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Development and Quality Assessment of South African Indigenous Goat Meat Products

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Abstract

The role of Indigenous goat meat as a sustainable and culturally significant protein source remains critically underexplored and insufficiently recognised across Sub-Saharan African countries. The study aimed to examine how culture, technological advancements, and consumer expectations affect the acceptance of value-added Indigenous goat meat products. Using an experimental design, indigenous Nguni goat meat was utilised to develop three meat food products: namely, curry, burger patties, and dry wors. Physicochemical properties of the products were analysed, and consumer acceptability of the final product was evaluated by 15 trained sensory evaluation panel and a consumer panel (120). It is noted that the Microbial count in this study indicated no presence of Escherichia coli, Salmonella, or Listeria monocytogenes. However, low levels of Staphylococcus aureus (<103) and Total plate count (<106) were observed in all three products, which were within the acceptable level. The texture analysis revealed goat curry was the most tender (46.4±5.29a), followed by burger patties (53.0±2,18a) and dry wors (273.0±48.62b). Findings show that processing and value addition can improve the sensory properties of goat meat, leading to consumer acceptability. Value addition of goat meat products enhances food and nutrition security and provides a viable revenue strategy for the meat industry. The study highlights the potential of these value-added goat meats for food and nutrition security. Promoting value-added goat meat products can address the needs of modern and future consumers.

Keywords: Goat meat, consumer acceptance, value-added products, texture, microbiological quality

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Introduction

Globally, goat meat, or chevon, is increasingly recognized for its unique flavour, lean characteristics, and socio-religious acceptability, nutritional components, and industrial uses(Umaraw et al., 2015), Several breeds of goat are widespread across the globe, with indigenous varieties, such as the Nguni goat, as one of the ecotypes characterized from small to medium breeds with multiple colours, and their faces flat with a dark pigmented muzzle (Mathapo et al., 2025). Due to its adaptability to the region's environment and climatic conditions, the Nguni goat is the most dominant in South Africa. This breed of goats plays a vital role in the lives of smallholder farmers, especially the rural dwellers of South Africa, who credit them as vital for cultural /religious practices, a source of protein for adequate nutrition, and as their bank for other utilities (Mathapo et al., 2025). However, the potential of indigenous goat meat as a sustainable protein source is underacknowledged and thus underutilized

Scarcity of novel processed goat meat products is identified as one factor restricting its acceptance, particularly among the urban and high-income consumers who value convenience food, sensory attributes appealing, with health benefits. This dilemma impacts consumer choices for goat meat as a source of animal protein, thus relegating the role of goat meat in policy and market discussions (Mazhangara et al., 2019). Therefore, strategic interventions are needed as this may enhance the visibility and desirability of goat meat as a protein source for food nutrition and security. Goat meat is an excellent source of riboflavin, iron, vitamin B12, zinc, and potassium, suggesting goat meat as an option for animal-derived meat for human consumption (Boada et al., 2016; Stephens et al., 2018). Although in terms of its uses as meat option for a diversified nutrition, and health benefits goat meat consumption remains limited in regions like South Africa because it has been reported that its consumption has been linked with special occasions such as traditional or religious practices, negative perceptions, and monotonous mode of its preparations leading to limited innovative product diversity(Mazhangara et al., 2019) Consequently, the role of goat meat in household food and nutrition security in South Africa is often restricted since it is mostly consumed only during special events. These factors, with their consumption driven by cultural practices, limit their broader economic

impact across countries where goat breeding is prevalent. This paradox of goat meat with high nutritional value and, with its constrained economic and social integration, underscores the necessity for innovative approaches to its market repositioning. Smart measures to enhance people's perception and accessibility of goat meat products can significantly contribute to household food security while fostering broader market expansion. Therefore, innovative product development is considered an important measure in this study to address gaps in goat meat consumption. The focus on diversifying goat meat into processed forms like ready-to-eat meals, home meal replacements, and other value-added products can be aligned with changing consumer lifestyles (Mathapo et al., 2025). These products enhance the appeal of goat meat while preserving its traditional flavours and nutritional benefits, bridging cultural heritage and modern conveniences (Teixeira et al., 2019) It is hypothesised that this shift could meet modern consumer demands and strengthen the economic viability of indigenous goat farming practices, especially in rural communities of South Africa. Developing value-added goat meat products supports global health and sustainability trends and local economies. Considering the growing demand for nutritious and sustainable animal food sources, Indigenous Nguni goats are cost-effective as browsers, completely dependent on natural veld, and should therefore be further explored to optimize their potential as a preferred protein source (Mathapo et al., 2025) Therefore, this study aims to develop and evaluate processed goat meat products derived from South African indigenous breeds to enhance their marketability and nutritional contribution.

Literature review

An overview and the relevance of goat meat

Besides plant-based protein food sources, meats, including Chevon, form part of the source of dietary quality protein, with low-fat, vitamins, and minerals for human nutrition in many populations of the world (Mazhangara et al., 2019). The demand for meat, including goat meat, in developed countries, including South Africa (SA), continues to rise at an increasing rate (Gawat et al., 2023). The increase in population emerges from diverse factors, including the expansion of many urban settlements across many regions of the world, and especially in developing countries (Mathapo et al., 2025). Increased income and changes in dietary lifestyle are projected as major drivers for production, and high demand for nutritious food, especially animal protein such as goat meat (Woma et al., 2025; Rich et al., 2022). It is generally reported that the demand for meat, including that of goat, in developing countries has facilitated a food revolution, which has offered tremendous opportunities for smallholder farmers, since they benefit from the increasing market. To this effect, goat meat production is considered higher in Southeast Asia, and sub-Saharan Africa, including South Africa, where it has been as considered appreciated. (González et al., 2020).The intrinsic characteristics of goat lean meat, compared to other domestic red meat species, its contribution as a source of quality meat, and its demand in the industry for fashion accessories have been identified to impact society with its implications on food and nutrition security, economic, and environmental sustainability, which are the element of the component of sustainable development goals (Mazhangara et al., 2019, Lu, 2023) Despite the potential of goat meat, studies show a lack of organized and safe goat meat industry and marketing structures, which may limit people of all statuses from accessing goat meat (Mazhangara et al., 2019, Dhanda et al., 2003). Thus, the need for a grading system for goat meat, emphasising safety standards, and functional infrastructures in developing countries, like South Africa cannot be overemphasised, as vital factors that will assist in establishing a sustainable goat meat industry. Religious or cultural and traditional taboos are identified to limit the consumption of goat meat carcasses (Palmer, 2023) Furthermore, the monotony of old methods, including the boiling method of preparing indigenous goat meat relative to other domesticated red meat species in Africa, and even in South Africa, is identified as one factor for people, especially the younger generation, not appreciating goat meat, thus, contributing to its being underutilised. Thus, enhancing the utilisation of indigenous goat meat as a protein source may demand innovative methods of value-added goat meat product development, which may foster its consumption. Therefore, this study explores the development and quality assessment of South African Indigenous goat meat products.

