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Exploring sociocultural and science aspect of *Manggulu:* a traditional food from Sumba Island, Indonesia

Mohammad Fathi Royyani[1*], R. Haryo Bimo Setiarto[2,3], Vika Tresnadiana Herlina[2], Resti Rambu Ana[4], Asep Hidayat[1], Yohanis Ngongo[1], Siti Sundari[1], Parwa Oryzanti[1], Resti Wahyuni[1], Tri Rizkiana Yusnikumah[1] and Saiful Hakam[5]

Abstract

Manggulu is a traditional food of the Sumba people in East Nusa Tenggara, primarily made from *pisang kepok* or saba bananas (*Musa paradisiaca var. balbisiana*) and peanuts (*Arachis hypogaea*). This food serves both as a snack and a key component in religious ceremonies and communal gatherings, highlighting its cultural significance. *Manggulu* is also recognized as an important source of energy, providing carbohydrates from bananas and protein and fats from peanuts. This study offers a comprehensive review of the literature and existing research on *manggulu*, focusing on its historical, sociocultural, nutritional, and sensory properties, as well as the role of local resources in its preparation. Additionally, the study examines challenges in preparation and development, along with the potential for future advancements. The findings suggest that *manggulu*'s role in cultural and religious ceremonies, alongside its practical use as a daily snack for energy, underscores its broader significance and potential for wider recognition. This research enhances the understanding of *manggulu* as a valuable part of Sumbanese heritage and proposes avenues for its promotion and preservation.

Keywords Banana, Cultural heritage, *Manggulu*, Traditional food, Sumbanese culture

Introduction

Bananas (*Musa* spp.) are perennial evergreen plants from the Musaceae family and rank among the most important tropical and subtropical fruits worldwide [1]. They serve as an excellent source of carbohydrates, essential minerals such as potassium, magnesium, and phosphorus, as well as vital vitamins, including A, B12, and C. Additionally, bananas contain various bioactive compounds, including phenolic acids, flavonoids, terpenoids, and catecholamines, which contribute to their nutritional and functional properties [2]. However, as climacteric fruits, bananas are highly perishable, leading to significant post-harvest losses if not properly managed [3]. To extend their shelf life and reduce waste, bananas are commonly processed into various products such as flour, *sale*, brownies, *dodol*, jams,

*Correspondence:
Mohammad Fathi Royyani
moha026@brin.go.id
[1] Research Center for Ecology and Ethnobiology, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor KM. 46, KST Soekarno, Cibinong, Bogor 16911, Indonesia
[2] Research Center for Applied Microbiology, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor KM. 46, KST Soekarno, Cibinong, Bogor 16911, Indonesia
[3] Research Collaboration Center for Traditional Fermentation, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor KM. 46, KST Soekarno, Cibinong, Bogor 16911, Indonesia
[4] Matalawa National Park, Ministry of the Environment and Forestry, Jl. Adam Malik KM 5, Kambajawa, Waingapu, Sumba, Indonesia
[5] Research Center for Area Studies, National Research and Innovation Agency (BRIN), Widya Graha 8th floor, Jl. Jendral Gatot Subroto 10, South Jakarta 12710, Indonesia

and chips. These processing methods not only enhance their economic value, but also support food diversification efforts [4].

Traditional communities across Indonesia have long developed banana preservation techniques to optimize their abundant supply, particularly in regions where year-round harvests create a surplus that requires sustainable utilization [5]. One notable example is *manggulu*, a traditional delicacy from Sumba, an island in Indonesia's East Nusa Tenggara province (Fig. 1). Sumba is characterized by a relatively dry and arid climate, necessitating the development of food preservation techniques to ensure year-round food availability. In response to these environmental challenges, the Sumbanese people have developed *manggulu* as a method of utilizing their agricultural resources efficiently, particularly *pisang kepok* or saba bananas (*Musa paradisiaca var. balbisiana*) and peanuts (*Arachis hypogaea*). The traditional preparation process involves drying bananas to reduce moisture content, followed by mixing them with peanuts and palm sugar to enhance both shelf life and nutritional value [6].

