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Development and quality evaluation of carabeef spread incorporated with almond gum and foxtail millet

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Abstract
The present study was conducted to develop a nutritionally enriched carabeef spread incorporated with almond gum and foxtail millet and to evaluate its proximate composition and sensory attributes. Two formulations were prepared: T_1 (control, without foxtail millet) and T_2 (treatment with foxtail millet), with functional ingredients such as butter, almond gum and corn flour added to improve texture, stability and spreadability. The proximate composition analysis showed that moisture content slightly decreased from 67.13% in T_1 to 66.43% in T_2, while crude protein decreased from 19.50% to 17.64% due to the partial replacement of meat with foxtail millet. Crude fat content also reduced from 9.58% to 8.42% in the millet-incorporated treatment. However, the incorporation of foxtail millet significantly increased crude fibre (0.59% to 1.20%), ash (1.69% to 1.79%) and calcium content (0.07% to 0.14%), indicating improved nutritional value, while gross energy decreased from 2071 kcal/kg to 1927 kcal/kg. Sensory evaluation revealed that the millet-incorporated spread showed slightly higher scores for appearance (7.78), flavour (7.65), taste (7.83), adhesive ability (7.73), aftertaste (7.66) and overall acceptability (7.80), although spreadability was slightly lower due to increased viscosity caused by millet starch and fibre. The present results indicated that the incorporation of almond gum and foxtail millet enhanced the nutritional profile, particularly fibre and calcium content, without adversely affecting sensory quality, suggesting its potential use as a functional ingredient in the development of nutritionally enriched carabeef spreads.

Keywords: Buffalo meat, spread, proximate composition, sensory quality, almond gum and foxtail millet

Introduction
Buffalo meat, commonly referred to as carabeef, is derived from the water buffalo (*Bubalus bubalis*) and serves as an important source of animal protein in many Asian countries, particularly in India. Nutritionally, buffalo meat is considered superior in several aspects when compared with cattle beef, as it contains lower levels of fat and cholesterol while providing high-quality protein, essential amino acids, iron, and zinc. Despite these advantages, buffalo meat is sometimes perceived as less tender due to its relatively higher connective tissue content and lower intramuscular fat. Because of these characteristics, processing technologies are widely applied to enhance its tenderness, flavor, shelf life and overall consumer acceptance.

One effective approach to improving the utilization of buffalo meat is the development of value-added meat products. Value addition involves converting raw meat into processed products through techniques such as mincing, curing, cooking, smoking, fermentation, and restructuring, often combined with the incorporation of ingredients like spices, binders, extenders, and preservatives. These processing methods help improve the sensory attributes, texture, and storage stability of the meat while also increasing its commercial value. A wide range of products can be produced from buffalo meat, including sausages, nuggets, patties, meatballs, cutlets, and restructured meat products. Such products not only enhance the palatability of buffalo meat but also allow efficient utilization of lower value cuts and processing by-products. (Lawrie and Ledward, 2006; Kandeepan *et al.*, 2009; Mendiratta *et al.*, 2012; Naveena *et al.*, 2014) [13, 11, 4, 10].

The production of value-added buffalo meat products offers several economic and technological benefits. It contributes to reducing postharvest losses, extending shelf life, and increasing the market demand for buffalo meat. In addition, these processed products cater to the growing consumer preference for convenient ready-to-cook and ready-to-eat foods. With the expanding global demand for processed meat, value addition plays a crucial role in improving the profitability and export potential of buffalo meat. Consequently, continued research and development in buffalo meat processing are essential for maximizing its utilization and strengthening the growth of the meat industry.

