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Functional Development and Consumer Acceptability of GABA Rice Enriched with Nutrient-Rich Bamboo Shoots (*Bambusa merrilliana*) and Jute Leaves (*Corchorus olitorius*)

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Abstract. Bamboo shoots are gaining recognition globally as a nutritious health food. This study evaluates the sensory attributes and consumer acceptance of a novel product made from bamboo shoots, jute leaves, and GABA rice, focusing on color, taste, texture, and odor and overall acceptability. The research focused on developing convenient, shelf-stable meals for disaster situations using bamboo shoots and GABA rice, resulting in a nutritious dish. Bamboo shoots are high in fiber, while GABA rice offers health benefits due to its gamma-aminobutyric acid content. A completely randomized design was employed, and 50 untrained panelists aged 21 to 50 were randomly assessed. The samples were assessed using a 9-point hedonic scale and descriptive scorecards. Using statistical software, data analysis utilized descriptive statistics, including mean, frequency, percentage, and one-way ANOVA. The findings indicated that Treatment 3, consisting of 700 grams of GABA rice and 300 grams of bamboo shoots with jute leaves, was the most acceptable, characterized by a light brown color, a well-balanced saltiness, very soft and free from any grittiness, very pronounced odor, and an overall acceptability rating of "Like Extremely.", indicating a significant difference in color, taste, odor, texture, and overall acceptability. Additionally, proximate analyses showed that the product contained 0.09% Crude Protein, 4.96% Crude Fiber, 7.07% Crude Fat, 71.73% Moisture, 0.49%. Ash Content. Additional research is needed to evaluate the sensory properties, nutritional value, and microbial safety of the thermally processed product to ensure it is commercially sterile and has a stable shelf life.

Keywords: Consumer acceptability; Functional development; Nutrient-rich Bamboo shoots; Nutrient-rich Jute leaves.

1.0 Introduction

As an environmentally vulnerable nation, the Philippines faces ongoing threats from hydrological disasters like tropical cyclones and floods. In the aftermath of these disasters, a key responsibility of governments and relief agencies is to provide emergency food supplies to affected communities. The Philippines ranks among the most disaster-prone countries globally, placing 9th in the 2020 World Risk Index for vulnerability to extreme weather events and 4th in a United Nations report on disaster-affected nations (Congressional Policy and Budget Research Department, 2021; Saludes, 2020; Gonzales et al., 2022). From 2000 to 2019, the country experienced a staggering 304 out of 7,348 recorded disasters (Saludes, 2020). Calamities are a significant cause of hunger, affecting all aspects of food security: economic and physical access to food, availability, and stability of supplies, and nutritional

quality. The aftermath often shows a substantial lack of basic needs for the affected population (Membrebe & Briones, 2016).

During local disasters, the government primarily manages access to food by coordinating food distribution in shelters (Mugabe et al., 2021; Gomez & Ignacio, 2020; Gonzales et al., 2022). Losing introductory provisions restricts access to various food types, notably healthier options (World Health Organization, 2020; Gonzales et al., 2022). Commonly donated items and local food staples, such as rice, root vegetables, coffee, and instant noodles, often necessitate preparation before they can be consumed (Membrebe & Briones, 2016; Gomez & Ignacio, 2020; Aguinaldo, 2022; Gonzales et al., 2022). Calamities disrupt utilities, requiring targeted measures to ensure food security. One effective solution is providing ready-to-eat (RTE) foods that are safe to consume without water or heating. While locally donated canned foods often fit this category, they usually lack variety, mainly sardines, corned beef, and meatloaf (Aguinaldo, 2022; Gonzales et al., 2022). In contrast, donated ready-to-eat (RTE) foods from foreign sources—such as canned meals, Meals Ready to Eat (MRE), energy bars, high-energy biscuits, and specialized nutritional products—typically meet safety and nutritional standards. However, they may lack cultural familiarity with the end-users (Azanza & Estilo, 2015; Gonzales et al., 2022). The principle of cultural familiarity suggests that each society has food items considered suitable or acceptable. For example, Filipinos typically view a meal as consisting of rice accompanied by at least one viand. In contrast, the U.S. Meals Ready to Eat (MRE) concept includes a main course, side dish, and dessert (Gonzales et al., 2022).