Manggulu has historically been an important food in Sumbanese society due to its portability and high-energy content, making it a practical sustenance for long journeys, tribal migrations, and periods of food scarcity. The preparation of *manggulu* was traditionally entrusted to women, who ensured that family members embarking on extended travels had a durable and nutritious food source. In addition to its practical role, *manggulu* became associated with cultural practices, often prepared for communal gatherings, traditional ceremonies, and offered to guests as a form of respect and hospitality [7]. From a commercial perspective, *manggulu* remains largely a locally consumed product with limited market penetration beyond Sumba. Its sales are predominantly conducted through traditional markets, small roadside vendors, and community-based trade networks. Unlike mass-produced snacks that benefit from modern branding, extensive distribution channels, and advanced packaging technologies, *manggulu* struggles to compete due to a lack of formalized marketing strategies and commercial investment. The absence of mechanized production

Fig. 1 Geographical map of Sumba Island, Indonesia, depicting the region of origin for the traditional snack *manggulu* and highlighting its indigenous cultural and culinary heritage

facilities further limits its ability to scale, making it difficult for producers to meet potential demand from larger retail markets, supermarkets, or export opportunities [6, 7].

Despite its cultural significance, *manggulu* remains largely unexplored in scientific literature, with limited studies on its nutritional, sociocultural aspects, and development potential. This narrative review aim to provide a comprehensive overview, integrating these perspective, positioning *manggulu* as an essential part of Indonesia's culinary heritage. By exploring indigenous knowledge, sustainable preservation methods, and food science principles, this review highlights its relevance to food security, local economies, and cultural identity. Additionally, *manggulu* serves as a case study of how ancestral food practices contribute to modern sustainability efforts. This review not only addresses a critical knowledge gap, but also establishes a foundation for future interdisciplinary research on traditional foods.

Methods of review

A bibliographic synthesis was conducted through a narrative review to systematically integrate and analyze academic sources related to *manggulu*, including its historical background, sociocultural significance, traditional preparation methods, nutritional composition, sensory properties, and potential for further development. The literature search employed targeted keywords such as "*manggulu*," "dodol Sumba," "Sumba culinary," "*manggulu* philosophy," "nutrition of *manggulu*," and "*manggulu* characteristics." These terms were used to retrieve relevant sources from scholarly databases and scientific repositories, including Google Scholar, ScienceDirect, Springer, Web of Science, and Wiley Online Library. Additional references, such as books, ethnographic studies, and governmental reports, were also considered. The publication timeframe was set between 1998 and 2024. To ensure consistency and accessibility, only literature published in English or Indonesian was included, while publications in other languages were excluded. The selection process involved screening titles, abstracts, and full texts to determine the relevance and reliability of the sources. The findings from the reviewed literature were synthesized to provide an objective analysis of *manggulu* within historical, cultural, and scientific contexts.

Historical and cultural significance of *manggulu* in Sumbanese society

Manggulu, a traditional food from Sumba, Indonesia, represents the cultural heritage, traditional knowledge, and ecological adaptations of local communities [8]. This snack is composed of bananas, peanuts, and palm sugar, ingredients that are commonly found in the region. It has a chewy texture with a slightly sticky surface due to its natural sugars, and its compact cylindrical/rectangular shape facilitates storage and transport (Fig. 2). With a shelf life ranging from one to two months at room temperature and up to six months in cooler conditions, *manggulu* has historically served as a durable food source during extended travels [9]. Additionally, it is frequently present at traditional ceremonies and communal gatherings in Sumba [10].

Manggulu originated in early Sumbanese civilization, where indigenous communities relied on locally available resources for sustenance. Sumba Island, characterized by its dry and arid climate, presented challenges to agricultural productivity, making food preservation a critical practice. The development of *manggulu* emerged as a response to these environmental constraints, enabling the storage of food for extended periods without spoilage. This preservation method ensured the availability of essential nutrients during adverse seasons [9].

Fig. 2 *Manggulu*, a traditional delicacy from Sumba Island, is composed of dried bananas, peanuts, and palm sugar, encased in dried banana leaves. Its compact shape, chewy texture, and natural aroma contribute to its practicality as a commonly consumed snack within the Sumbanese community (*Source: Primary data, personal documentation*)

Historically, Sumba was integrated into the extensive maritime trading networks of the Austronesian peoples. Bananas and peanuts, key ingredients of *manggulu*, were among the crops cultivated and traded within these networks. Although rice was a valued commodity, it was not always accessible to every Sumbanese household, making *manggulu* a reliable and accessible alternative [10].

