$). As expected, pork exhibited the lowest WHC (29.04 %). Pork's low water-holding capacity could result from postmortem pH decline, protein denaturation (particularly the myofibrillar proteins), and structural changes, which disrupt the muscle's ability to retain water, leading to a decrease in WHC (Honikel, 2004). After slaughter, the muscle cells begin to convert glycogen into lactic acid through glycolysis, causing a rapid drop in pH. The decline of muscle pH is often faster in pork due to its muscle fibre composition, especially the longissimus (loin), which is predominantly composed of (faster) glycolytic fibres, specifically type IIb fibres. Previous studies have shown that the longissimus muscle in pigs contains a high proportion of type IIb glycolytic fibres (up to 71%)—making the longissimus muscle the most glycolytic among the muscles that have been studied, while other muscles like the psoas major are more oxidative (Lebedová et al., 2019; Park et al., 2024). As a result of low pH and high temperature, there is an incidence of protein denaturation and a reduction of water holding capacity, which can be assessed through measurements of purge or drip loss.

Similar to the report of Suliman et al., (2019), we observed that camel meat exhibited better meat quality attributes, including water holding capacity. From a meat processing standpoint, water holding capacity is a critical quality attribute; higher WHC contributes to improved juiciness. Thaw rigour values also varied significantly ($P < 0.05$) among the three meat types, with chevon exhibiting the highest value (18.53 %), followed by pork and camel meat (11.37% and 8.02%, respectively); these differences may be attributed to variations in muscle composition, fibre type, and postmortem metabolic activity during freezing and thawing. Higher thaw rigour values reflect greater susceptibility to contraction and toughness upon thawing, particularly in chevon.

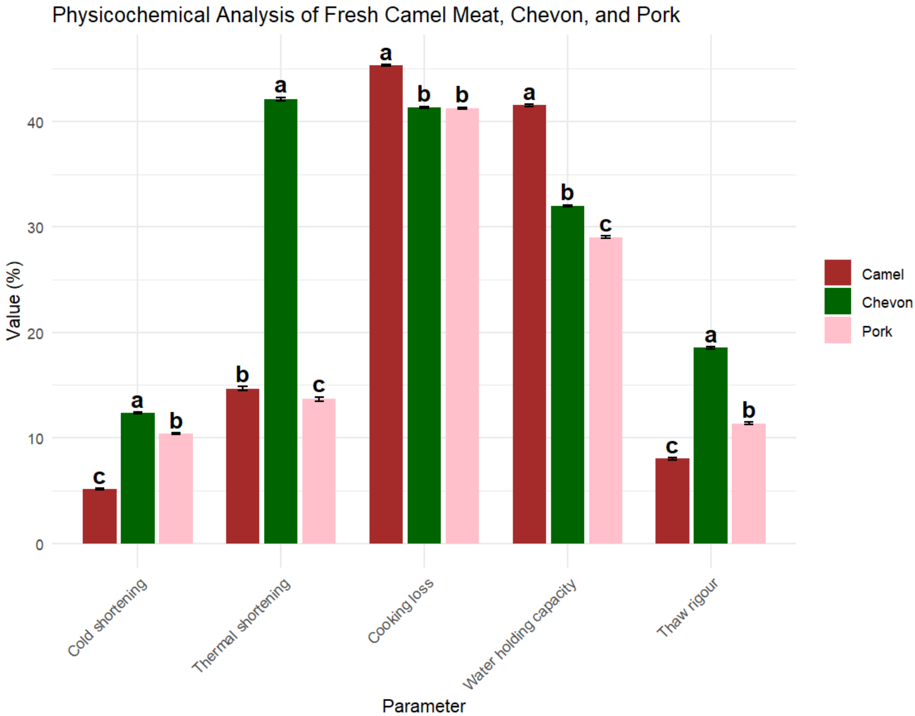

Figure 1. Physicochemical analysis of camel meat, chevon, and pork

[abc] means with different superscripts differ significantly (P < 0.05)

The Proximate, Mineral, and Vitamin Composition of Fresh Meats

The proximate composition of fresh camel meat, chevon, and pork samples is presented in Figure 2. Camel meat exhibited the highest protein content ($P < 0.05$), followed by pork and chevon. Conversely, pork contained the highest ether extract, indicating greater fat content, while camel meat had the lowest. Camel meat also obtained the highest ash value, suggesting the presence of a rich mineral profile. Moisture content was significantly highest ($P < 0.05$) in camel meat and lowest in pork (71.69 % vs. 64.99 %).