Healthy foods, particularly bamboo shoots, have seen a significant rise in demand and production in recent years, driven by consumer preferences for nutritious and low-calorie options (Narmilan & Amuthenie, 2015). This trend reflects a growing awareness of the health benefits of bamboo shoots, which are rich in fiber and essential nutrients. Bamboo shoots are a nutritional powerhouse, rich in essential proteins, amino acids, and carbohydrates, making them a valuable addition to a healthy diet. According to Nongdam and Tikendra (2014), bamboo shoots contain high levels of proteins, including essential amino acids such as leucine, isoleucine, and valine. These amino acids play crucial roles in muscle growth, repair, and maintenance. Additionally, bamboo shoots are a good source of complex carbohydrates, providing sustained energy and promoting digestive health due to their fiber content. The nutritional profile of bamboo shoots also includes vitamins and minerals, such as vitamin C, B6, potassium, and manganese, which support various bodily functions. With their impressive nutrient density and potential health benefits, bamboo shoots are well-positioned as a significant functional food that can contribute to overall well-being.

A study by Satya et al. (2012) emphasizes that bamboo shoots are rich in essential minerals, vitamins, and dietary fiber. Their low-fat content helps lower blood glucose and cholesterol levels, making them a versatile ingredient in various dishes. This versatility is paramount in addressing malnutrition and health challenges in the Philippines, especially amid the ongoing pandemic, which has intensified issues related to poverty and the consumption of unhealthy foods. Once dubbed "the poor man's timber," bamboo shoots have recently transformed into a celebrated delicacy, now regarded as "the food of the rich." In many Asian cultures, bamboo shoots have long been a staple ingredient in traditional dishes, appreciated for their unique flavor and nutritional benefits (Wang, 2020). This shift in perception underscores the growing appreciation for bamboo shoots in contemporary cuisine, highlighting their versatility and culinary value. Bamboo, a member of the Poaceae family, is celebrated as one of the most versatile and economically significant plants worldwide, with over 1,250 species primarily found in Southeast Asia. These remarkable plants boast more than 1,500 uses, highlighting their importance across various sectors (Nongdam and Tikendra, 2014). Growing awareness of the nutritional benefits of bamboo has contributed to its rising popularity, particularly bamboo shoots, which are praised for their health-promoting properties. Research suggests that bamboo shoots may play a role in preventing chronic diseases and enhancing overall well-being, further solidifying their value in contemporary diets.

Brown rice, which is hulled directly from rough rice, consists of bran layers (6–7%), an embryo (2–3%), and an endosperm (about 90%) (Wu et al., 2013). Germinated brown rice (GBR) is gaining recognition as a highly regarded functional food, celebrated for its fresh, natural origins, impressive nutritional profile, and beneficial physiological effects. While polished or white rice is often criticized for its low nutritional value and potential to increase the risk of type 2 diabetes, brown rice, despite its health benefits, typically faces challenges related to low digestibility and less-than-ideal organoleptic and cooking properties. GBR effectively overcomes these limitations by offering

superior texture and enhanced bioavailability of nutrients and phytochemicals (Nguyen et al., 2020). This makes GBR an appealing choice for those seeking a healthier alternative to white and brown rice, further solidifying its role in contemporary diets prioritizing wellness and nutrition. Rice (*Oryza sativa L.*) is the most important cereal crop and staple food consumed by more than half of the world's population (Ghosh et al., 2019; Wakte et al., 2017).

In addition to its nutritional benefits, rice is rich in several bioactive compounds, most notably γ-aminobutyric acid (GABA). GABA, a well-known derivative of free glutamic acid, has gained popularity as both a dietary supplement and a functional ingredient in health foods. As a result, GBR is known as a functional food with plenteously bioactive components, which increased significantly, including γ-butyric acid (GABA), ferulic acid (FA), γ-oryzanol (GORZ), and several phenolic acids (Cho & Lim, 2016). Many previous studies have shown that the continuous intake of germinated brown rice (GBR) helps to prevent diabetes in healthy human subjects (Ren et al., 2020) and have highlighted GABA's significant roles in stress reduction and the management of various chronic conditions, including hypertension, cardiovascular disease (Kittibunchakul et al., 2021). In rice, GABA is primarily concentrated in the germ and bran layers, making brown rice an excellent source of this beneficial compound, with higher levels than standard milled rice (Kittibunchakul et al., 2021).

