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Development and Nutritional Evaluation of Paragis (*Eleusine indica*) Enriched Filipino Traditional Puto (Steamed Cake): Phytochemical and Proximate Composition

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ABSTRACT

Background: *Eleusine indica* (Paragis) is an underutilized medicinal grass widely distributed in tropical regions and traditionally recognized for its bioactive phytochemical constituents. Despite its reported therapeutic potential, its application in food product development remains limited. This study aimed to develop Paragis-enriched Filipino traditional puto (steamed cake) and evaluate its phytochemical profile, proximate composition, mineral content and sensory acceptability to determine its potential as a functional food.

Methods: Qualitative phytochemical screening of Paragis extract was conducted using standard chemical tests to detect alkaloids, saponins, tannins, flavonoids and steroidal compounds. Four formulations were prepared, including a control (T_0: plain puto without Paragis) and three Paragis-enriched variants: plain (T_1), salted egg (T_2) and leche flan (T_3). Proximate composition and mineral content were analyzed using standard AOAC methods, including gravimetric analysis for moisture and ash, Kjeldahl method for crude protein, Soxhlet extraction for crude fat and dry ashing with ICP and AAS for mineral determination. Sensory evaluation was performed using a 9-point hedonic scale. Data were expressed as mean ± standard deviation (SD) and statistical differences were determined using one-way ANOVA followed by Tukey's HSD test at $p<0.05$ using IBM SPSS Statistics (Version 25).

Result: Phytochemical screening confirmed the presence of alkaloids, saponins, condensed tannins and cardiac glycosides, while leucoanthocyanins and unsaturated steroids were not detected. Proximate analysis showed moisture content ranging from 43.9 to 49.0 g/100 g, ash from 1.0 to 1.2 g/100 g, crude protein from 4.5 to 4.8 g/100 g and crude fat from 3.2 to 6.3 g/100 g across formulations. Mineral content varied significantly ($p<0.05$), with calcium (15.0-26.5 mg/100 g), magnesium (7.0-12.1 mg/100 g), iron (2.0-2.36 mg/100 g), zinc (0.24-0.56 mg/100 g), sodium (39.5-67.6 mg/100 g) and potassium (45.0-73.8 mg/100 g). Sensory evaluation indicated that all formulations were acceptable (7.40-8.40), with the leche flan variant (T_3) receiving the highest ratings in all attributes. Significant differences ($p<0.05$) were observed among treatments for both nutritional and sensory parameters.

Key words: *Eleusine indica,* Functional food, Paragis, Phytochemical analysis, Proximate composition, Traditional puto.

INTRODUCTION

In the Philippines, traditional foods offer an excellent opportunity for incorporating locally available plant ingredients into functional food products. One widely consumed Filipino snack is puto, a steamed rice cake made primarily from rice flour and commonly served as a breakfast or snack item (Granato *et al.*, 2020). Integrating indigenous plant resources into traditional food systems has been recognized as an effective approach for improving food security, promoting local agricultural biodiversity and encouraging sustainable food innovation (FAO, 2017).

Despite the documented medicinal and phytochemical properties of Eleusine indica, its utilization in food product development remains limited. Recent metabolomic studies have confirmed the presence of diverse phytochemicals in E. indica, highlighting its potential as a plant-based source of natural antioxidants and bioactive compounds suitable for functional food innovation (Sukor *et al.*, 2023). Expansion of cultivation demands an uninterrupted supply of quality planting material (Mullassery *et al.,* 2026). While, existing studies have largely focused on its phytochemical composition and medicinal properties, with little attention to its use in commonly consumed foods (Al-Zubairi *et al.*, 2011; Sukor *et al.*, 2023). Thermal processing, such as steaming, may alter the stability, bioavailability and functional efficacy of phytochemicals, yet this topic remains underexplored in the current literature (Shahidi and Ambigaipalan, 2015; Sukor *et al.,* 2023). The incorporation

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of plant-based ingredients into cereal-based foods has been widely studied as a strategy to enhance nutritional composition and functional properties while maintaining sensory acceptability (Boye *et al.*, 2012).