The protein content of camel meat (21.71 %) recorded in this study aligns with previous findings by Yam et al., (2015), who reported similar values, 24.72 % and 22.34 % in fresh camel meat, as well as Kazeem & Muhammad (2017), who documented 22.0 %. However, the protein content of chevon (16.63 %) obtained in this study was lower than the 28.0 % reported by Enock et al., (2017). Similarly, pork protein value (17.74 %) appeared to be lower than (20.65 %) documented by Patterson et al., (2009) for fresh boneless pork. The higher fat content in pork is associated with its lower muscle (protein) proportion and greater fat deposition, particularly in cuts such as pork belly, where fat levels can exceed 30 % (Enser et al., 1996; Hoa et al., 2021). The higher fat content of pork may be attributed to pork's relatively higher fat-to-protein ratio compared to other meats such as beef and lamb (Enser et al., 1996). Variations in fat content and composition among pork, beef, and lamb are largely influenced by species-specific factors, including genetics, diet, and digestive physiology. Non-ruminants, particularly pigs, deposit dietary fat more directly, while ruminants, such as beef and sheep, have more complex fat metabolism, often resulting in leaner muscle cuts (Enser et al., 1996; Scollan et al., 2017). Conversely, among the meat types evaluated in this study, camel meat exhibited the lowest fat content, which is consistent with its classification as a lean meat type. The leanness of camel meat facilitates easier drying and processing (Fakolade et al., 2014). These findings corroborate the observations of Bekhit & Farouk (2013), who stated that camel meat contains less fat than beef, lamb, and chevon, but has slightly higher fat content than ostrich meat.

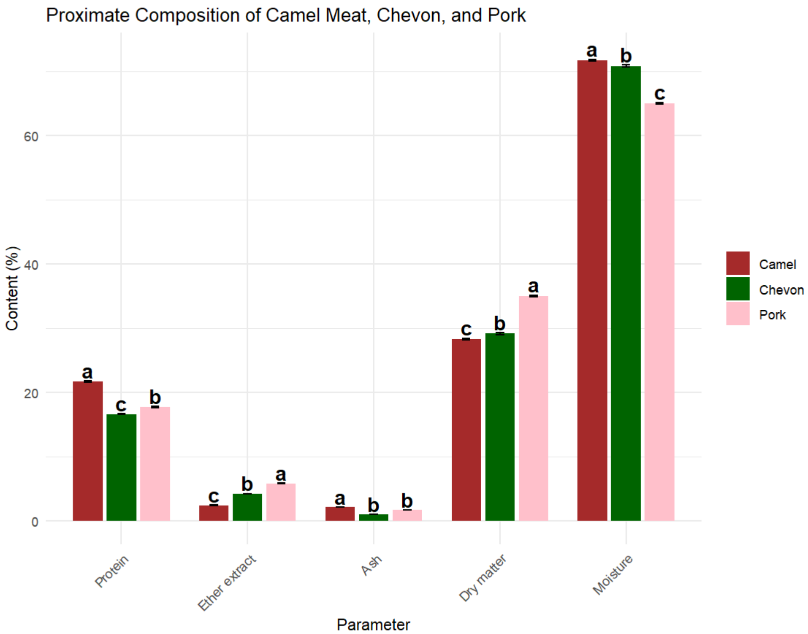

Figure 2. Chemical composition of camel meat, chevon, and pork

abc means with different superscripts differ significantly ($P < 0.05$)

The ash value (2.16 %) reported for camel meat in this study differed from those of Enock et al., (2017), who reported 0.50 %, and Yam et al., (2015), who reported 0.79 %. In this study, chevon (1.03 %) exhibited a lower ash content compared with the value (7.11 %) reported by Enock et al., (2017). In contrast, the ash content of pork appeared comparable to values documented by Patterson et al., (2009). Higher moisture content was recorded in camel meat (71.69 %) than in chevon and pork (70.84 %, 64.99 %, respectively; $P < 0.05$). Camel meat moisture content was slightly lower than the 76.29 % reported by Nikmaram et al., (2011) for fresh camel meat.

