Food Research 10 (5) : 171 – 175 (October 2026)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Formulation and sensory evaluation of Kajali (*Gigantochloa atter)* shoot flour as a meat loaf extender

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Article history:
Received: 10 February 2026
Revised: 26 March 2026
Accepted: 7 May 2026
Published: 2 October 2026

Keywords:
Bamboo shoot flour,
Meat extender,
Meat loaf,
Sensory evaluation,
Functional food

DOI:
https://doi.org/10.26656/fr.2017.10(5).134

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Abstract

In response to the growing demand for sustainable and functional food ingredients, this study explores the utilization of plant-based extenders in meat product development, particularly focusing on the incorporation of bamboo shoot flour in meat loaf formulation. Specifically, this study evaluated the potential of bamboo shoot flour as a meat extender in meat loaf formulation, with emphasis on its effects on sensory quality and overall acceptability. Bamboo shoot flour was prepared from fresh Kajali bamboo shoots through slicing, soaking, drying, grinding, and sieving. Meat loaf samples were formulated using a standard 70:30 lean meat–to–fat ratio, with bamboo shoot flour incorporated at graded substitution levels ranging from 15%, 55% and 100%, alongside a control formulation without bamboo shoot flour. The products were steamed at 75°C and subjected to sensory evaluation by ten experienced panelists using a hedonic rating scale. Results showed that all sensory parameters, including color, aroma, texture, taste, and general acceptability, obtained an overall mean score ranging from 6.00 to 6.50, corresponding to a descriptive rating of "like very much." The incorporation of bamboo shoot flour did not negatively affect the sensory attributes of the meat loaf. Statistical analysis indicated no significant differences ($p > 0.05$) among treatments for most sensory parameters, suggesting that varying levels of bamboo shoot flour substitution were acceptable to panelists. The findings demonstrate that bamboo shoot flour can be effectively utilized as a meat extender in meat loaf formulation while maintaining acceptable sensory quality. This study highlights the potential of bamboo shoot flour as a functional, sustainable ingredient for the development of healthier meat products.

1. Introduction

In recent years, the improvement of quality of life has become a central concern in the context of human health. The steady increase in life expectancy, accompanied by escalating healthcare costs and the rising prevalence of metabolic disorders—including cardiovascular diseases, obesity, diabetes, and arthritis—underscores the urgent need for effective preventive health strategies (World Health Organization, 2003; GBD 2019 Risk Factors Collaborators, 2020). These trends exert a substantial impact on population health and impose significant burdens on healthcare systems globally. Consequently, there has been a growing emphasis on approaches that prioritize health promotion and disease prevention rather than treatment alone.

A substantial body of scientific evidence has established a strong association between dietary patterns and overall health outcomes, highlighting the critical role of nutrition in the prevention and management of chronic diseases (Hu, 2002; Willett, 2012). Appropriate dietary intake has been shown to reduce the risk of coronary heart disease, certain forms of cancer, neurodegenerative and respiratory conditions, and to contribute to healthier aging (World Health Organization, 2003). Within this framework, functional foods—defined as foods that provide physiological benefits beyond basic nutritional requirements—have gained increasing recognition as a viable strategy for addressing diet- and lifestyle-related diseases (Roberfroid, 2000).

Bamboo shoots, the immature edible portions of bamboo plants, are widely consumed across various Asian regions and are recognized for their nutritional value and potential health benefits (Satya *et al*., 2012; Nongdam and Tikendra, 2014). It is estimated that approximately 1,500 bamboo species exist worldwide, with species such as *Bambusa vulgaris* and *Bambusa*

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eISSN: 2550-2166 / © 2026 The Authors.
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balcooa among those commonly utilized for culinary applications (Scurlock *et al*., 2000). Bamboo is regarded as one of the fastest-growing plant species, producing tender shoots that rapidly emerge from the soil prior to lignification (Scurlock *et al*., 2000). Despite their documented nutritional attributes—including high dietary fiber content and the presence of bioactive compounds—consumption of bamboo shoots remains largely concentrated in Southeast and East Asian countries (Chongtham *et al*., 2011; Nongdam and Tikendra, 2014). In light of the increasing incidence of lifestyle-related disorders, there is a growing demand for accessible, plant-based functional food sources. Given their nutritional potential and limited utilization in other regions, bamboo shoots constitute a promising functional food ingredient. Further research is warranted to comprehensively evaluate their nutritional composition, phytochemical properties, and associated health benefits in order to support their broader application in health-promoting diets.

Therefore, this study aimed to evaluate the potential of bamboo shoot flour as a functional food ingredient by assessing its incorporation into meat loaf formulations and determining its effects on nutritional quality and consumer acceptability.

2. Materials and methods

This study focuses on the potential of bamboo shoot flour as a meat extender in meat loaf formulation, with emphasis on its effects on sensory quality and overall acceptability. The study utilized an experimental and descriptive research design. Experimental research is suited to determine which formulation is suited for the bamboo shoot flour as the meat loaf extender. Descriptive research design was utilized in determining the sensory characteristics of the product through selected trained panels. As shown in Figure 1, the following preparation and processing of the product has been carried out.