The study sought to determine the phytochemical composition of the developed Paragis-enriched puto to identify the presence of bioactive compounds such as flavonoids and phenolic compounds that contribute to antioxidant and functional food properties (Sukor *et al.*, 2023). Furthermore, the identification of micronutrient-rich donors and their association with agro-economic traits can pave the way for improved nutrition and food security (Tripathy, 2024). The proximate nutritional composition of the developed food product, including moisture, protein, fat, carbohydrate and ash content, was analyzed using standard analytical procedures to evaluate its nutritional value and potential contribution to dietary intake (AOAC, 2019). Finally, the study aimed to assess the potential of Paragis-enriched puto as an innovative functional food product that integrates traditional Filipino culinary practices with plant-based nutritional enhancement derived from Eleusine indica, which has been reported to possess antioxidant and antimicrobial bioactive compounds beneficial for human health (Al-Zubairi *et al.*, 2011).

MATERIALS AND METHODS

This study was conducted during 2024-2025 at North Eastern Mindanao State University (NEMSU), Cagwait Campus, Surigao del Sur, Philippines. Fresh Paragis (*Eleusine indica*) plants were collected from local agricultural areas, thoroughly washed with mineral water, shade-dried and pulverized into a fine powder for use as a functional ingredient. Ingredients for the preparation of Filipino traditional puto, including flour, sugar, eggs, milk and salted egg, were procured from local markets. A completely randomized design (CRD) was employed, consisting of four treatments: (T_0) control puto without *Eleusine indica* (Paragis), (T_1) Paragis-enriched plain puto, (T_2) Paragis-enriched puto with salted egg and (T_3) Paragis-enriched puto with leche flan. The inclusion of a control formulation (T_0) enabled a direct comparison to assess the effect of Paragis incorporation on the physicochemical, nutritional and sensory properties of the developed products. Qualitative phytochemical screening was performed using standard procedures to detect alkaloids (confirmatory test), saponins (Froth test), tannins (Ferric chloride test), cardiac glycosides (Keller-Killiani test) and unsaturated steroids (Liebermann-Burchard test), based on observable color changes and precipitate formation.

Proximate composition analyses, including moisture, ash, crude protein and crude fat, were conducted following standard AOAC methods, while sodium content was determined using AOAC procedures at the DOST Regional Standards and Testing Laboratory. Nutritional evaluation was based on laboratory-generated data aligned with FNRI and US FDA guidelines, including caloric content and the amounts of fat, sodium, carbohydrates and protein per serving. Sensory evaluation was conducted using a 9-point hedonic scale to assess appearance, aroma, taste, texture and overall acceptability, with samples presented in a randomized order. Functional food properties were inferred from phytochemical composition and nutrient profile. All experimental data were reported as mean ± standard deviation (SD) across three determinations. Statistical analysis was performed using one-way analysis of variance (ANOVA) to assess significant differences among treatments at $p<0.05$. When significant differences were observed, Tukey's Honestly Significant Difference (HSD) test was used for post hoc comparison of means. Statistical analyses were conducted using IBM SPSS Statistics (Version 25).

RESULTS AND DISCUSSION

Phytochemical screening and functional properties of Paragis extract

The phytochemical screening of the Paragis (*Eleusine indica*) extract (Table 1) revealed the presence of important bioactive compounds, including alkaloids, saponins, tannins and cardiac glycosides, whereas quaternary bases, amine oxides, unsaturated steroids and leucoanthocyanins were not detected. The positive result for alkaloids indicates the presence of primary, secondary and tertiary alkaloids, which are known for their antimicrobial, antioxidant and anti-inflammatory activities. Similarly, saponins detected by the Froth test are associated with cholesterol-lowering and immune-modulating effects, while tannins confirmed by the Ferric chloride test exhibit strong antioxidant properties. The presence of cardiac glycosides further supports Paragis as a source of biologically active compounds with potential cardioprotective functions. These findings agreed with previous reports on the phytochemical and bioactive properties of *Eleusine indica* (Al-Zubairi *et al.*, 2011; Shahidi and Ambigaipalan, 2015).

The phytochemical profile observed in Table 1 suggested that Paragis possesses significant functional properties that may contribute to the development of value-added food products. Although certain compounds, such as leucoanthocyanins and unsaturated steroids, were not detected, the presence of major bioactive constituents is sufficient to confer antioxidant, antimicrobial and health-promoting effects. Variations in phytochemical composition may be influenced by environmental conditions, plant maturity and extraction methods. The incorporation of Paragis into Filipino traditional puto, therefore, provides an innovative approach to enhancing the nutritional and functional value of indigenous food products while maintaining consumer acceptability. Similar approaches in functional food development have been reported to improve both nutritional quality and health benefits of plant-based food systems (Granato *et al.*, 2020).