With respect to mineral content (Figure 3), camel meat also exhibited higher content of calcium (9.70 mg/100g) and potassium (274 mg/100g) compared to other meat types. Chevon had intermediate values, while pork recorded the lowest calcium and moderate potassium. The value recorded for calcium appeared lower than the 29.39 mg/100g reported by Kazeem & Muhammad (2017) for camel meat. The mineral contents in chevon appeared lower than those reported by Moawad et al., (2013). A similar pattern was observed in magnesium, being most abundant in camel meat and least in pork. In comparison with other studies, the differences in nutritional composition may reflect differences in animal age, diet, and muscle anatomical location.

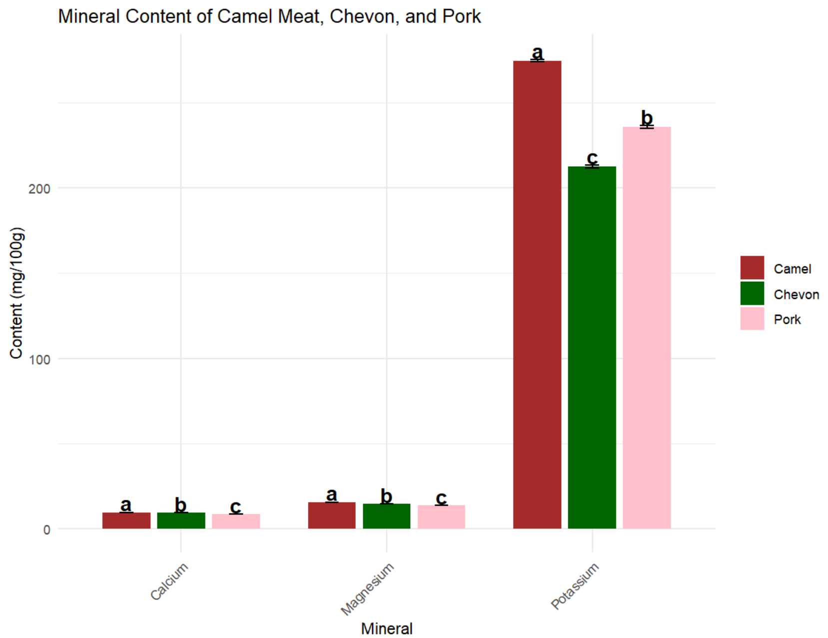

Figure 3. Mineral composition of camel meat, chevon, and pork

abc means with different superscripts differ significantly ($P < 0.05$)

In Figures 4 and 5, camel meat had substantially higher levels of vitamin B_{12}, vitamin D, and vitamin B_2 (2.32 µg/100g, 0.87 µg/100g, 0.57 mg/100g, respectively), compared to both chevon and pork, suggesting that camel meat is a particularly rich source of essential vitamins, especially B-complex vitamins, which are critical for energy metabolism and neurological function (Gonçalves & Portari, 2021; Schellack et al., 2019).

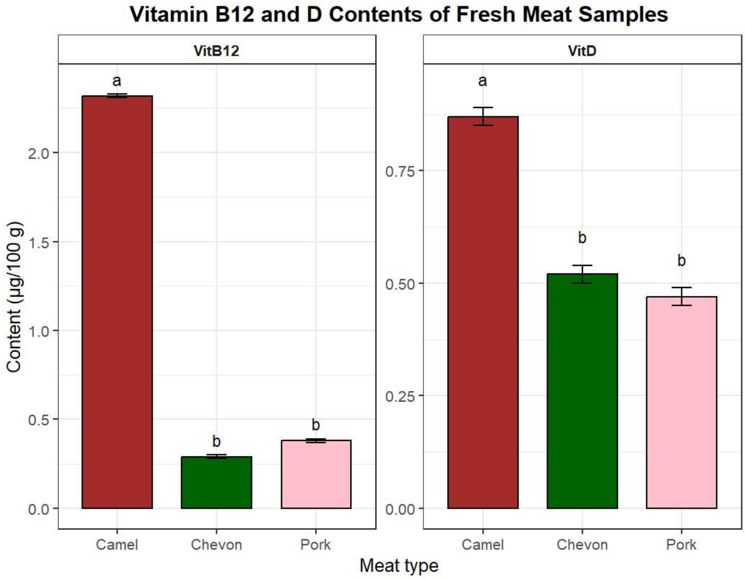

Figure 4. Vitamin B_{12} and D composition of camel meat, chevon, and pork

^{abc} means with different superscripts differ significantly (P < 0.05)