Sumba Island participated in trade with neighboring regions such as Flores, Timor, and Java, operating within a barter-based economy where preserved food items played a critical role. *Manggulu* was valued for its long shelf life and nutritional content, making it a preferred commodity for trade and travel. Warriors, traders, and travelers commonly carried *manggulu* as a source of sustenance during extended journeys. Moreover, *manggulu* was exchanged in local markets, particularly during times of scarcity when fresh food was less accessible. Its production and trade reinforced the economic interdependence of Sumbanese villages, contributing to the island's economic stability [9].

One of the notable historical aspects of *manggulu* is its role in sustaining communities during periods of hardship. During times of drought, famine, or conflict, when access to fresh food was limited, *manggulu* functioned as a primary food source for many Sumbanese people. Its capacity for long-term storage, ranging from weeks to months, made it a critical food resource in times of crisis [9]. Oral histories from Sumba document the use of *manggulu* during tribal wars and colonial resistance. Warriors, who often spent extended periods in the wilderness or on campaigns, relied on *manggulu* for sustenance, highlighting its importance as a dietary essential and its symbolic value of resilience and endurance [10].

Beyond its practical function, *manggulu* holds considerable sociocultural significance. It is an integral part of traditional ceremonies, such as weddings, harvest festivals, and funerals, where it is offered and exchanged as a gift. In these contexts, *manggulu* symbolizes abundance, gratitude, and communal respect. For example, during weddings, it is exchanged as part of familial offerings, reflecting goodwill and unity. The practice of gifting *manggulu* highlights its importance not only as a food item, but also as a medium for social cohesion and spiritual connection [8]. The preparation of *manggulu* is typically a communal activity, which strengthens social bonds and supports the continuity of cultural practices. Traditionally, its production involves collaboration, often among women, fostering social interaction and the transmission of cultural knowledge [6, 11]. Additionally, *manggulu* is tied to the Indigenous belief systems of Sumba, with certain communities making food offerings, including *manggulu*, to ancestral spirits as a form of respect and gratitude. The sharing of *manggulu* within the community further symbolizes hospitality and unity, values that are central to Sumbanese culture [7].

Although modern food options have become more accessible on Sumba Island, *manggulu* remains valued for its historical and cultural significance. It is often promoted as a traditional delicacy in tourism efforts, supporting local economies by offering an authentic Sumbanese product to visitors. As Sumba gains recognition as a travel destination, *manggulu* serves as a cultural representation introducing visitors to Sumbanese heritage while contributing to the local economy [10]. More than just a traditional food, *manggulu* reflects Sumba's resilience, trade, and cultural practices. From its origins as a survival food to its role in trade and cultural traditions, *manggulu* illustrates the adaptability of the Sumbanese people. Its legacy endures, linking past and present, ensuring its preservation for future generations [8].

Traditional *manggulu* preparation

The traditional preparation of *manggulu* involves a systematic process that incorporates specific ingredients and processing techniques (Fig. 3). The primary components of *manggulu* include ripe bananas, peanuts, and palm sugar. Among the various banana cultivars, saba banana is commonly utilized due to its favorable ripeness and textural attributes, which influence the physicochemical properties of the final product [6, 7]. The processing begins with the removal of the banana peel, followed by slicing the fruit into thin pieces to optimize moisture reduction during drying. The sliced bananas are subsequently subjected to sun drying for a duration that varies depending on environmental conditions. The use of drying racks or trays facilitates uniform airflow, thereby promoting efficient dehydration and minimizing microbial spoilage. The drying process continues until the banana slices achieve a pliable yet non-brittle texture [6]. Concurrently, peanuts undergo a roasting step, which is traditionally conducted using a heated pan or an open flame. This thermal treatment enhances the flavor profile and modifies the texture of the peanuts through Maillard reactions and lipid oxidation. Following roasting, the peanuts are manually dehulled and coarsely crushed to retain their structural integrity, thereby contributing to the textural and sensory attributes of the final product [11, 12].