Methodology

The uMhlathuze Local Municipality in Northern KwaZulu-Natal, Republic of South Africa, was chosen as the study site. Two sites within the municipality were selected using a purposive convenience random sampling technique. Participants were recruited from the University of Zululand and the Owen Sithole College of Agriculture. The study received ethical approval from the University of KwaZulu-Natal with ethics number (HSSREC/00003190/2021). Ten randomly selected live indigenous goats were sourced from the CEDARA Agricultural College Farm. The Goats were reared from the farm till 18- 36 months old. The goats were transported to the nearest accredited abattoir for slaughtering and processing. The slaughtering of goats at the abattoir was done according to the guidelines for red meat abattoirs (American Veterinary Medical Association, 2016; Mench, 2019). The goats were allowed an ad-libitum supply of water and were slaughtered early in the morning after a 16-18 hour fasting period. Dressed carcasses were weighed within an hour (hot carcass weight), and slaughter by-products were collected and weighed within 30 minutes. Thereafter, carcasses underwent the process of ripening for 24 hours at 4°C, followed by the cutting process into prime cuts based on age and through the quarter segmentation procedure. The fore-quarter portions (neck, thick ribs, eye ribs, loin, shoulder, and breast) were differentiated from the hind-quarter portions (flank, chump, leg, and shank). All meat portions were immediately vacuum-packed into polyethylene film pouches (size 200x300) of 250 gauge and transported in a refrigerated vehicle to a domestic food laboratory and stored in a freezer at -18°C. During all product development, several trials, strict food safety practices, and hygiene standards were maintained following the Foodstuffs and Cosmetics Disinfectants Act, R638 legislation (South African Department of Health 2018:1-38), which specifies regulations for food safety and best practices for food preparation. Similarly, studies show that access to diverse, safe, and nutritious diets is necessary for health and well-being (Traoré et al., 2018, Palmer, 2023). Three goat meat products were developed based on

the results of a preliminary study, which focused on the assessment and documentation of the original favourite goat meat recipes of different ethnic groups and preferences, and utilization patterns of goat meat in the African continent (Nigeria, Congo, Kenya Mozambique, and Southern Africa perspective) (Rich et al., 2022, Woma et al., 2025). Three of the most popular recipes selected for acceptability were categorised into moist, dried, and processed products, namely: goat meat stew, roasted goat leg, and goat meatballs. Using this information, goat meat curry, dry wors (dried meat), and burger patties were reformulated to modernise goat meat consumption for the South African context (Palmer, 2023).

a) Goat meat curry

Moist-heat cooking methods were used to prepare the goat meat curry, including braising and slow cooking. This cooking method is often used for tough cuts of meat that require a longer cooking process (Brown 2018). Vegetable oil (sunflower) was added to a preheated pan, followed by the sauteing of onions until golden brown. Garlic pastes, ginger, and spices were added and cooked until aromatic. Cubed goat meat selected from the shoulder, leg, and rib sections was added to the pot, followed by tomatoes, salt, and water. The curry was thoroughly mixed, and the pot was covered with a lid to allow the meat to cook to tender. After approximately 2 hours, peeled medium-sized potatoes (*Sifra* variety) were added to the curry. The meat and potatoes were cooked until tender within 1 hour and 45 Minutes.

b) Goat meat burger patty

To prepare the goat meat burgers, meat from the leg and shoulder was deboned, cubed, and minced using a 6mm die plate (Palmer, 2023). Seasoning is added, the mixture is minced again to form an emulsion, and it is shaped into 100mm diameter patties using a manual press. For frying, 10 ml of sunflower oil, with a high smoke point of 210°C, is used in a non-stick pan (Bastida and Sánchez-Muniz, 2015). The patties are cooked for 10 minutes, 5 minutes on each side, allowing the Maillard reaction to caramelize and brown them. The internal temperature is measured to ensure it reaches 75°C for food safety (Jones et al. 2017). After frying, the patties are drained on paper towels. For sensory evaluation, samples are provided to panellists in clear plastic containers with lids (Rodriguez et al., 2022).

c) Goat meat dry wors

Dried wors is a South African type of savoury snack prepared without any other form of heat. To prepare dried wors, the following steps were followed: before the curing process, the goat meat was deboned and cubed (Palmer, 2023). Spices were added to the meat before it was minced and filled into sheep casing to form the dried wors. The dried wors was placed in a drying box to cure. Specific adjustments and ingredient modifications were applied to enhance the texture and aroma attributes of the dried wors. Drying parameters were determined and maintained throughout the curing process. The drying parameters considered the temperature of 25°C, at a relative humidity of 30%, and an air velocity of 2 m/s, for 5 days. Thereafter, the dried wors was cut into individual samples 8cm long for the sensory evaluation process, using a food slicer (OMAS, Type H 300, Italy).