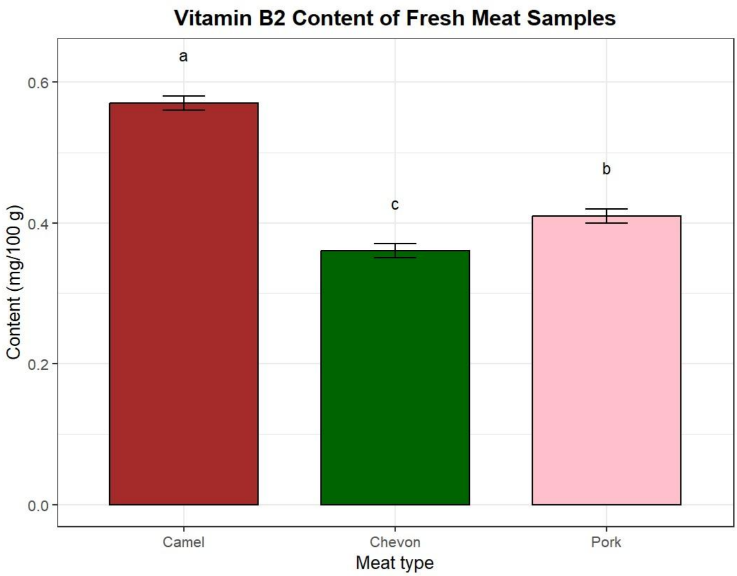

Figure 5. Vitamin B_2 composition of camel meat, chevon, and pork

^{abc} means with different superscripts differ significantly (P < 0.05)

Overall, camel meat exhibited superior nutritional qualities in terms of protein, essential vitamins, and minerals.

The Proximate Composition of Dambu-Nama Products

Table 1 presents the proximate composition of *dambu-nama* products prepared using different processing methods (boiled only, boiled then oven-dried, and boiled then fried) across three meat types: camel meat, chevon, and pork.

Table 1. Proximate composition of camel, chevon, and pork *dambu-nama* products (mg/100g)

Meat type	Processing Method	Proximate Composition (%)				
		CP*	EE†	ASH	CF‡	DM§
Camel	Boiled||	58.12[a]	12.92[a]	2.95[ab]	0.02[a]	39.96[c]
	Oven-dried¶	51.12[b]	10.10[c]	2.65[b]	0.02[a]	43.62[b]
	Fried#	48.11[c]	11.50[b]	3.05[a]	0.10[a]	95.11[a]
Chevon	Boiled||	48.87[b]	9.65[c]	2.97[b]	0.02[a]	49.71[c]
	Oven-dried¶	58.47[a]	12.40[a]	2.35[c]	0.01[a]	62.91[b]
	Fried#	30.40[c]	11.49[b]	3.25[a]	0.02[a]	92.30[a]
Pork	Boiled||	42.50[a]	11.91[a]	3.30[a]	0.02[a]	34.94[c]
	Oven-dried¶	41.91[a]	10.10[b]	3.01[b]	0.01[a]	84.02[b]
	Fried#	22.45[b]	8.85[c]	3.02[b]	0.01[a]	93.65[a]
SEM[a]		0.30	0.20	0.07	0.03	0.22

Within each column, means followed by different superscript letters differ significantly (P < 0.05) *CP- Crude protein, †EE- Ether extract, ‡CF- Crude fibre, §DM- Dry matter ||Boiled- Boiled only, ¶Oven-dried - Boiled and oven-dried, #Fried -Boiled and fried
[a]SEM- Standard error of means