Proximate composition and nutritional evaluation

The proximate composition and nutritional evaluation of the puto(steamed cake) formulations, including the control

(T_0) and Paragis-enriched samples (T_1-T_3), are presented in Table 2. Significant differences ($p<0.05$) were observed among treatments, indicating that the incorporation of *Eleusine indica* and complementary ingredients influenced the product's physicochemical properties. Moisture content ranged from 43.9 to 49.0 g/100 g, with the highest value recorded in the control (T_0) and significantly lower values in T_3. The reduction in moisture content in enriched formulations may be attributed to ingredient interactions affecting water-binding capacity during steaming. Such variations are typical in cereal-based steamed products and directly influence texture and shelf stability (Fellows, 2009).

Ash content was significantly higher ($p<0.05$) in Paragis-enriched formulations (T_1-T_3) compared to the control, indicating an increase in total mineral content due to the addition of Paragis. Crude protein content also showed a significant increase from T_0 (4.5 g/100 g) to T_1 and T_2 (4.8 g/100 g), although no significant difference was observed among the enriched treatments ($p>0.05$). This improvement may be attributed to the combined contribution of plant-derived proteins and egg-based ingredients, which are known to enhance protein quality (Whitney and Rolfes, 2018). Crude fat content increased significantly across treatments, with the highest value observed in T_3 (6.3 g/100 g), reflecting the addition of lipid-rich components such as egg yolk and milk, which are known to improve flavor and mouthfeel (Belitz *et al.*, 2009). Similarly, carbohydrate content increased significantly in

Table 1: Phytochemical screening and functional properties of Paragis extract.

Parameter	Phytochemical properties			
	Test/Method used	Observation	Result	Functional significance
Alkaloids	Confirmatory alkaloid test	Presence of primary, secondary and tertiary alkaloids	+	Antimicrobial and antioxidant activity
Quaternary bases and amine oxide	Specific alkaloid test	No characteristic reaction observed	-	Not detected
Steroids (Cardiac glycosides)	Keller-Killiani test (2-deoxysugars)	Positive reaction indicating cardiac glycosides	+	Potential cardioprotective activity
Unsaturated steroids	Liebermann-Burchard test	No color change observed	-	Not detected
Flavonoids (Leucoanthocyanins)	Bate-Smith and Metcalf method	No detectable reaction	-	Not detected
Saponins	Froth test	Persistent froth formation	+	Cholesterol-lowering and immune-supportive effects
Tannins	Ferric chloride test	Brownish-green coloration indicating condensed tannins	+	Antioxidant and antimicrobial properties

*(+) Presence detected; (–) Not detected.

Table 2: Proximate composition and nutritional evaluation.

Nutrients	Content (g/100 g and mg/100 g)			
	T_0	T_1	T_2	T_3
Moisture (g/100 g)	49.0±0.12^a	48.6±0.12^a	47.9±0.10^b	43.9±0.11^c
Ash (g/100g)	1.0±0.02^b	1.2±0.02^a	1.2±0.01^a	1.2±0.02^a
Crude protein (g/100 g)	4.5±0.04^b	4.8±0.05^a	4.8±0.04^a	4.7±0.03^a
Crude fat (g/100 g)	3.2±0.05^c	3.6±0.06^c	4.3±0.05^b	6.3±0.07^a
Total carbohydrates (g)	9.5±0.07^c	10.0±0.08^b	11.0±0.09^a	11.0±0.07^a
Protein (g/100g)	0.70±0.02^c	0.80±0.02^b	1.00±0.03^a	1.00±0.02^a
Calcium (mg/100 g)	15.0±0.20^c	18.6±0.21^c	19.4±0.24^b	26.5±0.31^a
Magnesium (mg/100)	7.0±0.10^c	8.68±0.11^b	7.23±0.10^c	12.1±0.18^a
Zinc (mg/100)	0.50±0.01^a	0.56±0.01^a	0.25±0.01^b	0.24±0.01^b
Iron (mg/100)	2.0±0.03^b	2.30±0.03^a	0.92±0.02^c	2.36±0.04^a
Sodium (mg/100)	60.0±0.60^b	67.6±0.64^a	55.5±0.52^b	39.5±0.41^c
Potassium (mg/100)	45.0±0.50^c	46.0±0.46^c	73.8±0.69^a	73.8±0.69^a