The development of meat spreads has gained importance due to the increasing consumer demand for convenient and ready-to-eat meat products. With rapid urbanization and changing lifestyles, many consumers prefer foods that require minimal preparation time and are easy to consume. Meat spreads meet this demand because they can be directly applied to bread, crackers, buns, or sandwiches, making them suitable for quick meals, snacks, and breakfast items. Their smooth and spreadable texture, along with a pleasant flavor, enhances consumer acceptance and makes them appealing to a wide range of age groups. In addition to convenience, the production of meat spreads allows for the efficient utilization of meat trimmings, lower-value cuts, and tougher portions that may not be suitable for direct sale as fresh meat. Additionally, they can be fortified with spices, herbs, or functional ingredients to improve nutrition and sensory quality. Meat spreads increase nutritional quality, product diversity, profitability and consumer satisfaction in the processed meat industry.

Almond gum is a natural exudate polysaccharide composed mainly of arabinose and galactose units. It exhibits high water-holding capacity and emulsifying ability (Alvarez-Sánchez *et al.*, 2019) [1]. These properties make it suitable for stabilizing fat-protein emulsions in spreads and pastes. In food systems, almond gum has been studied as a fat replacer, texture modifier and carrier of micronutrients. (Mirhosseini and Amid *et al.*, 2012) [12] reported that almond gum improves viscosity and prevents phase separation in emulsified foods. Its prebiotic potential further enhances nutritional value by supporting beneficial gut microflora (Rashid *et al.*, 2018) [15]. When incorporated in meat products, almond gum improves softness, spreadability and moisture retention.

Foxtail millet (Setariaitalica), an ancient cereal, is increasingly recognized for its nutritional potential, offering high levels of resistant starch, dietary fibre, vitamins, and minerals (Saleh *et al.*, 2013) [16]. Millet incorporation in protein-rich products can enhance both nutrient density and functional properties, including textural modification and glycemic regulation (Kumar *et al.*, 2018) [6]. The synergy of almond gum and foxtail millet as functional ingredients creates an opportunity for nutritionally enhanced meat spreads.

The present study was undertaken to develop a value-added carabeef spread incorporated with almond gum and foxtail millet and to evaluate its proximate composition and sensory attributes. The study also aimed to compare the nutritional and sensory quality of control (without foxtail millet) and treatment (with foxtail millet) formulations.

Material and Methods

Preparation of carabeef Spread

The experiments were conducted in the Department of Livestock Products Technology, Veterinary College and Research Institute, Namakkal - 637002, Tamil Nadu Veterinary and Animal Sciences University, India. Frozen deboned buffalo meat (from animals aged 6 to 7 years) was procured from the Meat Technology Unit, Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, KVASU, Kerala. Carabeef powder was prepared as per the method described by Goswami *et al.*, 2018. The preparation of buffalo meat spread incorporated with almond gum and foxtail millet was carried out following a standardized processing protocol, with slight modifications to the method described by Kumar *et al.* (2015). The basic formulation of the buffalo meat spread (Table 1) was optimized through several preliminary trials to achieve desirable sensory, nutritional, and functional characteristics.

Table: Standardized formulation for the processing of carabeef spread

Ingredients	T_1	T_2
Cara beef powder	60	50
Foxtail millet	-	10
Almond gum powder	2	2
Spice mix	3.5	3.5
Salt	2.5	2.5
Condensed milk	10	10
Onion & Ginger paste	6	6
Oil	2	2
Tomato pure	2	2
Corn flour	2	2
Butter	10	10

T_1-without Foxtail millet: T_2-with Foxtail millet

Fresh raw materials were procured from reliable local markets in Namakkal. Garlic and ginger were cleaned, peeled, and separately ground into a fine paste using a domestic grinder (Bajaj make). The condiment mix was prepared by blending garlic and ginger paste in a 2:1 ratio. The prepared condiment mix was packed in low-density polyethylene (LDPE) bags and stored at-18±1°C until further use to retain freshness and flavor. Spices were also procured from the local market and cleaned thoroughly to remove impurities. The cleaned spices were oven-dried at 45±2°C for 2 hours to reduce moisture content and enhance shelf stability. The dried spices were ground into a fine powder using a domestic grinder (Bajaj make) and sieved through a fine mesh to obtain uniform particle size. The powdered spices were then mixed in pre-standardized proportions to prepare the spice mix, which was stored in moisture-proof polyethylene terephthalate (PET) containers until further use.