The highest (P < 0.05) crude protein (CP) contents were recorded in both oven-dried chevon *dambu-nama* and boiled camel *dambu-nama,* 58.47 % and 58.12 %, respectively. In contrast, the lowest (P < 0.05) CP values were obtained in fried pork and fried chevon *dambu-nama* (22.45 % and 30.40 %, respectively). Across all meat types, boiled and oven-dried *dambu-nama* products had higher CP values than the fried products, suggesting that frying *dambu-nama* products might have a protein content-reducing effect. Additionally, there are two key observations about the CP content results. First, there was generally an increase in the CP content of *dambu-nama* compared to the fresh meat samples (Figure 2), suggesting that processing increases the CP content of *dambu-nama*. Secondly, camel meat exhibited increased CP content regardless of the processing method. These observations are comparable to the findings of Eke et al., (2012), who reported CP values (46.51 % and 39.19 %) for laboratory and traditionally prepared beef *dambu-nama*, respectively. The discrepancies in CP content could be attributed to differences in meat type, formulation, and processing procedures.

The ether extract (EE) content varied across meat types and processing methods, without a definite trend. In camel *dambu-nama*, the boiled product (12.92 %) had the highest EE value (P < 0.05) compared to the oven-dried and fried products. In chevon *dambu-nama,* oven-dried products had the highest EE content (P < 0.05; 12.40 %), compared to fried and boiled products, while in pork *dambu-nama*, boiled *dambu-nama* obtained the highest EE value (P < 0.05; 11.91 %), followed by oven-dried *dambu-nama,* and fried *dambu-nama* was the lowest (10.10 %, 8.85 %, respectively). From our findings, it appears that boiling resulted in higher fat in camel and pork *dambu-nama* products. Boiled meat products generally exhibit elevated fat content, due to the fact that boiling results in less fat loss during cooking, in contrast to oven drying and frying, which more effectively eliminate fat. The difference in fat retention could be traced to the effect of wet vs. dry heat cooking methods; in this study, boiling represents the wet cooking method, while oven-drying and frying both represent the dry heat cooking (Abdel-Naeem et al., 2021).

Ash content varied significantly (P < 0.05) across meat types and processing methods. Across all meat types and processing methods, ash content was highest in pork *dambu-nama*, with boiled pork (3.30 %) recording the highest value (P < 0.05), followed by fried chevon. Conversely, ash content was lowest in oven-dried chevon *dambu-nama* (2.35 %). Crude fibre (CF) levels were relatively low and negligible, with no statistically significant differences (P > 0.05) across all meat types and processing methods. The CF values obtained in this report are consistent with Eke et al., (2012) and Tanko et al., (2024), who reported levels below 1 % in *dambu-nama* products.

According to Table 2, meat type × processing method interaction influenced crude protein, ether extract, ash, and dry matter (P < 0.001); however, meat type × processing did not affect crude fibre content (P = 0.336) of the *dambu-nama* products. Camel *dambu-nama* consistently showed higher protein values across all methods; the value of protein content was highest in boiled camel *dambu-nama*, suggesting the interactive effect between this meat type and low-heat processing.

Generally, camel *dambu-nama* exhibited superior nutritional quality to other products. Processing methods significantly influence the proximate composition of *dambu-nama* products. From a nutritional standpoint, boiling offers the best balance between preserving protein and maintaining moderate fat and ash content. Boiling also substantially shows higher fat content retention, while frying results in reduced protein content. Oven-drying appears to give a balanced nutritional profile but might lead to moderate nutrient losses. The relatively high nutrient values across all samples in this study may also reflect the influence of added ingredients, which can enhance the nutritional profiles and provide antioxidative benefits (Eke et al., 2012).

Table 2. Two-way ANOVA summary for proximate composition of *dambu-nama* (Effect of meat type, processing method, and their interaction)

Source of variation	DF*	Crude Protein	Ether Extract	Ash	Crude Fibre	Dry Matter
		F-Statistic (P-value)	F-Statistic (P-value)	F-Statistic (P value)	F-Statistic (P-value)	F-Statistic (P-value)
Intercept	1	195115.70 (P<0.001)	26030.87 (P<0.001)	15556.85 (P<0.001)	10.93 (P = 0.004)	842064.60 (P<0.001)
Meat type	2	2347.44 (P<0.001)	28.69 (P<0.001)	11.61 (P=0.04)	1.373 (P = 0.279)	2246.55 (P<0.001)
Processing method	2	2967.06 (P<0.001)	14.71 (P<0.001)	35.40 (P<0.001)	1.56 (P = 0.240)	43837.08 (P<0.001)
Meat type × processing method interaction	4	473.21 (P< 0.001)	68.28 (P<0.001)	10.43 (P<0.001)	1.22 (P = 0.336)	3850.51 (P<0.001)
Error	18	-	-	-	-	-
Total	27	-	-	-	-	-