Palm sugar undergoes a heating process to produce a viscous syrup that functions as a binding agent for the dried bananas and crushed peanuts. In certain formulations, a controlled addition of water or coconut milk may be incorporated to modulate the syrup's viscosity and improve its homogenization with other ingredients [13]. Once all components are prepared, the dried banana slices and crushed peanuts are thoroughly mixed,

Fig. 3 Traditional preparation of *manggulu* reflects the cultural heritage and technical craftsmanship of local culinary practices (*Source: Primary data, personal documentation*)

followed by the gradual incorporation of the heated palm sugar syrup to ensure uniform distribution and adhesion of the mixture. The final mixture is then shaped into compact, cylindrical units, optimizing portability and consumption convenience. Traditionally, *manggulu* is encased in dried banana or *lontar* leaves, which not only serve as a natural wrapping material, but may also impart subtle organoleptic characteristics. In contemporary commercial production, alternative packaging materials, such as plastic or biodegradable films, are utilized to enhance product shelf stability and marketability, particularly for distribution in local markets or as regional specialty products [6, 11].

In Sumba, *manggulu* has traditionally been produced in limited quantities for household consumption or as an integral component of ceremonial offerings. While the fundamental processing steps remain consistent, compositional variations are observed depending on regional or familial preferences. Some modifications include the incorporation of sesame seeds, coconut flakes, or spices to diversify the sensory attributes of the final product [13]. Despite these variations, the combination of bananas, peanuts, and palm sugar remains the predominant formulation. The preservative properties of palm sugar contribute to the stability of *manggulu* by acting as a humectant, which regulates moisture retention and extends the product's shelf life to approximately one week. This characteristic has historically positioned *manggulu* as a suitable food for extended storage and transport, particularly among travelers in Sumba. Whether produced at the household level or in small-scale commercial enterprises, *manggulu* remains an essential element of Sumba's culinary heritage, reflecting both its cultural significance and functional role as a traditional food product [6, 11].

Nutritional and sensory characteristics of *manggulu*

The nutritional profiles of *manggulu* offer essential energy, nutrients, and dietary fiber, underlining its potential nutritional significance as a traditional food. Each primary ingredient—banana, peanuts, and palm sugar—contributes specific nutrients that enhance the overall composition of *manggulu*. Table 1 presents the detailed nutritional properties of *manggulu*'s raw materials and their individual contributions, while Table 2 outlines the nutritional composition of these ingredients. Bananas serve as the principal carbohydrate source in *manggulu*, providing naturally occurring sugars that contribute to its energy content [14]. The drying process concentrates these sugars, making dried bananas an efficient source

Table 1 Nutritional breakdown of *manggulu*'s ingredients

Raw materials	Nutritional components	Details	References
Banana	Calories	Dried bananas are energy-dense due to the concentration of natural sugars during the drying process. The reduction in moisture content leads to a higher caloric value in dried bananas compared to their fresh counterparts, as the nutrients and energy become more concentrated	[15–17]
	Carbohydrates	Dried bananas are rich in carbohydrates, primarily derived from easily digestible natural sugars such as glucose, fructose, and sucrose, making them an excellent rapid energy source	
	Dietary fiber	Dried bananas are a notable source of dietary fiber, The majority of the dietary fiber in dried bananas is insoluble, which plays a crucial role in promoting healthy digestive function	
	Vitamins	Dried bananas contain several essential vitamins, including vitamin B6, vitamin A, and vitamin C. However, the levels of certain vitamins, particularly those sensitive to heat and oxidation, such as vitamin A and vitamin C, may be reduced during the drying process	
	Minerals	Dried bananas are a rich source of essential minerals, particularly potassium, magnesium, and phosphorus. Additionally, trace amounts of other minerals, such as iron and calcium, are also present in dried bananas	
Peanuts	Calories	Peanuts are highly energy-dense, making them an excellent source of sustained energy. Their caloric content, primarily derived from healthy fats and proteins, makes them particularly beneficial in high-calorie diets, supporting energy needs over extended periods	[18]
	Protein	Peanuts are an excellent source of plant-based protein and essential amino acids	
	Fats	Peanuts are a rich source of healthy fats, primarily composed of monounsaturated fats and polyunsaturated fats. These fats play a key role in supporting cardiovascular health by reducing low-density lipoprotein (LDL) cholesterol levels and promoting higher levels of high-density lipoprotein (HDL) cholesterol	
	Minerals	Peanuts are rich in magnesium	
	Fiber	Like bananas, peanuts contribute to the fiber content of *manggulu*	
Palm sugar	Natural sweetener	Palm sugar is a natural sweetener and has a lower glycemic index compared to refined sugar	[36]
	Calories	Palm sugar contributes to the calorie content, primarily from carbohydrates	
	Vitamins	Palm sugar contains small amounts of vitamin C	