For the preparation of the buffalo meat spread, all ingredients were processed under hygienic conditions. The dry ingredients, including carabeef powder, foxtail millet powder, salt, spice mix, and corn flour, were weighed accurately and mixed thoroughly to ensure uniform distribution. Soaked almond gum was then added as a natural stabilizer to improve binding, consistency, and spreadability of the product. Tomato puree was prepared separately

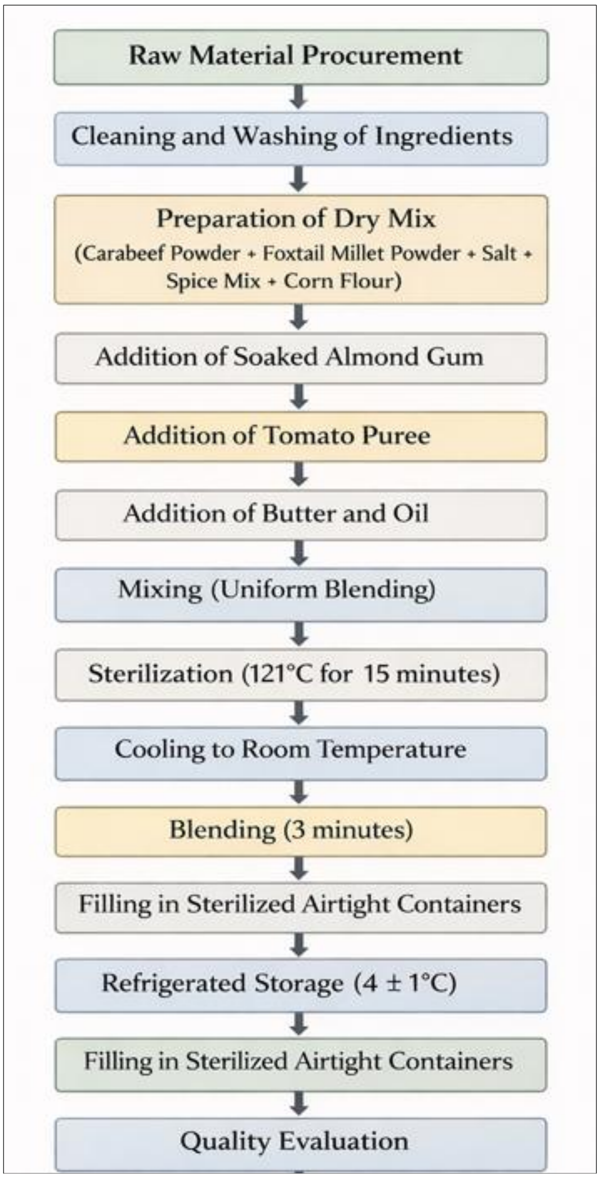
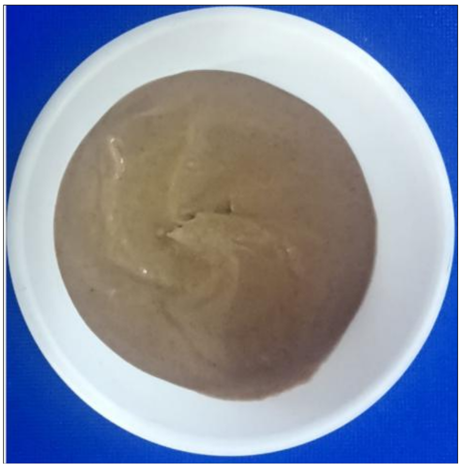


Fig 1: Flow chart of preparation of carabeef spread incorporated with foxtail millet and almond gum