*DF = Degree of freedom

Vitamin Composition of Dambu-nama Products

As presented in Tables 3 and 4, meat type × processing method influenced the vitamin contents of *dambu-nama* ($P < 0.001$). In camel *dambu-nama*, the highest concentration of vitamin B_{12} ($P < 0.05$) was recorded in boiled camel *dambu-nama* (0.92 µg/100g), which was greater than oven-dried and fried camel products. In chevon, fried *dambu-nama* (0.95 µg/100g) exhibited the highest vitamin B_{12} content among oven-dried and boiled products. In pork *dambu-nama*, fried and oven-dried pork products had similar values ($P > 0.05$), but were higher than boiled products ($P < 0.05$).

Across all meat types and processing methods, the concentration of vitamin B_2 in boiled camel *dambu-nama* was the highest (0.54 mg/100g; $P < 0.05$), followed closely by fried chevon and oven-dried camel *dambu-nama*. Oven-dried and fried pork *dambu-nama* products had the lowest B_2 values (0.28 mg and 0.34 mg/100g, respectively). Again, vitamin D was highest in boiled camel *dambu-nama* ($P < 0.05$;1.55 µg/100g), followed closely by fried chevon *dambu-nama*. Notably, camel *dambu-nama* maintained relatively high vitamin D levels across all processing methods, with only slight decreases observed in oven-dried samples. Chevon and pork *dambu-nama* obtained less pronounced differences among treatments, suggesting that vitamin D is relatively stable during thermal processing (Hanson & Metzger, 2010; Kazmi et al., 2007).

Table 3. Vitamin composition of camel, chevon, and pork *dambu-nama* products

Meat type	**Processing Method**	**Composition**		
		Vit. B_{12}* (µg/100g)	**Vit. B_2†** (mg/100g)	**Vit. D‡** (µg/100g)
Camel	Boiled§	0.92^a	0.54^a	1.55^a
	Oven-dried‖	0.56^c	0.50^b	0.83^c
	Fried¶	0.87^b	0.44^c	1.45^b
Chevon	Boiled§	0.61^c	0.38^c	1.22^c
	Oven-dried‖	0.82^b	0.42^b	1.36^b
	Fried¶	0.95^a	0.50^a	1.51^a
Pork	Boiled§	0.61^b	0.38^a	1.22^b
	Oven-dried‖	0.66^a	0.28^c	1.16^c
	Fried¶	0.67^a	0.34^b	1.31^a
SEM#		0.06	0.05	0.06

Within each column, means followed by different superscript letters differ significantly ($P < 0.05$)

*Vit B_{12} – Vitamin B_{12}

†Vit B_2 – Vitamin B_2

‡Vit D – Vitamin D

§Boiled – Boiled only

‖Oven-dried – Boiled and oven-dried

¶Fried – Boiled and fried

#SEM- Standard error of means

Comparatively, the vitamin contents of the processed *dambu-nama* products were generally similar to those recorded in the fresh meats (Figures 4 and 5), indicating minimal losses and, in some cases, an increase during processing when mild methods, particularly boiling, are used. This outcome is supported by Garg et al., (2021), who reported that boiling of food products results in minimal loss of B-vitamins. The minimal losses in B-vitamins can be attributed to leaching (Garg et al., 2021; Moravcová et al., 2025). Previous research has established that an increase in vitamin D, particularly in pork, could be traced to an increase in dry matter content, due to loss of moisture (Clausen et al., 2003).