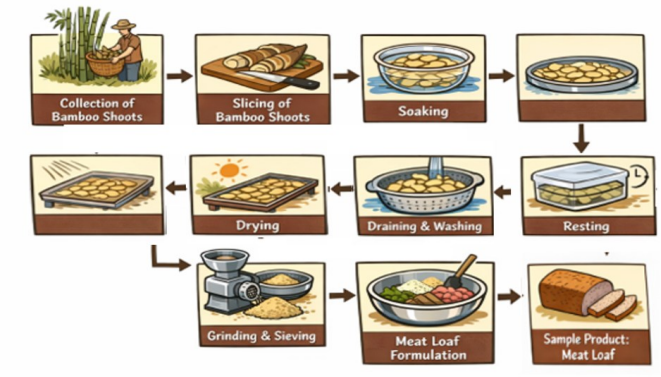

Figure 1. Preparation and processing of the product.

2.1 Preparation and processing of the product

2.1.1 Collection of bamboo shoots

Fresh Kajali bamboo shoots were harvested and immediately processed. The outer sheaths and hard basal portions were removed to isolate the edible, tender portion of the shoots. Only fresh and undamaged samples were selected for further processing.

2.1.2 Slicing of bamboo shoots

The edible portions of the bamboo shoots were sliced into uniform thicknesses of approximately 3–4 mm. Uniform slicing was carefully maintained, as slice thickness directly influences the rate and efficiency of the drying process.

2.1.3 Soaking

The sliced bamboo shoots were submerged in a prepared brine solution containing salt, ensuring complete immersion of all samples. The shoots were soaked for a period of 24 h to facilitate the reduction of bitterness and the leaching of water-soluble compounds.

2.1.4 Resting

After soaking, the bamboo shoot slices were removed from the brine and transferred into a clean, covered container. The samples were allowed to stand overnight to enable complete salt penetration and further moisture removal through osmotic action.

2.1.5 Draining and washing

The salted bamboo shoot slices were placed in nylon net bags and manually pressed to expel the exuded liquid, which contains a significant portion of the bitter compounds. The slices were then thoroughly washed under running tap water to remove excess surface salt prior to further processing.

2.1.6 Drying

Immediately after washing, the bamboo shoot slices were evenly spread on clean drying racks in a single layer. The samples were sun-dried until they became brittle and were visually assessed to be free of residual moisture. Drying was continued until a constant weight was achieved, indicating complete moisture removal.

2.1.7 Grinding and sieving

The dried bamboo shoot samples were ground using a grain mill grinding machine to obtain a powdered form. The resulting powder was then passed through a 60-mesh sieve to produce a uniformly fine bamboo shoot flour suitable for use as a meat extender.

https://doi.org/10.26656/fr.2017.10(5).134
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2.1.8 Preparation of meat loaf formulation

Meat loaf samples were prepared using a 70:30 lean meat–to–fat ratio. Bamboo shoot flour was incorporated into the formulations at substitution levels of 15%, 55%, and 100% as a meat extender. All ingredients were thoroughly mixed until a uniform consistency was achieved and then transferred into loaf pans measuring 6.5 × 9.8 × 16.2 cm. The meat loaves were steamed at 75°C for 55 to 60 min. After cooking, the loaves were allowed to cool to room temperature before further evaluation. The cooked meat loaves were cut into approximately 1.5 cm^3 uniform samples for sensory analysis.

2.2 Sensory evaluation

Sensory evaluation was carried out by a panel of ten trained panelist who were familiar with food quality appraisal. Each panelist systematically evaluated the prepared samples using established sensory criteria, focusing on key attributes such as color, aroma, texture, taste, and overall acceptability to ensure a comprehensive assessment of product quality. The sensory acceptability of the developed product samples was evaluated using a 7-point hedonic scale. The sensory evaluation was conducted to determine the degree of liking of the samples in terms of the identified sensory attributes. The panelists were instructed to evaluate each sample independently and indicate their level of liking by assigning a score from 1 to 7, where 7 represented the highest degree of liking and 1 represented the lowest. The mean sensory scores were interpreted using the following scale: 6.15–7.00 (like very much), 5.29–6.14 (like moderately), 4.43–5.28 (Like slightly), 3.57–4.42 (Neither like nor dislike), 2.71–3.56 (Dislike slightly), 1.85–2.70 (Dislike moderately) and 1.00–1.84 (Dislike very much).

3. Results and discussion

3.1 Sensory evaluation

The sensory evaluation results of the bamboo shoot extended meat loaf formulations as shown in Table 1 indicate that bamboo shoot flour as a meat extender was generally well accepted by the panelists, with all evaluated parameters—color, aroma, texture, taste, and general acceptability—falling within the "like very much" category on the overall mean based on the established sensory legend. These findings support the feasibility of incorporating bamboo shoot flour into meat products without compromising sensory quality.