Carabeef spread Carabeef

Spread served with bread

Fig 3: Developed carabeef spread Carabeef spread

Carabeef spread served with bread by washing fresh tomatoes, blanching them to facilitate peeling, followed by peeling and grinding to obtain a smooth puree. This puree was incorporated into the formulation. Subsequently, the prepared condiment mix (garlic and ginger paste), butter, and oil were added to enhance flavor, texture, and mouthfeel. The entire mixture was thoroughly mixed to obtain a uniform blend. The resulting mixture was subjected to thermal processing by sterilization at 121°C for 15 minutes to ensure microbial safety and extend shelf life. After sterilization, the product was cooled to room temperature and blended for approximately 3 minutes to achieve a smooth, homogeneous, and spreadable consistency. Flow chart of preparation of carabeef spread incorporated with almond gum and foxtail millet is given in figure 1. The finished product was filled into sterilized, airtight containers under hygienic conditions and stored under refrigerated conditions (4±1°C). The developed buffalo meat spread was subsequently evaluated for proximate composition and sensory attributes.

Parameter Assessed

Proximate composition

The proximate composition of developed carabeef spread was determined as per the methods recommended by AOAC (2016). The crude protein content was determined by the Kjeldahl method and the crude fat content was determined by the Soxhlet method. The total ash content was determined by ashing the samples overnight at 550°C. Moisture content was determined by drying the samples overnight at 105 ^ °C.

Calcium content

The Calcium content of developed carabeef spread samples as determined as per the methods recommended by AOAC (2016). Calcium was estimated by the permanganimetric titration method.

Sensory evaluation

Sensory evaluation of the developed carabeef spread was assessed by semi-trained panelists at the Department of Livestock Products Technology (Meat Science), Veterinary College and Research Institute, Namakkal - 637 002, using an eight-point hedonic scale. Panelists were instructed to cleanse their mouths with water between sample assessments (Keeton, 1983).

Statistical Analysis

The data generated from six trials of each experiment were analyzed in SPSS (version 20.0) software by following standard procedures (Snedecor and Cochran, 1995) [19] for *t* test means were compared and the effects of treatments were interpreted.

Proximate composition of Carabeef Spread Incorporated with Almond Gum and Foxtail Millet

The proximate composition of the developed carabeef spread enriched with foxtail millet is presented in Table 2. The incorporation of foxtail millet, along with functional ingredients such as butter, almond gum and corn flour, significantly influenced the physicochemical characteristics, nutritional profile and storage stability of the product.

Table 2: Proximate Composition of Carabeef spread Enriched with Fibre and Calcium

S.NO	Parameters	T_1	T_2
1.	Moisture (%)	67.13±0.06^b	66.43±04^a
2.	Crude protein (%)	19.5±0.08^b	17.64±0.02^a
3.	Crude fibre (%)	0.59±0.04^a	1.20±0.01^b
4.	Crude fat (%)	9.58±0.12^b	8.42±0.08^a
5.	Crude ash (%)	1.69±0.02^a	1.79±0.01^b
6.	Calcium (%)	0.07±0.01^a	0.14±0.02^b
7.	Gross Energy(Kcal/kg)	2071±0.20^b	1927±.15^a

T_1 -Without Foxtail Millet T_2 - With Foxtail Millet

Mean ± SE with same superscript between classes do not differ significantly (p>0.05). n =6 for each treatment

Moisture content

The moisture content of the control sample (T_1) was 67.13%, whereas the foxtail millet incorporated treatment (T_2) recorded a slightly lower value of 66.43%. The marginal reduction in moisture content in T_2 can be attributed to the higher water absorption capacity of dietary fibres present in foxtail millet, which bind free water and reduce its availability. Such fibre-mediated water binding has been reported to enhance emulsion stability and reduce syneresis in meat products. Similar findings were observed in meat spreads developed from spent hens and in formulations incorporating cereal-based extenders, where fibre addition resulted in reduced free moisture and improved product consistency (Yadav *et al.*, 2016; Kumar *et al.*, 2018) [22, 6]. Moreover, reduced free water contributes to improved microbiological stability during refrigerated storage, as microbial growth is directly related to water activity (Toldrá *et al.*, 2017) [20].