Microbial analysis

Microbiological testing was conducted for all three goat products: curry, dried wors, and burger patty. The samples were prepared on the same day and sent for microbiological testing, excluding dried wors which were prepared ahead to allow an adequate drying process. Goat curry (100 g) was packed in a pre-sterilised bottle and closed, while (110 g) burger patty and (100 g) dried wors were packed separately in a sterile bag and placed in a cooler box with ice packs to maintain the cold chain at about 4°C. Product samples were sent to an AOAC-accredited laboratory to be analysed for total plate count, *Presumptive E. coli*, *Salmonella spp.*, and *Enumeration* of *S. aureus*. Microbiological analyses were conducted to ensure the safety of the consumers and the reliability of the results presented. The total microbial plate count was determined using a 10 g sample of each goat product, homogenised in 90 ml sterile 0.1% peptone water, and analysed using the plate count agar. The samples were analysed using the plate count agar at 30°C for 72 hours - ISO 4833:2003[E]. Each sample was measured in Colony Forming Unit (CFU/g), respectively, and mean values for microbial total count were established for goat curry, burger patty, and dried-wors. Detection method for *Presumptive E. coli* using broths and peptone water at 37°C and 44ºC for 2-6 days - guided by the South African National Standard (SANS) 7251:2005 ed.2 was conducted for all three goat meat samples. The mean values were determined from the readings recorded for each sample. Salmonella detection was carried out using South African National Standards (SANS) ISO 6579 in 25g of goat meat curry and burger patty. The *Listeria monocytogenes* collections were developed following a 48-hour incubation period at 37°C under the guidelines provided by SANS 5763:2006 & ISO 11290-2:1998 (E). Each sample was measured in CFU/g, respectively, and mean values for *Listeria* monocytogenes were concluded in all three goat meat samples. *Staphylococcus aureus* bacterial load was conducted using the Baird Parker agar at 37°C for 48 hours, guided by SANS 5763:2006.

Physicochemical quality assessments

Parameters such as texture profiling were ensured during this study for the acceptability of the safe value-added goat meat products. Similarly, Texture Profile Analysis is a method used to evaluate the textural attributes of all food products (Gawat et al., 2022; Gawat et al., 2023). Thus, in this study, the properties of the goat meat product's texture were evaluated by chewing through a two-cycle compression test as reported by previous researcher (Gawat et al., 2023). In this exercise, measures that include characteristics like hardness, cohesiveness, springiness, chewiness, and resilience were evaluated to ensure the value-added goat meat ' quality and consistency, meet the consumer expectations for texture and palatability. The physical quality of the resulting goat products was determined by using an instrumental TA-XT Plus Texture Analyser. The texture analyser or tetrameter is an instrument used to measure the mechanical properties of food materials (Paniagua and Benitez-Alfonso, 2020).

Three-point Warmer-Bratzler blade attachment that mimics the consumer's teeth and the amount of pressure to bite into the food was connected to a 30 kg load cell of a universal TA-XT texture analyser. The maximum peak force (Newtons) for triplicate samples per product from the force deformation curve was recorded. Hence, this action determined the amount of force needed to determine the texture of the product's tenderness/ toughness of the products. Colour was measured using a HunterLab ColorFlex Colorimetric Spectrophotometer (model 45/0, HunterLab Reston, USA) (Estrada-León et al., 2022). The readings of each sample were taken in triplicate for validity sake, with the mean values for L*, a*, and b* determined (L*= lightness and ranges from 0 [black] to 100 [white], a*= redness and ranges from green [–] up to red [+], b*= yellowness and ranges from blue [–] to yellow [+]). The three colour readings were taken from moist and dry cooked products and the dried product. However, the trained panel results from this study indicated that the preparation technique for the three goat meat products could enhance consumer acceptance of products with the potential to meet the consumers' demands for convenient and healthier animal products from their natural origin.

Consumer acceptability

After the products were developed and tested based on the physicochemical and microbial parameters, the products were evaluated for consumer acceptability. The 120 untrained consumers from two higher education institutions under the uMhlathuze Municipality, KwaZulu-Natal, were recruited to evaluate the three goat meat food products. Inclusion criteria specific to this study were participants who were students or staff members without food-related allergies and who were goat meat consumers (Civille et al., 2024). The cohort was recruited based on the assumption that it adequately represents both current and potential future consumers, thereby ensuring the relevance and applicability of the findings to evolving consumer markets. This recruitment approach was designed to enhance the reliability and validity of the study, providing a robust foundation for concluding consumer preferences and behaviours. Before the evaluation of the products, panelists were informed about the procedure of the sensory test they were invited to perform, without disclosing sample information. Panellists were requested to evaluate and record their product preference on the five-point hedonic scale to show how much they loved the products (5 = very good, 1 = very bad), for general aroma, tenderness, flavour, juiciness, aftertaste, and overall acceptability of products as 1 = Extremely pleasant, 5 = extremely unpleasant. The 5-point Hedonic scale was followed by the preference ranking test to cross-check which product was mostly, moderately, and least preferred among the three developed products. Thereafter, a food action rating scale was administered to determine if they liked the products enough to buy them, and how often they would consume the products. Goat meat curry and burger patty samples were prepared and kept in warm water baths to maintain a standardized temperature before serving, while goat dry wors was served at room temperature (Stone et al., 2020). Each 40g sample was assigned a unique three-digit code and served in a random order to prevent bias. Samples were placed in clear plastic containers with lids to maintain warmth. They were served on a tray with a cup of water, a plain cracker (for palate cleansing), a scorecard, a pencil, an eraser, and a small plastic bag for expectorating samples if needed, as shown in Figure 1. Sensory evaluation screens were used to separate participants and allow for a controlled and unbiased sensory evaluation process as depicted in Figure 2.

Figure 1: Sensory evaluation tray set up. Figure 2: Sensory evaluation environment

Food action rating scale (FACT)

The Food Action Rating Scale (FACT) is a psychological measurement tool to assess food acceptance and consumer intent regarding food products. This category scale aims to gauge participants' willingness to consume specific items, such as goat meat curry, burger patties, and dry wors. The FACT rating scale was conducted for the products preferred the most, and for validity, the researcher cross-checked if the product was rated high in the hedonic results, which is then correlated with the results from the FACT (Alcalde et al., 2023)

Data analysis

The data collected was analysed using variance (ANOVA) in Statistical Package for Social Sciences (SPSS) Software version 28.0. Significant F tests at levels of probability ($p<0.05$) are reported. Samples were analysed in triplicate, and mean values were established for each food product.

4. Results and discussion

Goat meat product development

The three value-added goat meat products were developed, involving several key steps to enhance the overall sustainability and appealing end products in the food system (Palmer et al., 2023). Goat meat curry, burger patties, and dried wors are depicted in Figures 3, 4, and 5. The detailed recipes for these products are described in Table 1.