Table 4. Two-way ANOVA summary for vitamin composition of *dambu-nama* (Effect of meat type, processing method, and their interaction)

Source of variation	**DF**[1]	**Vitamin B_{12}**	**Vitamin B_2**	**Vitamin D**
		F-Statistic (P-value)	F-Statistic (P-value)	F-Statistic (P-value)
Intercept	1	160320.16 ($P < 0.001$)	56108.52 ($P < 0.001$)	449049.04 ($P < 0.001$)
Meat type	2	642.52 ($P < 0.001$)	688.74 ($P < 0.001$)	396.26 ($P = 0.004$)
Processing method	2	612.64 ($P < 0.001$)	34.61 ($P < 0.001$)	2241.37 ($P < 0.001$)
Meat type × processing method interaction	4	804.70 ($P < 0.001$)	135.04 ($P < 0.001$)	1563.93 ($P < 0.001$)
Error	18	-	-	-
Total	27	-	-	-

[1]DF = Degree of freedom

Mineral Composition of Dambu-nama Products

As shown in Table 5, boiled camel *dambu-nama* had the highest calcium content ($P < 0.05$; 13.83 mg/100g), followed closely by fried chevon (13.76 mg/100g), suggesting that frying and boiling are more effective at retaining or enhancing calcium concentration compared to oven-drying, which consistently yielded lower calcium values across all meat types and processing methods. The oven-dried camel *dambu-nama*, for example, recorded the lowest calcium level (12.87 mg/100g). For potassium, boiled camel *dambu-nama* again recorded the highest value (364.00 mg/100g), while fried chevon and fried pork also showed higher amounts.

A consistent pattern was noted in magnesium content, with boiled samples across all meat types exhibiting the highest magnesium values. Boiled camel *dambu-nama* had the highest concentration ($P < 0.05$; 22.01 mg/100g), while the lowest was recorded in oven-dried camel *dambu-nama* and fried pork *dambu-nama*. From the obtained results, there appeared to be a decline from boiling to oven drying and frying, indicating that the magnesium content decreases in *dambu-nama* based on the intensity of heat application. Again, meat type × processing method interaction influenced the mineral content (calcium, potassium, and magnesium) composition of *dambu-nama* products (Table 6; $P < 0.001$). Boiling (with water retention) and frying often enhance mineral retention by reducing mineral loss into water. However, the actual retention is dependent upon the type of food, minerals, and cooking methods employed. Frying is very efficient since it requires minimal water; yet it may not consistently be the healthiest option owing to elevated fat content (Bognár, 1998; Ikanone & Oyekan, 2014; Issa et al., 2019).

Table 5. Mineral composition of camel, chevon, and pork *dambu-nama* products (mg/100g)

Meat type	**Processing Method**	**Composition**		
		Ca*	**K†**	**Mg‡**
Camel	Boiled§	13.83^{a}	364.00^{a}	22.01^{a}
	Oven-dried‖	12.87^{c}	297.00^{c}	19.61^{c}
	Fried¶	13.69^{b}	348.00^{b}	21.75^{b}
Chevon	Boiled§	13.58^{b}	326.00^{c}	21.91^{a}
	Oven-dried‖	13.43^{c}	335.00^{b}	21.62^{b}
	Fried¶	13.76^{a}	355.33^{a}	21.51^{c}
Pork	Boiled§	12.94^{c}	306.00^{c}	21.74^{a}
	Oven-dried‖	13.19^{b}	332.00^{b}	21.14^{b}
	Fried¶	13.35^{a}	348.00^{a}	20.67^{c}
#SEM		0.007	0.703	0.009

Within each column, means followed by different superscript letters differ significantly ($P < 0.05$)
*Ca- Calcium, †K- Potassium, ‡ Mg- Magnesium
§Boiled – Boiled only, ‖Oven-dried – Boiled and oven-dried, ¶Fried – Boiled and fried
#SEM- Standard error of means

Interestingly, processing methods did not reduce mineral levels; in many cases, the values were maintained or even slightly increased after processing, this outcome supports the findings of Kazeem and Muhammed (2017), who noted that thermal processing can improve mineral content of a processed meat, *kilishi*. However, this present study contradicts Eke et al., (2013), who reported lower mineral content in *dambu-nama* products after processing.

Sensory Evaluation of Dambu-nama Products

Table 4 shows the sensory evaluation results for *dambu-nama*. Pork *dambu-nama* consistently received the highest panel ratings for key sensory parameters, including juiciness (6.85) and overall acceptability (7.20) compared to camel and chevon, indicating pork *dambu-nama's* superior sensory profile in these attributes.