Crude protein

The crude protein content decreased from 19.50% in T_1 to 17.64% in T_2. This decrease is primarily due to the partial replacement of meat with foxtail millet, which contains lower protein levels compared to meat. The dilution effect of non-meat ingredients on protein content is a common observation in extended meat products. Similar reductions in protein content have been reported in studies on spent chicken meat spread incorporating poultry liver and rice starch, where the addition of plant-based or non-meat ingredients lowered the overall protein percentage while enhancing functional and sensory properties (Biswas *et al.*, 2019; Kumar *et al.*, 2018) [2, 6]. However, the protein content of T_2 still remains within acceptable levels for a protein-rich spreadable product.

Crude Fat

The crude fat content showed a reduction from 9.58% in T_1 to 8.42% in T_2. The decrease in fat content can be attributed to the replacement of meat and fat with millet, which is inherently low in lipids. Lower fat content contributes to reduced caloric density, making the product more suitable for health-conscious consumers. However, fat plays a crucial role in determining the sensory attributes of meat spreads, particularly in terms of flavor, mouthfeel, and spreadability. In the present study, butter and oil were included in the formulation to compensate for fat reduction and to maintain desirable textural properties. Butter, in particular, acts as a plastic fat, contributing to a smooth, creamy consistency and improved lubrication, which enhances spreadability. Studies on meat spreads and emulsified products have reported that the addition of fat sources such as butter significantly improves sensory attributes, including flavor, juiciness and overall acceptability (Singh *et al.*, 2017; Sharma *et al.*, 2021) [17, 18]. Furthermore, butter improves product stability under refrigerated storage by forming a stable fat matrix that prevents phase separation.

Crude Fibre

A significant increase in crude fibre content was observed in T_2 (1.20%) compared to T_1 (0.59%), indicating the successful incorporation of dietary fibre through foxtail millet.

This improvement enhances the functional value of the product by contributing to digestive health and reducing the glycemic response. The development of fibre-enriched meat products has gained attention due to increasing consumer demand for healthier alternatives. Previous studies have demonstrated that incorporation of cereals and millets improves fibre content without adversely affecting product acceptability when optimized appropriately (Verma *et al.*, 2020) [21].

Total ash content

The ash content increased slightly from 1.69% in T_1 to 1.79% in T_2, indicating an enhancement in total mineral content. This is further supported by the calcium content, which increased from 0.07% in the control to 0.14% in the millet-incorporated treatment. The increase in mineral content can be attributed to the inclusion of foxtail millet and almond gum powder, both of which are known sources of minerals, particularly calcium. The enrichment of meat products with minerals enhances their nutritional profile and adds functional value. Similar improvements in mineral content have been reported in fortified meat products incorporating plant-based ingredients (Verma *et al.*, 2020) [21].

Calcium (%)

The calcium content of the developed spread increased from 0.07% in T_1 to 0.14% in T_2, indicating a two-fold increase due to millet incorporation and dairy ingredients. In conventional meat spreads, calcium content is typically low unless fortified. Studies on enriched meat products have reported calcium levels ranging from 0.05% to 0.12% (Verma *et al.*, 2020) [21]. The higher calcium content in T_2 suggests improved nutritional value and potential benefits for bone health, making it a functional meat product.

Gross energy: The gross energy value decreased from 2071 kcal/kg in T_1 to 1927 kcal/kg in T_2. This reduction is primarily due to the decrease in fat content, as fat contributes significantly to the caloric value of foods. The lower energy content, combined with increased fibre and mineral levels, makes the developed product a healthier alternative to conventional high-fat meat spreads.