Figure 3: Goat meat curry

Figure 4: Goat meat burger patty

Figure 5: Goat meat dry wors

Table 1: Value-added goat meat product recipes

Goat meat curry		**Goat meat burger patty**		**Goat meat dry wors**	
Quantity	**Ingredient**	**Quantity**	**Ingredient**	**Quantity**	**Ingredient**
Goat meat: neck, shoulder, shoulder shank, and breast	3 kg	Goat meat: leg, flank, and shoulder	3 kg	Goat meat: leg, flank, and shoulder	3 kg
Sunflower oil	270 ml	Fine salt	30 ml	Spark	1000g
Star anise -grounded	15 ml	Black pepper, cracked and ground	7,5 ml	Black pepper was cracked and ground	7.2g l
Curry leave	15 ml	Coriander and cumin powder	7.5ml	Ground coriander and cumin	30 g
Red onion	3 large	Garlic powder	7.5 ml	Garlic powder	12 g
Ginger and garlic paste	90 ml	Ginger powder	7.5 ml	Ginger powder	12 g
Masala curry powder	90 ml	Paprika	22.5 ml		7.5 ml
Turmeric powder	15 ml	Onion powder	30 ml		
Garam masala	15 ml	Worcestershire sauce	30 ml		
Coriander and cumin	15 ml	Egg beaten	3		
Tomatoes are peeled and finely chopped	6 medium tomatoes	Granulated sugar	7.5 ml		
Iodised salt	30 ml	Butter	15 ml	Iodised salt	72 g
Hot water	2 250 ml	Sunflower oil	15 ml		
Potatoes cubed	9 medium potatoes				
Preparation method:		**Preparation method:**		**Preparation method:**	
1. Wash the meat in water with vinegar until it's clean.		1. Cut the meat into small pieces of 3x3 cm, removing the bones.		1. Cut the meat into small pieces of 3x3 cm, removing the bones.	
2. Cut meat into small pieces of 25x25mm, removing all bones.		2. Place pieces of meat in a bowl, add seasonings, sugar, and egg, and mix thoroughly.		2. Place pieces of meat in a bowl, add seasonings, and mix thoroughly.	
3. Place the meat in a bowl, rub in 30ml of oil and Worcestershire sauce. Cling wrap and allow to rest for 15 minutes.		3. Rub the meat with Worcestershire sauce, butter, and oil.		3. Cling-wrap the bowl of meat and refrigerate for 10 minutes. Sprinkle the rest of the ingredients and rub well.	
Cooking method		4. Cling wrap and allow to chill overnight in the refrigerator.		4. Cling wrap and allow to chill overnight in the refrigerator.	
1. Heat 15ml of oil in a non-stick pan and braise the meat for 10 minutes.		5. Using the 8mm grinding plate, mince the formulation through the mincing funnel.		5. Using the 8mm grinding plate, mince the formulation through the mincing funnel to mince.	
2. Take out the meat into a bowl and cover it, and add curry leaves to fry.		6. The mincemeat was Shaped into a 120 g burger patty using the manual patty machine (100mm).		6. To prepare the casing, rinse thoroughly with tepid water to remove all residual salt for preservation.	
3. When it starts spluttering, add onions.		**Cooking method**		7. Using a manual sausage-filling machine with a size 26mm sheep casing, fill the goat meat mince into the casing.	
4. Fry onions until translucent, then add ginger and garlic paste.		1. The frying pan was preheated, and the sunflower oil was added.		8. After the casing was filled, it was left open on the sides for water to ooze out during dehydration.	
5. masala curry, turmeric, garam masala, cumin, and star anise.		2. The burger patty was fried for 5 minutes on each side, with the internal temperature measuring 75°C.		9. Allow the wounds to dry for about a week. thereafter, cut it into a desired shape.	
6. Add goat meat to the fry and add tomatoes as well as salt.					
7. Allow to simmer until the tomato juice dries out.					
8. Add water and cook for a further 40 minutes or until the meat is almost tender.					
9. Add potatoes and allow to cook slowly.					
10. Cook until potatoes are soft and the sauce has thickened.					
11. Once ready, allow 10 minutes to rest and serve it.					

Ingredients were selected to prepare all three products which are primarily known to mask the distinct flavour/aroma associated with red meat. In addition, a pre-treatment which included rinsing the goat meat with a solution of vinegar and water - a typical practice followed by South African Indians- was followed to reduce the distinct smell associated with goat meat that influences consumer acceptability (Palmer, 2023, Hamad et al., 2024). Aromatic spices, including garam masala, masala curry powder, star anise, coriander, and cumin in powder form, were included to mask the distinct goat meat smell and improve the overall aroma in the curry (Palmer, 2023) Similar spices/ seasonings were used for the preparation of the burger patty and dry wors. Common ingredients used in all three recipes included garlic and ginger (paste or powder form, depending on the recipe), coriander powder, and cumin powder.

Microbiological results

Microbiological testing was conducted to determine the safety of the developed products before consumption. The findings of the microbial test are described in Table 2.

Table 2: Microbiological results for goat meat curry, burger patties, and dry wors

Microbial Test Analysis	Goat meat curry (cfu/g)	Goat burger patty (cfu/g)	Goat dried wors (cfu/g)	Acceptable limits cfu/g
Total plate count	3.7×10^2	1.6×10^6	1.6×10^2	$<10^6$
Escherichia (*E. coli*) /0.1g	Absence	Absence	Absence	<10
Salmonella spp. / 25g	Absence	Absence	Absence	0/25g
Listeria monocytogenes (CFU/g)	Absence	Absence	Absence	0/25g
S. aureus (CFU/g)	<100	<100	<100	$<10^3$
Yeast	-	-	<100	$<10^4$
Mould	-	-	<100	$<10^4$
Clostridium perfringens	-	-	<10	$<10^2$

Colony-forming units per gram (cfu/g)

Three products developed were further compared in terms of the number of microorganisms count between two replicates using the Comparison Pairwise Welch's t-test, as illustrated in Table 3.