of energy. In addition to carbohydrates, bananas provide essential minerals, including potassium, magnesium, and phosphorus, which are critical for various physiological functions. Some vitamins, such as vitamin C and vitamin B6, are present but may be degraded during the drying process due to oxidation [15–17]. Peanuts significantly enhance the protein and fat content of *manggulu*, while palm sugar primarily contributes to the carbohydrate and energy content, with its high sugar concentration making it a potent source of energy [18, 19]. The combination of these ingredients results in a traditional food with a balanced macronutrient composition, providing carbohydrates from bananas and palm sugar, protein and healthy fats from peanuts, and essential micronutrients from all three components. This composition suggests that *manggulu* could serve as a sustainable energy source, particularly in regions where it is traditionally consumed.

Retang and Singapurwa [7] reported the nutritional composition and sensory characteristics of *manggulu* made from saba bananas, with varying proportions of peanuts (10–50% w/w), as shown in Table 3. Moisture content exhibited a decreasing trend as the proportion of peanuts increased up to 30%, but beyond this point, no significant difference was observed ($p > 0.05$). This reduction in moisture content is beneficial for extending the shelf life of *manggulu*, as lower water content helps inhibit microbial growth and slow down enzymatic reactions that contribute to food spoilage [20]. Ash content, indicative of mineral composition, showed minor variations but remained within a narrow range (2.05%–2.31%). The highest ash content was found in formulations with 20% and 30% peanuts.

Fat content increased significantly with the incorporation of peanuts, rising from 3.60% to 14.75% (Table 2). This result aligns with the well-documented high lipid content of peanuts (over 45% in dry weight), which enhances the energy density of food products [21]. Protein content also exhibited a significant increase, from 4.32% to 10.51%. However, carbohydrate content displayed an inverse relationship with increasing peanut concentration, declining from 69.14% to 55.01% (Table 2). This study demonstrates that incorporating peanuts into *manggulu* significantly enhances its nutritional properties. Higher peanut proportions lead to increased protein and fat content while reducing carbohydrate levels, making the product more nutrient-dense. Table 2 also indicates that sensory evaluation shows an increase in consumer acceptance with higher peanut content,

Table 2 Nutritional composition of *manggulu*'s ingredients (per 100 g)

Nutrients	Banana	Peanuts	Palm sugar
Energy (kcal)	98.0	588	375
Moisture (g)	75.3	4.82	4.11
Ash (g)	0.70	2.20	0.47
Protein (g)	0.74	23.2	–
Fat (g)	0.29	43.3	0.11
Carbohydrates (g)	23.0	26.5	–
Fiber (g)	1.70	8.00	–
Sugar (g)	15.8	–	95.3
Calcium (mg)	5.00	49.0	–
Iron (mg)	< 0.40	1.55	–
Magnesium (mg)	28.0	180	–
Phosphorus (mg)	22.0	380	–
Potassium (mg)	326	636	–
Sodium (mg)	< 4.00	1.00	–
Zinc (mg)	0.16	278	–
Copper (mg)	0.10	0.46	–
Manganese (mg)	0.26	1.68	–
Selenium (µg)	< 2.50	17.8	–
Vitamin C (mg)	12.3	–	1.76
Thiamin (mg)	0.06	–	–
Riboflavin (mg)	< 0.10	–	–
Niacin (mg)	0.66	–	–
Vitamin B6 (mg)	0.21	–	–
Folate (µg)	14.0	–	–
Vitamin A (µg)	1.00	–	–
References	[37]	[37]	[19]

particularly in terms of color, aroma, texture, taste, and overall preference. These findings indicate that *manggulu* is a nutritious product with strong sensory appeal, leading to high consumer acceptance.