From a technological perspective, the role of functional ingredients such as almond gum and corn flour is critical in the development of spreadable meat products. Almond gum acts as a hydrocolloid, improving water retention, emulsion stability and viscosity, thereby preventing phase separation during storage. Corn flour contributes to thickening and binding, resulting in a uniform and stable matrix. These properties are essential for achieving the desired spreadability and consistency. Studies on steam-cooked meat spreads and emulsified meat products have highlighted the importance of hydrocolloids and binders in improving texture and storage stability (Kumar *et al.*, 2018; Yadav *et al.*, 2016) [22, 6]. The inclusion of butter further enhances the rheological properties of the spread by providing a smooth and cohesive structure. During refrigerated storage, fat crystallization plays a key role in maintaining the firmness and spreadability of the product. An optimal level of fat ensures that the spread remains soft and easily spreadable at low temperatures without becoming too firm or greasy. This is particularly important for consumer acceptability, as spreadability is a key quality attribute of such products.

The sensory attributes of carabeef spread incorporated with almond gum and foxtail millet flour are presented in Table 3. Sensory evaluation was carried out using an 8-point hedonic scale to evaluate the effect of foxtail millet incorporation on quality attributes such as appearance, flavour, taste, spreadability, adhesive ability, aftertaste/mouth coating and overall acceptability.

Table 3: Sensory Attributes of Carabeef Spread Incorporated with Almond Gum and Foxtail Millet

Sensory Attributes	T_1	T_2
Appearance	7.60±0.10^a	7.78±0.01^b
Flavour	7.48±0.08^a	7.65±0.14^b
Taste	7.70±0.05^a	7.83±0.01^b
Spreadability	7.71±0.05^b	7.66±0.03^a
Adhesive ability	7.63±0.01^a	7.73±0.01^b
After taste/mouth coating	7.33±0.03^a	7.66±0.05^b
Overall acceptability	7.71±0.08^a	7.80±0.11^b

T_1 -Without Foxtail Millet T_2 - With Foxtail Millet

Mean ± SE with same superscript between classes do not differ significantly (p>0.05). n =6 for each treatment

The results revealed that both treatments (T_1 and T_2) were well accepted by the sensory panel, with mean scores above 7.0 for all sensory attributes, indicating that the products were rated between “liked moderately” and “liked very much.” However, slight variations were observed between the treatments due to the incorporation of foxtail millet flour in T_2. The inclusion of millet flour and almond gum appeared to influence the texture, flavour and overall sensory perception of the product.

The appearance scores ranged from 7.60±0.10 in T_1 to 7.78±0.01 in T_2, indicating that the addition of foxtail millet flour slightly improved the visual appeal of the spread. The higher appearance score observed in T_2 could be attributed to the improved structure and uniform consistency imparted by millet flour, which acts as a natural binder and stabilizer in meat products. Similar observations were reported by Kumar *et al.* (2018) [6] and Biswas *et al.* (2019) [2], who stated that incorporation of cereal-based binders improves the structural integrity and visual quality of meat spreads. Studies on foxtail millet incorporated meat products such as chicken nuggets also reported improved appearance and structural stability due to the starch and fibre content of millet (Kumar *et al.*, 2019) [8].

The flavour scores were 7.48±0.08 for T_1 and 7.65±0.14 for T_2, indicating a slight improvement in flavour in the foxtail millet incorporated treatment. The mild nutty flavour characteristic of foxtail millet might have enhanced the flavour profile of the carabeef spread. Plant-based ingredients are known to interact with fat and flavour compounds in meat systems, thereby improving flavour retention and perception. Similar findings were reported by Singh *et al.* (2017) [18]. Studies on foxtail millet incorporated chevon sausages also reported improved flavour and consumer acceptability due to the natural flavour and nutritional properties of millet (Kumar *et al.*, 2021) [7].