Table 3: Microorganism results using Comparison Pairwise Welch's t-test,

Goat meat products	Total plate count (cfu/g)	Mean	Standard deviation (SD)	P-value	Significance
Goat curry vs Burger patty	382,77 354,07	368,42	20,29	0,0260	P < 0.05
Goat curry vs Dried wors	1750000 1612500	1,681,250.00	97,227.18	0.0182	P < 0.05
Burger patty vs Dried wors	180 149	160.00	28.28	0.0260	P < 0.05

The total plate count (TPC) indicated that the number of viable microorganisms per gram of the goat burger patties was P < 0.05, goat meat curry P < 0.05 and goat dried wors P < 0.05. Thus, all three products were within acceptable limits based on the raw state of burger patties. However, the TPC was owing to decreased as goat burger patties were cooked before consumption. This suggests that the goat burger patties' microbial contamination level was temporally high, owing to drop due to the heating process, while the goat meat curry and dried wors plate count was lower than that of the goat burger patties. The absence of *Escherichia coli*, *Salmonella,* and *Listeria monocytogenes* in all three products reassured that food safety and hygiene practices were adhered to, as these bacteria can cause moderate to severe food poisoning if consumed (Kannan et al., 2021). While the goat meat curry and burger patty were cooked, the dry wors was a raw-cured product, preserved using only salt and vinegar (natural preservatives), which reduced the water content, resulting in limited conditions for food spoilage microorganisms' survival (Jabeen et al., 2023, Zioud et al., 2024) The results indicated that all three goat meat products were safe for consumption when aligned with the government legislation standards based on the International Commission of Microbiological Specifications for Foods, and international standards in food safety and quality (GSO 1016/2015).

Physicochemical parameters

The physicochemical parameters were determined to evaluate the quality value added to goat meat products. Findings for the properties are described in Table 3.

Table 4: Results for texture and colour analysis of goat meat products

Treatments	A	B	L	Firmness (N)	Toughness(mm)
Goat Curry	5.95 ± 1.29^{ab}	20.62 ± 4.08^{b}	$28.68 \pm 2,21^{b}$	46.4 ± 5.29^{a}	27094 ± 2352^{a}
Dried Wors	2.760 ± 0.06^{a}	4.37 ± 0.61^{a}	21.10 ± 0.73^{a}	273.0 ± 48.62^{b}	39666 ± 13450^{a}
Burger Patty	8.093 ± 0.71^{b}	14.59 ± 0.92^{ab}	35.48 ± 1.40^{b}	$53.0 \pm 2,18^{a}$	80587 ± 1541^{b}
P-value	0,047	0.030	0,015	0,006	0,026

^{ab}Least square means (LSM) with different superscripts within a row are different at P<0.05. L*–reflects the lightness of meat colour, a*– reflects redness, and b*– reflects the yellowness.

The instrumental texture results for determination of tenderness presented in Table 4, revealed the maximum shear force and workforce demonstrated on dry wors was the highest (273.0±48.62), while the minimum values were observed in goat curry (46.4±5.29), followed by the burger patty (53.0±2,18) with a better toughness than the dry wors. The textural values of meat are evaluated by the number of muscle fibres and thickness of connective tissue as measured by the texture profile analysis (TPA). The shear force value of goat curry and burger patty was within the range reported by (Umaraw et al., 2015), which is 32.6 – 56.34 N. Though the burger shear force was higher than that of goat curry, the mean shear force and work of shear area values of dried wors were significantly higher (P<0.05) than that of goat curry and burger patty, which could be attributed to the drying technique applied, which preserved the meat with up to 50% water loss for 118 hours (Jones et al., 2017). The shear force value of the meat prepared in the goat curry decreased due to the presence of water between the muscle fibres, owing to the cooking process applied (moist cooking method). The cooking process involves braising the meat cubes to seal the moisture content, simmering at a low temperature. In that way, the cooking time increased, and the shear force value decreased (Brown et al., 2015). Vasanti et al. (2007) and Brown (2018) observed similar findings of decreasing shear force value with increasing cooking time. Again, it was noted that as the meat cooled down (goat curry and burger patty), the weight loss gradually increased. However, dry processing can easily form charred skin on the meat surface, while wet processing methods result in a moist meat surface, which was another reason for differences in meat quality among the different thermal processing methods

(Liu and Lanier, 2016). Results for the *colour* of food. The colour results in Table 3 indicate the differences in colour values of goat meat samples with different cooking/processing methods. The results indicated a declining colour trend in all products (goat curry, dry wors, and burger patty), and showed a significant difference ($P < 0.05$) in the values for the a*, L*, and b* parameters. Declined colour scores in burger patties and dry wors could be attributed to lipid and pigment oxidation, as dry wors and patties' formulation were frequently handled during the massaging and mincing stage. As a result, enzymic browning and surface dehydration contributed to colour reduction. Several studies also confirmed that salt content has a pro-oxidant effect on lipids due to salt's inhibitory action on the antioxidant enzymes, leading to discoloration in meat products as well (Mariutti and Bragagnolo, 2017) Therefore, the study discovered that good management practices during food production are important for product quality. Ivanović and Pavlovi (2015) reported that meat colour may be affected by many factors, including type/breed, structure, the ratio of intramuscular fat, and many more (Ivanović et al., 2015, Ivanović et al., 2020).

Consumer acceptability

Sensory evaluation is an integral part of the product development process. Sensory testing was used to assess consumer approval (Teixeira et al., 2020). Various sensory evaluation tests were administered in this study to determine the consumers' attitudes and their perception of the three goat meat food products. The tests included a five-point hedonic scale test, a ranking preference test, and a food action rating scale to determine their intent to purchase. Consumer insight has always been crucial to ensure that new developments are in line with consumer preferences, and to enhance the likelihood of commercial success (Teixeira et al., 2020). The participants' demographic information in the acceptability evaluation of the goat meat-based product samples under study is described in Table 5. Representing the population gender pattern, there were more females than males, there were about 63% of females. The higher-level students who are youth were selected as the evaluators of the acceptability of the food products. The participants were all Africans, as goat meat is usually commonly consumed during festivities amongst this group. As reported in the literature, goat meat is underutilized and less consumed than other red meat types due to certain unacceptable attributes(Webb, 2014, Ngomane et al., 2022) Therefore, the demographic featured gender, ethnicity, and targeting the youth population group were of fundamental importance in the study, as it assumed that they may support or reject the prospects of goat meat marketing.

Table 5: Demographic information of the consumer acceptance participants (n=120)

Variables	Frequency	Percentage (%)
Gender		
Male	45	37.5
Female	75	62.5
Age		
Less than 20 years	12	10.0
20 - 25 years	63	52.2
26 - 30 years	14	11.6
Above 30 years	31	26.2
Ethnic group		
African	120	100
Educational level		
1sy year	11	9.2
2nd year	41	34.2
3rd year	42	35.0
4th year	16	13.3
Postgraduate	10	8.3

Five-point hedonic rating test was used to evaluate the sensory attributes based on consumer perceptions. The use of a validated Likert scale facilitates easy interpretation of the consumer preference results (Ceave, 2017). The results in Table 6 described the scores received from the participants on the 5-point hedonic rating test.