Yaputra et al. [13] developed a modified *manggulu* by replacing peanuts with cowpea and incorporating coconut milk, resulting in significant changes in its nutritional composition. Compared to the peanut-based formulation (Table 2), the modified *manggulu* had a lower moisture content (12.32%), which can improve the shelf life. Additionally, the ash content increased to 2.95%, indicating a potential rise in mineral content. The fat content was significantly higher (29.68%), likely due to the addition of coconut milk, compared to the peanut-based formulation, which ranged from 3.60% to 14.75%. Protein content increased to 29.68%, far exceeding that of the peanut-based *manggulu*, which ranged from 4.32% to 10.51%, suggesting that cowpea contributes significantly to protein enrichment. Conversely, the carbohydrate content in the modified *manggulu* decreased to 42.29%, compared to the peanut-based formulation, which had a higher carbohydrate content (55.01%–69.14%). Overall, the modified *manggulu* with cowpea and coconut milk exhibited a more protein- and fat-rich nutritional profile but with lower carbohydrate levels [13]. However, while this enhances its nutrition, it may compromise authenticity by altering the traditional taste, texture, and cultural significance.

Bora [11] reported that the chemical and sensory properties of *manggulu* are influenced by both the proportion of peanuts and the variety of bananas used, as shown in Table 4. Water activity showed slight variations across formulations, with *manggulu* from

Table 3 Nutritional and sensory characteristics of *manggulu* made from saba bananas with varying proportions of peanuts [7]

Characteristics	*Manggulu* made from saba bananas with varying proportions of peanuts				
	10% peanuts*	20% peanuts*	30% peanuts*	40% peanuts*	50% peanuts*
Proximate composition (g/100 g)					
Moisture	20.7^{b}	18.58^{ab}	17.56^{a}	17.33^{a}	17.56^{a}
Ash	2.21^{ab}	2.31^{b}	2.29^{b}	2.05^{a}	2.14^{ab}
Fat	3.60^{a}	6.22^{b}	9.44^{c}	12.63^{d}	14.75^{d}
Protein	4.32^{a}	5.21^{a}	8.03^{b}	8.46^{b}	10.51^{c}
Carbohydrate	69.14^{c}	67.65^{c}	62.64^{b}	59.33^{b}	55.01^{a}
pH	5.04^{a}	5.15^{ab}	5.21^{bc}	5.31^{cd}	5.36^{d}
Sensory characteristics (hedonic test)					
Color	5.07^{a}	5.18^{a}	5.60^{ab}	5.69^{ab}	6.02^{b}
Aroma	5.00^{a}	5.18^{a}	5.29^{a}	5.36^{a}	5.38^{a}
Texture	4.80^{a}	4.89^{ab}	5.16^{ab}	5.49^{b}	5.51^{b}
Taste	5.16^{a}	5.54^{ab}	5.71^{ab}	5.73^{ab}	5.82^{b}
Overall	5.74^{a}	5.76^{a}	5.98^{ab}	6.00^{ab}	6.53^{b}

*Different superscript letters in the same row show significant differences ($p < 0.05$)

Table 4 Chemical and sensory characteristics of *manggulu* made from different types of bananas with varying proportions of peanuts [11]

Characteristics	*Manggulu* from saba banana			*Manggulu* from ambon banana			*Manggulu* from kepok banana		
	25% peanuts	50% peanuts	75% peanuts	25% peanuts	50% peanuts	75% peanuts	25% peanuts	50% peanuts	75% peanuts
Chemical characteristics									
Water activity	0.660^{a}	0.667^{a}	0.657^{a}	0.570^{b}	0.533^{bc}	0.560^{b}	0.563^{b}	0.550^{c}	0.550^{c}
Fat (%)	7.86^{c}	8.43^{c}	9.73^{c}	8.04^{c}	9.87^{bc}	10.93^{ab}	8.55^{c}	10.77^{ab}	12.50^{a}
Protein (%)	7.42^{d}	8.69^{c}	9.83^{bc}	9.57^{bc}	10.18^{b}	11.60^{a}	11.43^{a}	11.62^{a}	11.26^{a}
Glucose (%)	31.66^{f}	33.73^{e}	35.25^{e}	38.31^{d}	40.51^{c}	44.58^{a}	37.19^{d}	41.70^{b}	45.56^{a}
Sensory characteristics (hedonic test)									
Color	2.33^{c}	2.42^{c}	2.38^{c}	2.92^{b}	3.13^{b}	3.67^{a}	2.96^{b}	3.08^{b}	3.67^{a}
Aroma	2.04^{c}	2.46^{c}	2.38^{c}	3.42^{b}	3.87^{b}	4.51^{a}	4.54^{a}	4.83^{a}	4.96^{a}
Flavor	2.04^{e}	2.46^{e}	2.38^{e}	3.87^{d}	3.87^{c}	4.58^{ab}	3.00^{d}	4.25^{bc}	4.86^{a}