The Philippine government promotes brown rice (BR) for its health benefits. However, its adoption is limited among Filipinos due to challenges in cooking, its hard texture, and the presence of phytic acid, which reduces nutrient absorption. To overcome these issues, germination through soaking has been employed to create GABA rice, which enhances the taste and texture of BR. GABA rice improves digestibility and nutrient availability and offers cognitive and health benefits, including stress reduction, improved sleep quality, and lower blood pressure. This initiative aims to encourage healthier dietary choices among Filipinos while addressing the drawbacks of traditional brown rice (Bulatao et al., 2017).

Corchorus spp. (jute) is a plant native to tropical regions of Africa and Asia, with its distribution now extending to Australia, South America, and parts of Europe. The leaves of this plant are not only excellent culinary ingredients but also possess various medicinal properties. These benefits highlight the potential of jute leaves to promote health and nutrition (Ahmid & Sarkar, 2022). The leaves are recognized for their rich content of vitamins and micronutrients and notable antioxidant properties, particularly due to their significant levels of α-tocopherol, equivalent to Vitamin E. The mucilaginous texture of the leaves makes them a valuable addition to various culinary dishes. Furthermore, this plant is cultivated not only for its fiber but also for its culinary applications. Young leaves of the cultivated jute species *Corchorus olitorius L.* and *C. capsularis L.* are commonly consumed either fresh or processed (Nasreen et al., 2021). Consequently, consuming jute leaves could significantly contribute to the World Health Organization's global initiative to promote increased vegetable intake (Ali et al., 2020).

Two of the most beloved Filipino dishes, ginataang labong (bamboo shoots cooked in coconut milk and chilies) and dinengdeng na labong (bamboo shoots in fish bagoong with string beans, jute leaves, and smoked fish, exemplify the culinary versatility of bamboo shoots (Kumar et al., 2019). In addition to these traditional recipes, a wide array of bamboo shoot products is commercially available in countries such as China, Japan, Thailand, and Malaysia. These products include canned bamboo shoots, fermented bamboo shoots, bamboo pickles, bamboo shoot powder, bamboo shoot juice, and bamboo beer made from bamboo culms. The growing popularity of bamboo shoots in various culinary applications underscores their nutritional benefits and adaptability in traditional and modern cuisines, making them an increasingly sought-after ingredient in diverse dishes.

This study on a novel GABA rice product that incorporates bamboo shoots and jute leaves aims to focus on creating a functional food product that combines the health benefits of GABA rice with the nutritional advantages of bamboo shoots and jute leaves, optimizing formulation and processing for enhanced quality. This study aims to develop a nutritious and acceptable GABA-enriched rice product that promotes healthier rice-based foods and addresses the need for effective disaster food solutions. By incorporating underutilized ingredients such as bamboo shoots, the research seeks to create a versatile food option that enhances food security during emergencies while providing essential nutrients and health benefits.

2.0 Methodology

2.1 Research Design

The study utilized a Completely Randomized Design (CRD) featuring four treatments. The treatments were defined as follows: Treatment 1 with 300 grams of GABA rice with 700 grams of bamboo shoots and jute leaves, Treatment 2 with 500 grams of GABA rice with 500 grams of bamboo shoots and jute leaves, Treatment 3 with 700 grams of GABA rice with 300 grams of bamboo shoots and jute leaves and Treatment 4 with 900 grams of GABA rice with 100 grams of bamboo shoots and jute leaves. This structured approach systematically evaluated the sensory attributes associated with varying proportions of GABA rice and bamboo shoots.

2.2 Research Participants

Random sampling was employed to recruit at least 50 untrained panelists, primarily staff from DOST Region 2 and faculty from Isabela State University Cauayan Campus between 21 and 50 years old.