The taste scores were slightly higher in T_2 (7.83±0.01) compared to T_1 (7.70±0.05), indicating that the addition of foxtail millet flour enhanced the palatability of the product. Foxtail millet contains carbohydrates, dietary fibre and micronutrients which may contribute to a balanced taste and improved mouthfeel in meat products. Similar improvements in taste scores were reported in foxtail millet incorporated meat products such as chicken nuggets and duck meat sausages (Kumar *et al.*, 2019; Rajkumar *et al.*, 2017) [14, 8]. Functional meat products enriched with cereal flours have also been reported to show enhanced sensory attributes and improved nutritional value (Verma *et al.*, 2020) [21].

The spreadability scores were slightly lower in T_2 (7.66±0.03) compared to T_1 (7.71±0.05). This slight reduction may be attributed to the increased viscosity and thicker consistency caused by the presence of millet flour. Foxtail millet contains starch and fibre that absorb moisture and increase the product thickness. However, the spreadability scores remained within an acceptable range, indicating that the product retained desirable spreading characteristics. Similar observations were reported by Sharma *et al.* (2021) [17], who noted that variations in binders and ingredient composition can influence the spreadability of meat spreads.

The adhesive ability of the spread was slightly higher in T_2 (7.73±0.01) compared to T_1 (7.63±0.01). This improvement could be attributed to the binding properties of foxtail millet flour along with almond gum, which enhance cohesiveness and structural stability. The presence of natural polysaccharides and starch components in millet flour improves binding ability and texture in processed meat products. Similar improvements in texture profile and cohesiveness were reported in foxtail millet incorporated duck meat sausages (Rajkumar *et al.*, 2017) [14].

For aftertaste/mouth coating, T_2 recorded a higher score (7.66) compared to T_1 (7.33±0.03). The improved mouthfeel may be due to the combined effect of almond gum and foxtail millet flour, which contribute to better emulsification and smooth texture in the spread. According to Toldrá (2017) [20], hydrocolloids and plant-based stabilizers influence mouthfeel and aftertaste characteristics by improving emulsion stability and fat distribution in meat products.

The overall acceptability scores were 7.71±0.08 for T_1 and 7.80±0.11 for T_2, indicating that the foxtail millet incorporated carabeef spread was slightly more preferred by the sensory panel. The improved acceptability may be attributed to the combined effects of enhanced flavour, taste, appearance and mouthfeel provided by foxtail millet flour and almond gum. These findings are in agreement with Yadav *et al.* (2016) [22] and Biswas *et al.* (2019) [2], who reported that incorporation of functional ingredients and binders improves the sensory quality and consumer acceptability of meat spreads. Similarly, the use of foxtail millet flour in meat products such as chicken nuggets, chevon sausages and duck meat sausages was reported to enhance sensory attributes and consumer preference (Kumar *et al.*, 2019; Kumar *et al.*, 2021; Rajkumar *et al.*, 2017) [14, 7, 8].

Overall, the results indicate that incorporation of foxtail millet flour along with almond gum positively influenced most sensory attributes of carabeef spread without adversely affecting product quality. The millet incorporated spread exhibited good sensory acceptability, improved texture characteristics and enhanced functional value. Therefore, foxtail millet can be effectively utilized as a functional ingredient in the development of nutritionally enriched meat spreads and other value-added meat products.

Conclusion

The present study successfully developed a carabeef spread incorporated with almond gum and foxtail millet and evaluated its proximate composition and sensory quality. The incorporation of foxtail millet improved the nutritional profile by increasing crude fibre, ash and calcium content while slightly reducing moisture, protein, fat and gross energy values. Functional ingredients such as almond gum and corn flour enhanced emulsion stability, binding and texture, while butter contributed to desirable flavour and spreadability. Sensory evaluation indicated that both control and millet incorporated samples were highly acceptable, with the treatment showing slightly higher scores for most sensory attributes. Overall, the results suggest that foxtail millet can be effectively utilized as a functional ingredient for developing nutritionally enriched carabeef spreads with good sensory acceptability.

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