*Different superscript letters in the same row show significant differences ($p < 0.05$)

saba banana maintaining the highest values (0.657–0.667), whereas *manggulu* made from *ambon* banana (*Musa paradisiaca subsp. sapientum* (L.) Kuntze) and *kepok* banana (*Musa acuminata*) exhibited lower values, especially at higher peanut levels. These findings indicate that *manggulu* can be classified as an intermediate moisture food, typically characterized by a water activity range of 0.6–0.9 [22]. Consistent with the findings of Retang and Singapurwa [7], the fat and protein contents increased as the proportion of peanuts rose across all banana varieties. *Manggulu* made from *kepok* banana with 75% peanuts exhibited the highest fat and protein levels, reaching 12.50% and 11.26%, respectively (Table 4). Similarly, glucose content also showed an increasing trend with higher peanut proportions, with the highest levels found in *manggulu* formulated with ambon and *kepok* bananas.

Sensory evaluation results highlight significant differences in color, aroma, and flavor across different formulations (Table 4). *Manggulu* from berangga banana received the highest scores in all sensory attributes, particularly with 75% peanuts, suggesting that its natural sweetness and peanut-enhanced richness contributed to better overall acceptance. Aroma and flavor scores improved with increasing peanut content across all banana types, likely due to the roasted and nutty flavors of peanuts complementing the banana's inherent sweetness. Notably, *manggulu* made from ambon banana also demonstrated favorable sensory attributes, particularly in aroma and flavor, making it a strong candidate for consumer preference. These findings suggest that banana variety selection and peanut proportion significantly influence the chemical and sensory properties of *manggulu*, with *kepok* banana providing the most favorable outcomes in both aspects [11].

Challenges and future perspectives of *manggulu*

Manggulu faces several critical challenges that are fundamentally similar to those encountered by other traditional food products, hindering its development and broader market acceptance. These challenges predominantly arise from limitations in production capacity, supply chain constraints, inadequate branding and marketing strategies, and a lack of technological innovation [23, 24]. Addressing these issues requires a systematic and multi-stakeholder approach to ensure the sustainable development and long-term competitiveness of *manggulu* in the market.

One of the major challenges is the small-scale production that relies on traditional methods [11]. While these methods are integral to maintaining the authenticity of *manggulu*, they also limit production scalability, making it difficult to meet higher market demands. The introduction of appropriate mechanization, such as automated mixing and molding machines, can improve efficiency while maintaining the artisanal characteristics of *manggulu*. However, the lack of advanced processing technology and adequate infrastructure further exacerbates these limitations, hindering productivity and increasing labor demand [25]. Another critical challenge is the limited market reach and weak brand recognition of *manggulu* outside Sumba. Traditional foods often struggle to compete with modern commercial products that benefit from aggressive marketing, attractive packaging, and extensive distribution networks [23]. *Manggulu*'s reliance on local markets restricts its exposure, and its branding remains underdeveloped. In addition, the absence of formal marketing strategies and product standardization makes it difficult for *manggulu* to gain consumer trust and penetrate broader domestic or international markets.