2.2 Research Instrument

This study used a modified sensory evaluation scoresheet adapted from Gatchalian (1989) and Mabesa (1986) and validated by a Professional Food Technologist. The sensory evaluation scoresheet is divided into two sections. Part I focuses on collecting demographic data, including age, gender, and affiliation, and Part II focuses on assessing the sensory attributes of the sample product through a detailed descriptive scoresheet. Scoresheets were distributed to the selected panelists, who will independently assess the sensory characteristics of the samples, including color, taste, texture, and odor. Descriptive scorecards were used to evaluate the quality of the products using the scale 1 to 5, with 5 presenting the highest rate and 1 as the lowest rate, and a nine-point hedonic scale to determine the general overall acceptability of the finished products (1: dislike extremely, 2: dislike very much, 3: dislike moderately, 4: dislike slightly, 5: neither like nor dislike, 6: like slightly, 7: like moderately, 8: like very much, 9: like extremely).

2.4 Data Gathering Procedure

This study followed a systematic approach to data collection. The researcher developed a sensory evaluation scoresheet, which experts approved, and then conducted a sensory evaluation with the panelists. Adhering to established procedures and precautions for sensory evaluation as recommended by previous studies, the panelists received a briefing on proper evaluation conduct prior to tasting. Equal samples from each treatment were presented in identical containers, coded with three-digit random numbers, and served in a randomized order. To ensure unbiased evaluations, water was provided for rinsing between sample tastings. Each panelist independently assessed the samples based on color, taste, texture, odor and, overall acceptability. Conducted in a dedicated sensory evaluation facility, this structured approach ensured a thorough assessment of the sensory qualities of bamboo shoots with Jute leaves in GABA rice, yielding valuable insights into its acceptability among a diverse panel of consumers. After the sensory evaluation, the researchers collected and tallied the scoresheets for statistical analysis.

2.6 Ethical Considerations

This research study followed ethical guidelines. Consent forms were provided to the selected panelists, outlining essential information regarding the sensory evaluation process. These forms included details about the potential risks and benefits, safety assurances, disclosure of any conflicts of interest, and acknowledging participants' rights. Additionally, the forms emphasized the confidentiality of the study results to protect the privacy of all participants.

3.0 Results and Discussion

3.1 Profile of the Respondents

Table 1 shows respondents' frequency and percentage distribution according to their age. Among the 50 respondents surveyed, the age breakdown is as follows: 21-25 years: 44%, 26-30 years: 18%, 31-36 years: 24%, and 37-50 years: 14%. These findings indicate that most respondents are within the 21-25 age range, underscoring a predominantly youthful demographic in the sample. In terms of sex, analysis indicates that, among the 50 respondents, 56% identified as female and 44% identified as male. This distribution highlights a notable representation of female participants within the sample (see Table 2).

Table 1. *Frequency and percentage distribution of respondents in terms of age*

Age	Frequency	Percentage
21–25	22	44
26–30	9	18
31–36	12	24
37–50	7	14

Table 2. *Frequency and percentage distribution of respondents in terms of gender*

Gender	Frequency	Percentage
Male	22	44
Female	28	56

3.2 Sensory Quality Preferences

The data presented in Table 3 reveals that Treatment 1 achieved a mean score of 4.50, corresponding to a dark brown color. In comparison, Treatment 2 received a mean score of 3.83, indicating a brown color, while Treatment 3 scored 3.47, reflecting a light brown color. Treatment 4, on the other hand, attained a mean score of 2.43, categorized as brownish. Color is a critical parameter in the evaluation process, as it indicates the suitability of the raw materials used in preparation and offers valuable insights into the formulation and overall quality of the products (Mustafa et al., 2016).