Table 6. Two-way ANOVA summary for mineral composition of *dambu-nama* (Effect of meat type, processing method, and their interaction)

Source of variation	**DF***	**Calcium**	**Potassium**	**Magnesium**
		F-Statistic (P-value)	F-Statistic (P-value)	F-Statistic (P-value)
Intercept	1	30461880.56 (P < 0.001)	2040328.90 (P < 0.001)	46711167.90 (P < 0.001)
Meat type	2	2813.51 (P < 0.001)	169.08 (P < 0.001)	3229.87 (P < 0.001)
Processing method	2	2809.33 (P < 0.001)	1317.70 (P < 0.001)	8848.83 (P < 0.001)
Meat type × processing method interaction	4	1798.67 (P < 0.001)	1264.38 (P < 0.001)	7318.09 (P < 0.001)
Error	18	-	-	-
Total	27	-	-	-

*DF = Degree of freedom

In terms of tenderness, no significant differences existed among the three meat types (P > 0.05), as all products received similar ratings. Chevon and pork *dambu-nama* did not differ significantly in flavour; however, both products were rated significantly higher than camel *dambu-nama* (P < 0.05). Pork *dambu-nama* was juicier than both camel and chevon *dambu-nama* (P < 0.05). In terms of overall acceptability, pork *dambu-nama* was rated higher than other products, with chevon *dambu-nama* being intermediate and camel the lowest (P < 0.05). Texture was not significantly different across the three products (P > 0.05).

The consistently higher ratings for pork *dambu-nama* suggest that meat possesses superior sensory characteristics, which may be attributed to the intramuscular fat content, which is said to contribute significantly to pork sensory quality by enhancing flavour and juiciness (Wood, 1990; Wood et al., 2004). The combination of juiciness and flavour likely contributed to its higher overall acceptability. These results are consistent with Fakolade & Fatola (2021), who reported similar sensory panel scores for pork *kilishi* (a meat product, similar to beef jerky) over other meat types, in terms of flavour, texture, tenderness, juiciness, and overall acceptability. Overall, these results indicate that meat type significantly influences the sensory qualities of *dambu-nama*, with pork emerging as the most palatable option among the other meat types evaluated in this study.

Table 7. The sensory panel evaluation of camel, chevon, and pork *dambu-nama* products

Parameter	***Dambu-nama* products**			SEM#
	Camel *dambu-nama*	**Chevon *dambu-nama***	**Pork *dambu-nama***	
Colour*	3.88^a	4.25^a	5.90^a	0.75
Flavour†	4.20^b	5.65^a	5.95^a	0.14
Tenderness‡	5.15^a	5.30^a	5.60^a	0.17
Juiciness§	4.65^b	4.80^b	6.85^a	0.19
Texture‖	4.88^a	4.80^a	5.45^a	0.23
Overall acceptability¶	5.40^c	6.05^b	7.20^a	0.21

Means with different superscripts within a row differ significantly ($P < 0.05$)
*Colour: 1 = Dark, 9 = Extremely light
†Flavour: 1 = Not acceptable, 9 = Extremely fine
‡Tenderness: 1 = Extremely tough, 9 = Extremely tender
§Juiciness: 1 = Extremely dry, extremely juicy
‖Texture: 1 = Extremely coarse, 9 = Extremely fine
¶Overall acceptability: 1 = Dislike extremely, 9 = Like extremely
#SEM- Standard error of means

CONCLUSION

This study has shown that, in addition to camel meat, chevon, and pork, can be effectively used in the production of *dambu-nama*, each offering unique nutritional benefits. Camel meat, when processed into *dambu-nama*, in particular, exhibited the highest levels of protein, calcium, magnesium, and vitamins (B_{12}, B_2, and D), especially when boiled, while chevon and pork were slightly lower in certain nutrients. From a sensory perspective, pork *dambu-nama* emerged as the most preferred by consumers, based on colour, texture, juiciness, and overall acceptability. Boiling appears to be the most effective processing method in terms of preserving the nutritional quality of camel, chevon, and pork *dambu-nama*.

Meat type × processing method interaction influenced proximate chemical, vitamin, and mineral composition of *dambu-nama* products, suggesting the importance of selecting optimal heat treatment combinations to maximize the nutritional content of *dambu-nama* products. Future studies are recommended to assess the shelf life, microbial stability of *dambu-nama* produced from the same meat types.

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