Table 6: Sensory attributes evaluated using a 5-point hedonic rating scale for the three goat meat products (n=120)

Attributes (Mean ± SD)	**Treatments**		
	Curry	**Burger patty**	**Dried wors**
Aroma	4.6 ± 0.57	4.4 ± 0.62	4.1 ± 0.71
Tenderness	4.8 ± 0.45	4.5 ± 0.59	0.0 ± 0.45
Juiciness	4.7 ± 0.50	4.0 ± 0.71	0.1 ± 0.24
Dryness	0.0 ± 0.41	0.1 ± 0.24	4.4 ± 0.61
Mouthfeel	4.7 ± 0.45	4.6 ± 0.59	4.3 ± 0.64
Flavour	4.7 ± 0.53	4.6 ± 0.61	4.3 ± 0.69
Aftertaste	4.6 ± 0.62	4.5 ± 0.74	4.2 ± 0.76
Overall acceptability	**1.8 ± 0.601**	**1.5 ± 0.56**	**1.3 ± 0.57**

Table 6. shows that tenderness in the curry was very good with an average of 4.8, followed by the juiciness and flavour of the curry, both with 4.7. The aroma was also good with a mean of 4.6. The overall acceptability level of the curry was 1.3, indicating that it was extremely pleasant. The literature supports the positive acceptability of goat meat curry, highlighting its potential as a viable and culturally significant product (Palmer et al., 2023). Research by Dolojan et al. (2014) demonstrated that goat curry is well-received in sensory evaluations, suggesting its suitability for commercialization in local markets. Similarly, Palmer (2023) found that goat curry resonated well with young adults in South Africa, reflecting its appeal to emerging consumer demographics and its potential in modern food markets. Xazela et al. (2011) further emphasized the impact of cooking methods on consumer acceptability level, with goat curry which was identified as one of the preferred method of preparations due to its favourable sensory attributes such as flavour and tenderness. Goat meat curry referred to as "curried goat", is a common dish in Indian communities, and the dish is known for its rich, flavourful sauce and tender meat, mostly

cooked with a combination of spices, including curry powder, garlic, ginger, and sometimes apricots or buttermilk for a unique variation (Palmer, 2023). In most of the South African cities, goat meat does not seem popular, or even easily accessible in retail stores. However, goat meat is widely consumed in rural areas for religious and cultural purposes (Ngomane et al., 2022) Despite its popularity, goat meat is often sold in informal markets rather than mainstream supermarkets, which can limit its availability and utilisation. Studies have demonstrated that curried goat meat is typically enjoyed with rice or bread. (Palmer et al., 2022, Palmer, 2023, Gawat et al., 2023). Curry dish's preparation can vary, as it usually involves a slow cooking method to ensure its tenderisation and to absorb the rich flavours of the spices The goat meat burger patty also received favourable results with a mean of 4.6, followed by tenderness with an average of 4.5. The juiciness and aroma of the goat burger were good, with averages of 4.4 and 4.0, respectively. On the contrary, Teixeira et al. (2021) found that goat burgers were sensorially harder and presented a more difficult chewiness than beef burgers (Teixeira et al., 2021). However, the overall acceptability of the goat burger was 1.5, indicating that it was pleasant. This implies that most of the participants found goat curry and the burger enjoyable. The dry wors sensory analysis showed that almost all the sensory attributes received were not as favourable as compared to the curry and burger patty. This could be because the participants do not eat dry wors as frequently compared to the other two products. Though the curry may not be the traditional Indian curry, but a stew with additional flavours. Whereas biltong traditionally originated among the Afrikaners in South Africa, it is not traditionalised for Zulu culture, and they might need to familiarise themselves with the taste of it as well. This is consistent with results from a previous study of food consumption in South Africa, which reported a significant increase in meat consumption, with chicken being the most consumed protein (Makusha et al., 2023). While a study on processed meat consumption by young Adults in South Africa reported meatballs and biltong (salted dried meat) as not commonly consumed meat products, with a significant percentage of participants reporting not consuming these items ($p<0.01$) (Palmer et al., 2022). This could be the reason why dried wors was not the popular choice for the students. Burger patties are always available, accessible, and cheap for students' accessibility.
The overall acceptability of goat products in Figure 6 was analysed based on the variance of 1= extremely pleasant, 3 = average, and 5 = extremely unpleasant. Therefore, Figure 6 below shows the overall acceptability of goat meat products in percentage, indicating that more than 70% of participants considered goat curry extremely pleasant which describe the highest percentage among the three goat meat food products. implying that curry was the most well-liked food products, which is consistent with previous studies that reported on goat meat as the most appreciated above other goat meat products (Palmer et al., 2023). Similarly, the results indicated that 49% of participants regarded burgers as extremely pleasant, as the second-highest percentage after goat curry. Meaning that, burger patties were the second most liked food products, and 30% of participants considered the wors from goat meat as extremely pleasant. This was the lowest percentage of the three developed foods. Therefore, wors was the least liked food item based on the results. The results showed only 6.6% of participants considered wors to have an average taste, while 2,5% of participants considered curry to have an average taste. Only 0.83% of participants gave the burger an average taste rating. Therefore, none of the products were considered extremely unpleasant by the participants. Most participants found all three products pleasant and extremely pleasant, as depicted in Figure 6.