Table 3. *Sensory quality preferences of GABA rice product*

Sensory Qualities	Treatment	Mean	Description
Color	1	4.50	Dark brown
	2	3.83	Brown
	3	3.47	Light Brown
	4	2.43	Brownish
Taste	1	4.40	Slightly salty
	2	3.87	Slightly salty
	3	3.43	Well-balanced saltiness
	4	1.57	Slightly noticeable
Texture	1	3.04	Moderately soft with noticeable grittiness
	2	3.64	Slightly soft with minimal grittiness
	3	4.70	Very soft and free from any grittiness
	4	2.45	Moderately soft with grittiness
Odor	1	3.47	Just recognizable
	2	2.44	Slight noticeable
	3	4.53	Very pronounced
	4	4.27	Pronounced
Overall Acceptability	1	6.82	Like Slightly
	2	7.71	Like Very Much
	3	8.51	Like Extremely
	4	7.30	Like Moderately

The taste preferences of the panelists revealed distinct differences among the treatments. Treatment 1 and Treatment 2 received mean scores of 4.40 and 3.87, respectively, indicating that both were perceived as slightly salty. In contrast, Treatment 3 achieved a mean score of 3.43, suggesting a well-balanced saltiness. Meanwhile, Treatment 4 scored significantly lower at 1.57, indicating a taste that was only slightly noticeable. Flavor is a critical factor that profoundly influences product acceptance and consumer preference (Mustafa et al., 2016). Bamboo shoots, with their high cellulose content, stimulate appetite and offer a unique culinary experience. Their crisp, crunchy, and tender texture, combined with a naturally sweet flavor, creates an enjoyable taste profile that makes them an excellent choice for appetizers (Chongtham, 2011). Ultimately, taste remains a key determinant in the acceptance and success of newly developed products (Mustafa et al., 2016).

The texture preferences of the panelists varied significantly among the treatments. Treatment 1 received a mean score of 3.04, indicating a moderately soft texture with noticeable grittiness. Treatment 2 scored 3.64, suggesting a slightly soft texture with minimal grittiness. In contrast, Treatment 3 achieved a high mean score of 4.70, reflecting a very soft texture free from any grittiness, which was well-received by the panelists. Lastly, Treatment 4 scored 2.45, interpreted as moderately soft with grittiness. Texture is a critical quality attribute that greatly impacts consumer acceptance and satisfaction in fresh and processed foods. It is key in determining a product's

perceived quality, palatability, and overall consumer appeal. Texture influences sensory aspects, including mouthfeel, flavor perception, appearance, and sound. It plays a crucial role in shaping consumer preferences and overall satisfaction with food products. Ultimately, texture is a vital component that enhances consumer engagement and satisfaction, making it essential for food manufacturers to prioritize product development (Kadam et al., 2015).

The analysis of odor preferences among the treatments reveals distinct differences. Treatment 1 received a mean score of 3.47, indicating a recognizable odor. Treatment 2 scored lower at 2.44, suggesting a slightly noticeable odor. In contrast, Treatment 3 achieved a high mean score of 4.53, reflecting a very pronounced odor that was well-received by the panelists. Treatment 4 also scored favorably with a mean value of 4.27, interpreted as having a pronounced odor. Aroma is a vital component of the intrinsic quality characteristics of food, playing a significant role in shaping its overall appeal and acceptability. It offers a comprehensive sensory profile that enhances the consumer experience and influences purchasing decisions (Fernandez et al., 2016). A product's aromatic qualities enhance its desirability and contribute to the perception of freshness and flavor, making aroma an essential factor in food quality.

The acceptability of GABA Rice Products with Bamboo Shoots (*Bambusa merrilliana*) and Jute Leaves (*Corchorus olitorius*) was significantly affected by the proportions of the ingredients. Treatment 1 received a mean score of 6.82 ("Like Slightly"), Treatment 2 scored 7.71 ("Like Very Much"), and Treatment 3 was the most favored with a score of 8.51 ("Like Extremely"). Treatment 4 had a mean score of 7.30 ("Like Moderately"). These results indicate that the optimal combination is Treatment 3, consisting of 700 grams of GABA rice and 300 grams of bamboo shoots. Hedonic testing is valuable for understanding consumer preferences by measuring the degree of liking for various products, helping to identify favored options. In today's market, consumers increasingly seek foods that provide energy and health benefits, with sensory attributes such as aroma, taste, and appearance often taking precedence over nutritional value (Santosh et al., 2018[a]). Key characteristics like visual appeal, fragrance, and flavor are crucial in food selection. Additionally, bamboo shoots are highlighted as a delicious and nutritious vegetable rich in health-promoting bioactive compounds (Santosh et al., 2018 [b]).