To address these challenges, strategic actions must be undertaken, particularly by the government and local

universities, as they play a crucial role in developing traditional food industries. The government can enhance production efficiency and infrastructure by providing financial support and incentives to small-scale producers to invest in processing technology that increases efficiency while maintaining traditional production values. In addition, the government should implement policies to protect and promote traditional foods, such as recognizing *manggulu* as a cultural heritage food and facilitating geographical indication (GI) certification to establish its authenticity and origin [26]. Local universities can contribute by conducting research on optimizing traditional production methods through mechanization that does not compromise the authenticity of *manggulu*. Universities should also provide technical assistance and training programs aimed at improving production consistency and quality control, ensuring that traditional methods are adapted to modern standards without losing their cultural value. Furthermore, universities can facilitate knowledge exchange by involving local producers in collaborative research that bridges the gap between traditional methods and modern innovations [27]. Strengthening marketing and branding strategies is also vital. A well-structured branding campaign should be developed by the government and universities together to increase consumer awareness of *manggulu*'s cultural significance and unique characteristics [28]. The government can facilitate market access by integrating *manggulu* into national and regional food promotion programs [29], while digital marketing platforms should be leveraged to expand market reach beyond local consumers [30].

Packaging limitations further complicate the development of *manggulu*. Traditionally, *manggulu* is wrapped in banana leaves, which, while environmentally friendly, offers limited protection [11]. This restricts its ability to be distributed widely, especially to urban markets and export destinations. Improving packaging solutions is another crucial step in the development of *manggulu*. Research on sustainable and cost-effective packaging alternatives should be encouraged, with support from universities and food technology institutions. The introduction of vacuum-sealed packaging or modified-atmosphere packaging can extend shelf life while maintaining product integrity [31]. Small-scale producers should be provided with access to subsidized packaging innovations to ensure affordability and adoption.

Furthermore, the nutritional profile of *manggulu*, particularly its high sugar content, may limit its broader consumer acceptance [11]. Increasing consumer awareness of sugar intake, coupled with dietary restrictions on high-sugar products, highlights the need for modification [32]. The absence of clear nutritional labeling also limits consumer confidence, as it may not provide sufficient information about the product's composition and its alignment with specific dietary needs [33]. To address this challenge, product innovation is necessary, including the development of low-sugar variants of *manggulu*. This can be achieved through collaboration with food scientists to explore alternative sweeteners or functional ingredients that retain the traditional flavor while improving nutritional quality. Additionally, implementing standardized nutritional labeling will provide greater transparency, helping consumers make informed decisions about the product's suitability for their dietary preferences. Finally, targeted marketing strategies should be employed to promote these reformulations, emphasizing their nutritional benefits while maintaining the cultural value of *manggulu* [34].

Addressing these challenges through structured interventions can enhance the potential of *manggulu* as a prominent traditional food product. The rising interest in cultural heritage and traditional cuisine creates an opportunity to establish *manggulu* as a valuable culinary heritage item [35]. By implementing targeted strategies for production enhancement, branding, packaging, and product innovation, *manggulu* can evolve from a niche traditional food to a well-recognized and competitive culinary product in the national and global market. Additionally, increasing collaborations between local producers, researchers, and policymakers will foster a supportive ecosystem that nurtures the growth and sustainability of *manggulu*. This multi-faceted approach can position *manggulu* not only as a cherished traditional food, but also as a viable commercial product with substantial export potential.

Conclusion

This study provides a comprehensive exploration of *manggulu*, integrating its historical, cultural, and scientific aspects. It highlights the role of traditional Sumbanese knowledge in sustainable food preservation. *Manggulu*, made from locally available ingredients such as dried bananas, peanuts, and palm sugar, embodies the island's history, culture, and environmental adaptation. Its energy-dense composition and durable nature have made it an essential provision for long journeys, rituals, and ceremonies. The communal preparation process reflects values of togetherness and mutual cooperation. *Manggulu* exemplifies sustainability through its preservation methods and serves as a vital part of Sumba's culinary heritage. The broader implications of this research emphasize the potential of traditional foods like *manggulu* in promoting sustainable food practices and preserving cultural identities. The study also contributes to the growing body of knowledge on indigenous food systems and their

resilience in the face of modern challenges. The development of traditional foods like *manggulu* requires a multi-stakeholder approach, with governments providing regulatory support, infrastructure, and marketing, and universities contributing through research and innovation. Future research should focus on enhancing production techniques, exploring modern preservation methods, and assessing the feasibility of scaling up production for broader market access, while ensuring the preservation of cultural heritage.

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