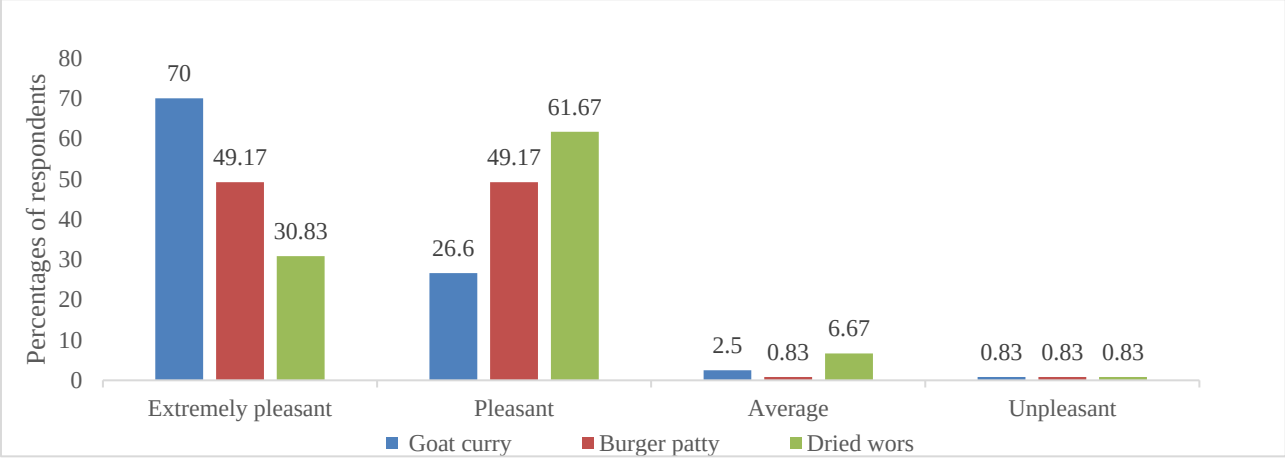

Figure 6: Percentage of responses for goat meat product acceptability (n=120).

Figure 6 presents the overall acceptability of innovative goat meat products by age. The results showed that age had a positive and significant impact on the goat curry at a level of 1%. This means that as age increases, the more goat curry is consumed. This could probably be because goat meat is more commonly used for customs and traditions that involve older people. However, the study results were substantiated by Liu et al. (2013), who reported that a substantial demand for goat meat with great growth potential was driven by demographic factors such as age. Again, this could probably be because young people are so determined to try new products for future potential consumers and markets. However, the age of participants did not have any significant impact on goat burgers. This means that the consumption of goat burgers was not influenced by age groups. However, the study conducted by (Ngomane et al., 2022) also found youths' perceptions as key factors in determining the future trends of goat meat marketing and consumption in South Africa. Ngomane further concluded that very little information

is available from the youth segment that can be used to inform product offerings in South African markets (Ngomane et al., 2022). The results in Table 6 show that the age of participants has a positive and significant ($p<0.05$) impact on the goat wors product. This implies that as the participants' age increased, more goat wors was accepted. This was in line with the results of Zenebe et al. (2014), who reported that older people tend to demand more goat products, such as wors, as they understand the nutritional values received from goat meat. However, a study on youths' goat meat consumption in South Africa reported biltong (salted dried meat) and meatballs (ground meat) as not commonly consumed items, with a significant percentage ($p<0.01$) ((Palmer et al., 2022) Palmer et al., 2022). In addition, biltong manufacturing would be more expensive compared to curry and burgers due to nutrient concentration. Moreover, biltong or dried wors is viewed more as a snack food item as compared to goat meat curry and patties, which contribute more towards satiety.

Table 7: **Overall acceptability of value-added goat products by age (n=120).**

Treatments	Age category	Mean	S. Deviation	P-value
Goat curry	Less than 20	1.53	0.68	
	20 to 25	1.39	0.59	0.005
	26 to 30	1.00	0.00	
	Over 30	1.06	0.24	
Burger patty	Less than 20	1.53	0.51	
	20 to 25	1.61	0.61	0.354
	26 to 30	1.42	0.51	
	Over 30	1.35	0.49	
Dried wors	Less than 20	1.90	0.55	
	20 to 25	1.84	0.61	0.034
	26 to 30	1.67	0.65	
	Over 30	1.41	0.51	

A value of $p<0.05$ is regarded as statistically significant

The preference ranking scale test is a category scale that was used to determine participants' preferences as to which product was highly preferred, moderately preferred, and least preferred. Results of the preference ranking test are shown in Table 8.

Table 8: Goat meat product preferences in percentage (n=120).

Treatments	Highly preferred (%)	Moderately preferred (%)	Least preferred (%)
Goat curry	61.7	26.7	11.7
Burger patty	30.8	57.5	11.7
Dry wors	7.5	15.8	76.7

Table 7 shows that about 61.7% of participants preferred goat curry, while 30.8% preferred burgers, and only 7.5% of participants preferred wors. The results showed that goat burgers were moderately preferred by almost 57.5% of participants, 26.7% of participants moderately preferred goat meat curry, and about 15.8% of the participants moderately preferred dried wors. Approximately 76.7% of the participants least preferred the wors, while 11.7% preferred the burger and curry, respectively. This means that dried wors was not as popular as curry and burger patty among the participants, as revealed in the study results. Dried wors was the least preferred product, probably due to a lack of familiarity and its characteristics. The study by Palmer et al. (2023) concerning the youths' consumption of processed meat products also found similar results, where biltong (salted dried meat) was not a popular option among young African students. Nevertheless, the nutritional content (protein quality) of biltong is higher, resulting in a more concentrated form. However, curries and burgers were preferable for students due to their familiarity and convenience from the students. Again, burger patties are students' fast food, easily accessible based on their availability in dining halls and retail for self-catering. Whereas biltong is viewed as a savoury snack that is expensive and not hunger-filling. Congruently, Mazhangara et al. (2019) and Web (2014), concerning this study, highlighted product popularity as one of the key factors that prompt consumers towards a certain product, as it centred around healthful attributes such as its low content of fat, cholesterol, and saturated fatty acids (Mazhangara et al., 2019).