At a 5% significance level, Table 4 indicates significant differences in color, taste, texture, odor, and overall acceptability among the various bamboo shoot and jute leaf GABA rice product treatments. These differences suggest the formulation can be further optimized to enhance sensory attributes. Product developers can refine and improve the GABA rice product by identifying the treatment with the most favorable combination of these qualities. The variations indicate that consumer preferences are specific and not due to chance, underscoring the importance of sensory evaluation in assessing food quality, as attributes like taste and odor are crucial for consumer satisfaction. Overall, these findings highlight the essential role of sensory evaluation in product development, consumer preference analysis, and quality assurance within the food industry.

Table 4. *Results of Analysis of Variance (ANOVA)*

Sensory Qualities	F value	p-value
Color	15.04	0.000
Taste	4.033	0.009
Odor	13.25	0.000
Texture	12.14	0.000
Overall Acceptability	**5.105**	**0.002**

3.3 Proximate Composition and Nutritional Evaluation

Table 5 shows the proximate compositions of Treatment 3, which includes bamboo shoots (*Bambusa merrilliana*) and jute leaves (*Corchorus olitorius*) incorporated into GABA rice, revealed the following composition: 0.09% crude protein, 4.96% crude fiber, 7.07% crude fat, 71.73% moisture, and 0.49% ash. These analyses are essential for evaluating food quality, ensuring microbial stability, and supplying critical information for nutritional labeling.

Table 6 shows the Nutrition Facts Label for GABA Rice with Bamboo Shoots and Jute Leaves. The nutritional evaluation was conducted on a product made from bamboo shoots (*Bambusa merrilliana*) and Saluyot (*Corchorus olitorius*) leaves incorporated into GABA rice. These findings highlight the product's nutritional profile and its potential health benefits. Overall, the balanced nutrient composition suggests that this product is suitable for dietary inclusion, offering a nutritious option for consumers. The label reveals the specific amounts of nutrients

present in the product, such as protein, fiber, fat, moisture, and ash content. This information allows consumers to assess the nutritional value and make informed choices based on their dietary needs and preferences (Nielsen, 2010). Brown rice offers superior nutritional benefits compared to white rice, as it is richer in essential nutrients and contains a higher concentration of bioactive compounds, including ferulic acid, γ-oryzanol, and gamma-aminobutyric acid (GABA). These valuable components are primarily found in the germ and bran layers of the grain. Consequently, brown rice is an excellent choice for those who prioritize health and nutrition due to its enhanced nutritional profile (Wu et al., 2013).

Table 5. *Proximate composition*

Crude Protein %	Crude Fiber %	Crude Fat %	Moisture %	Ash %
0.09	4.96	7.07	71.73	0.49

Table 6. *Nutrition Facts Label*

No. of servings per container: 1
Serving size: 140 g

Amount per serving		**% RENI**
Energy (kcal)	207	8%
Energy from fat (kcal)	89	
Total Fat (g)	10	
Total Carbohydrates (g)	29	
Crude Fiber (g)	7	
Total Protein (g)	0	0%

*Percent RENI values are based on 2018 RENI reference male adult requirement 19-29 years old
*Note: Calculations are based on the approximate analysis results of the sample.

4.0 Conclusion

Bamboo shoots, known as labong, are a traditional ingredient in Ilocano cuisine, particularly in dishes like Dinengdeng, where they provide unique flavor and texture. Their use reflects the resourcefulness of the Ilocano people and underscores the importance of local resources in preserving cultural identity. Using bamboo shoots and jute leaves supports sustainable agriculture by utilizing local resources that require minimal inputs while also embodying the cultural heritage of the Ilocano people. Preserving traditional recipes with these ingredients helps maintain culinary identity, fosters community resilience, and reinforces social bonds through shared cooking practices. The product development process can be further refined and leveraged by others to enhance the range of disaster foods available for local distribution. This project showcases the Department of Science and Technology's dedication to improving food security through innovative approaches. Utilizing underutilized ingredients illustrates the potential for creating nutritious dishes that preserve cultural heritage while promoting healthier diets and sustainable food practices.

5.0 Contributions of Authors

Not applicable

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7.0 Conflict of Interests

There are no conflicts of interest present.

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