3.1.1 Color

The color of the meat loaf, which obtained an overall mean score of 6.125, suggests that the inclusion of bamboo shoot flour did not adversely affect the visual appeal of the product. Similar findings have been reported in studies involving plant-based extenders such as oat fiber, mushroom powder, and bamboo fiber, where minimal color changes were observed at moderate substitution levels (Verma *et al*., 2010; Choi *et al*., 2014). The light color of bamboo shoot flour likely contributed to maintaining a visually acceptable cooked meat product.

3.1.2 Aroma

The aroma score indicates favorable consumer perception and suggests that bamboo shoot flour did not impart undesirable odors during cooking. Previous studies on fiber-enriched meat products have shown that plant-based extenders with low volatile compounds do not significantly alter meat aroma when properly processed (Fernández-Ginés *et al*., 2005). This supports the observation that bamboo shoot flour is compatible with conventional meat loaf flavor profiles.

3.1.3 Texture

In terms of texture, the weighted mean score of 6.00 reflects moderate liking, indicating that the structural integrity of the meat loaf was maintained. Bamboo shoot flour contains dietary fiber, which is known to enhance water-holding capacity and improve product cohesiveness (Yilmaz, 2005). Improved moisture retention may reduce cooking loss and prevent excessive hardness, contributing to acceptable texture in extended meat products.

3.1.4 Taste

The taste attribute, with an overall mean score of 6.50, suggests that the flavor of the meat loaf remained acceptable despite partial substitution of meat. This

Table 1. Sensory evaluation of the bamboo shoots extended meat loaf

Treatment level (%)	Color	Aroma	Texture	Taste	General acceptability	Description
0 (Control)	6.25	6.00	6.00	6.50	6.50	Like Very Much
15%	6.00	6.25	6.00	6.50	6.50	Like Very Much
55%	6.25	6.00	6.00	6.50	6.50	Like Very Much
100%	6.00	6.25	6.00	6.50	6.50	Like Very Much
Overall mean score	6.125	6.125	6.00	6.50	6.50	Like Very Much

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agrees with findings from studies using dietary fiber and vegetable flours as meat extenders, where acceptable taste was maintained due to proper seasoning and balanced formulation (Aleson-Carbonell *et al*., 2005). Bamboo shoot flour appears to be relatively neutral, allowing the characteristic meat flavor to remain dominant.

3.1.5 General acceptability

The general acceptability has an overall mean score of 6.50, the highest among all parameters, indicating that panelists evaluated the product favorably when considering all sensory attributes collectively. This result supports the potential of bamboo shoot flour as a functional ingredient in meat product development, particularly for improving dietary fiber content while maintaining consumer acceptance.

Statistical analysis of sensory data showed no significant differences ($p > 0.05$) among treatments for all sensory attributes, indicating that increasing levels of bamboo shoot flour did not significantly affect consumer perception. This suggests that bamboo shoot flour can be incorporated at varying substitution levels without compromising sensory quality. Similar observations have been reported in studies evaluating plant-based extenders in comminuted meat products (Verma *et al*., 2010; Choi *et al*., 2014).

Overall, the results demonstrate that bamboo shoot flour is a promising meat extender capable of producing an acceptable meat loaf while contributing to the development of healthier and more sustainable meat products.

4. Conclusion

This study demonstrated that bamboo shoot flour can be successfully utilized as a meat extender in meat loaf formulation without adversely affecting sensory quality. The incorporation of bamboo shoot flour produced meat loaf samples that were consistently rated as "like very much" across all sensory parameters, including color, aroma, texture, taste, and general acceptability, indicating favorable consumer acceptance. These findings are consistent with earlier research showing that plant-derived fibres can be incorporated into meat products without significantly compromising sensory attributes, while also improving nutritional value due to higher fibre content. The acceptable color and aroma suggest that bamboo shoot flour does not impart undesirable visual or olfactory characteristics to the product. Moreover, the satisfactory texture and taste scores indicate that bamboo shoot flour may contribute to product cohesiveness and palatability, likely due to its dietary fibre content and water-holding capacity—an effect previously observed with the addition of bamboo shoot dietary fibre improving water-holding and textural properties in comminuted meat systems (Zhuang *et al*., 2020).

Statistical analysis revealed no significant differences among treatments for all sensory attributes, suggesting that varying levels of bamboo shoot flour incorporation can be applied without compromising product quality. These findings support the potential of bamboo shoot flour as a sustainable, plant-based meat extender that can enhance dietary fibre content while maintaining consumer acceptability. Overall, the study provides scientific evidence supporting the use of bamboo shoot flour in meat products and highlights its potential application in the development of healthier, cost-effective, and functional meat-based foods. Further studies are recommended to evaluate nutritional composition, shelf life, and consumer acceptance on a larger scale.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The researchers would like to express their sincere gratitude to North Eastern Mindanao State University (NEMSU) for providing institutional support and resources necessary for the completion of this study.

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