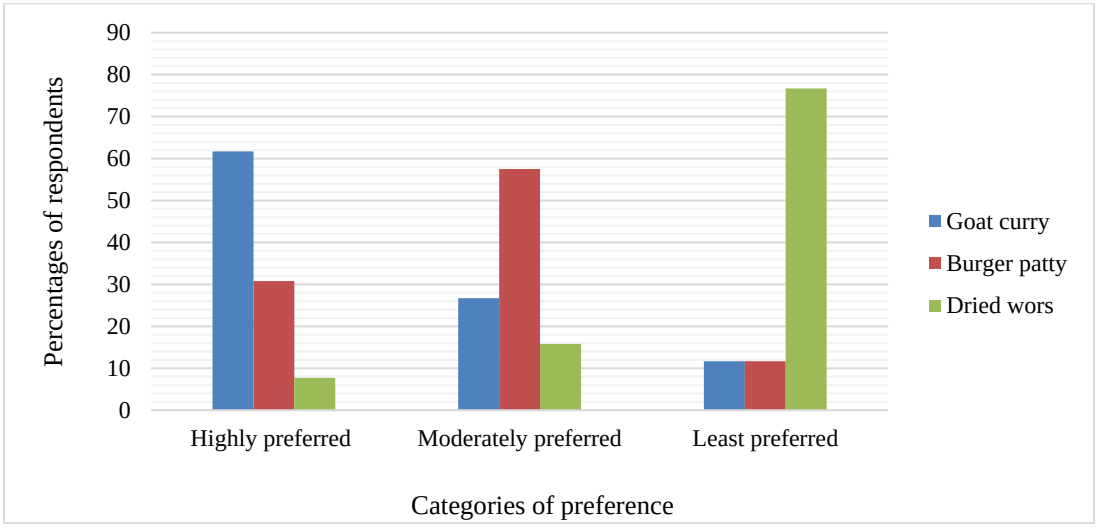

Figure 7: Goat meat products preference test results in percentage (n=120)

Food Action Rating Scale

The FACT rating scale was completed for the product that the panellist preferred the most. For validity, the researcher cross-checked if the product was rated high in the hedonic results The results show that the preference was high enough to prompt the participants to purchase the product should it be available in the market (Figure 8). Hence, the participants might like the product but may not be willing to buy it based on various factors such as the portion size and the price.

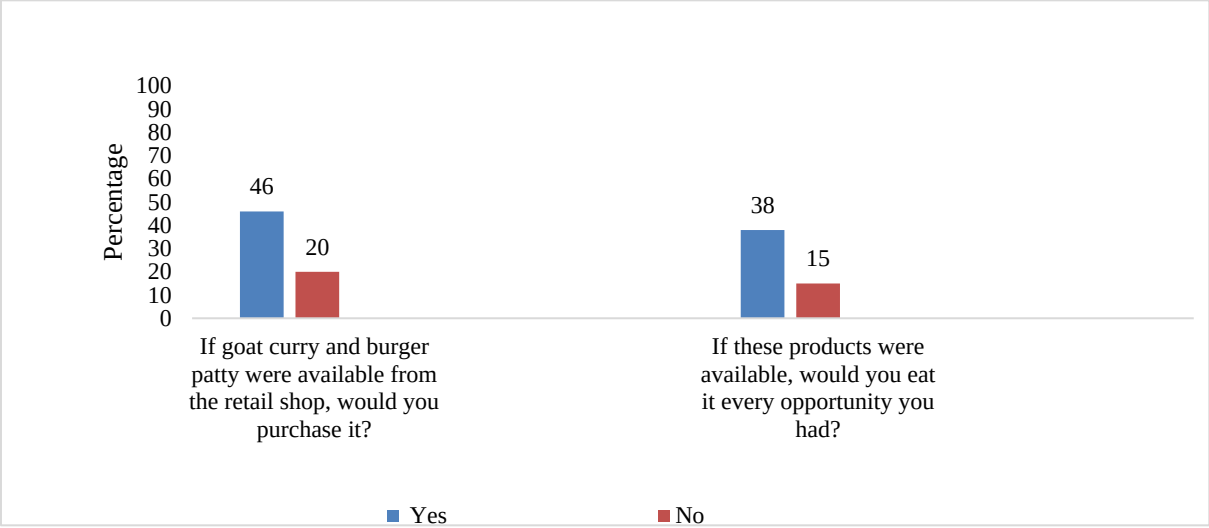

Figure 8: Participants' willingness to purchase goat meat curry and the burger patty (n=120)

These results affirmed what was highly rated in the hedonic and preference rating scale tests, and it is what consumers were willing to purchase in terms of the food action rating scale results. The consumer's willingness to purchase goat curry and burger patties in Figure 8 indicated that most participants would be willing to buy the goat meat curry, followed by the burger patty, should they be available in the markets. In comparison, 20% (curry) and 15% (burger patty) had no intention to purchase these products (not willing to purchase). Moreover, 46% and 38% indicated the willingness to consume these products at every opportunity, while 20% (curry) and 15% (burger patty) participants indicated not being willing to consume these products at every opportunity. Results indicate that, though goat meat is not viewed as a popular protein choice, people's personality traits, particularly their fear of trying new foods, play a significant role in their opinions about it. Consumption is also influenced by accessibility, with the least-utilised marketing channels for goat meat (4%, with most goat sales occurring through auctions (14%), butchers (10%), and informal traders (12%). These marketing channels, particularly the informal sector, play a crucial role in supplying goat meat for cultural and traditional purposes (Ntuli and Fourie, 2022). A stability gap in the goat meat market exists, where regular, retail-based supply channels are underdeveloped, and seasonal, need-based demand leads to an uneven supply chain. These dynamics reveal the socio-economic disparities that influence accessibility, whereby goat meat, due to cultural significance and limited supply infrastructure, remains a niche product largely accessible to higher-income consumers or those directly involved in cultural and religious practices. Therefore, more research effort should be channelled towards optimising the sensory characterisation of this meat type. While assurance of consumers' safety, education on culinary procedures, increased product variety, and availability to meet demands could enhance the expansion and sustainable utilisation of such a nutritious alternative to red meat in the goat meat industry. The value-added goat meat products as a viable strategy to enhance consumer acceptance and sustainable utilisation of goat meat. These products have the potential to compete with other red meats, offering a valuable source of nutrition and revenue for both household and commercial markets.

Conclusion

This study contributes to both academic knowledge and practical applications in the food industry. Thus, the study has the potential to serve as a reference for academics, practitioners, and policymakers interested in advancing the goat meat industry. Therefore, industry researchers are encouraged to collaborate on initiatives aimed at promoting goat meat consumption. Hence, goat meat value-addition has potential avenues for future research, such as investigating the effects of different cooking methods or incorporating functional ingredients into goat meat products. Overall, the study supports the development of value-added goat meat products as a strategy to enhance consumer acceptance and promote the sustainable use of goat meat, positioning them as competitive alternatives to other red meats. Future research should focus on optimising processing techniques to preserve key sensory and physicochemical qualities, including colour and tenderness, while exploring the relationship between raw meat quality and processed products. Proper preparation and processing of traditional animal foods with high nutritional value can enhance consumer acceptability, ensure product availability and accessibility while supporting sustainable food systems.

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