*Values are expressed as mean ± standard deviation (n = 3). Means within the same row followed by different superscript letters are significantly different ($p<0.05$) based on one-way ANOVA with Tukey's post hoc test. Mineral values originally expressed in ppm were converted to mg/100 g for uniformity. Analyses were conducted following AOAC methods.

enriched formulations, particularly in T_1 and T_3, consistent with the composition of cereal-based food systems (FAO, 2004; Patil *et al*., 2026).

Mineral analysis further revealed significant improvements ($p<0.05$) in calcium, magnesium and potassium contents in Paragis-enriched samples compared to the control. The highest calcium (26.5 mg/100 g) and potassium (73.8 mg/100 g) values were observed in T_3, which may be attributed to the synergistic contribution of Paragis and dairy-based ingredients. Magnesium levels followed a similar trend, indicating enhanced micronutrient density in enriched formulations (Soma *et al.,* 2026). Iron content was significantly higher in T_1 and T_3 compared to T_0 and T_2, suggesting that Paragis may contribute to improved iron availability. Zinc content, although present in smaller amounts, showed significant variation among treatments, reflecting differences in ingredient composition. These micronutrients are essential for various physiological functions, including oxygen transport, immune response and metabolic regulation (Abbaspour *et al.*, 2014; Prasad, 2013).

Sodium content varied significantly among treatments, with the highest value observed in T_1 (67.6 mg/100 g) and the lowest in T_3 (39.5 mg/100 g), indicating the influence of formulation components, particularly salted ingredients. While sodium plays an important role in electrolyte balance, its intake should be carefully moderated due to associated health risks (He and MacGregor, 2009). In general, the results demonstrate that the incorporation of Paragis significantly enhanced both macro- and micronutrient composition compared to the control formulation. These findings support the potential of *Eleusine indica* as a functional ingredient for improving the nutritional quality of traditional Filipino puto while maintaining its suitability as a culturally accepted food product (Granato *et al.*, 2020).

Sensory evaluation of paragis enriched puto (steamed cake) formulation

The sensory evaluation of the puto formulations, including the control (T_0) and Paragis-enriched samples (T_1-T_3), is presented in Table 3. All formulations obtained favorable ratings across the evaluated attributes, with mean scores ranging from 7.40 to 8.40 on the 9-point hedonic scale, corresponding to “like moderately” to “like very much.” Significant differences ($p<0.05$) were observed among treatments, indicating that the incorporation of *Eleusine indica* and complementary ingredients influenced the product’s sensory characteristics. The control (T_0) consistently recorded the lowest scores across all attributes, although it remained within the acceptable range, suggesting that the base formulation was generally acceptable to panelists.

Among the treatments, T_3 (Paragis puto with leche flan) obtained the highest scores for appearance (8.35), aroma (8.20), taste (8.40), texture (8.30) and overall acceptability (8.35), which were significantly higher ($p<0.05$) than those of T_0 and T_1. This improvement may be attributed to the presence of egg and milk components, which enhance flavor richness, sweetness and mouthfeel, leading to greater consumer preference. T_2 (Paragis puto with salted egg) also showed significantly higher scores than the control, particularly in taste and texture, indicating that the addition of complementary ingredients positively influenced sensory quality. In contrast, T_1 (plain Paragis puto) showed moderate improvement over the control, suggesting that while Paragis incorporation alone is acceptable, its combination with other ingredients further enhances palatability.

The progressive increase in sensory scores from T_0 to T_3 reflects the synergistic effect of Paragis and added ingredients on product acceptability. Improvements in sensory attributes, particularly taste and texture, are consistent with previous findings that lipid- and protein-rich ingredients enhance flavor development and overall eating quality in cereal-based products (Belitz *et al.*, 2009; Fellows, 2009). Sensory evaluation remains a critical determinant of consumer acceptance, as it directly influences food preference and market potential (Lawless and Heymann, 2010). Overall, the results indicate that the incorporation of Paragis does not compromise sensory quality and, when combined with suitable ingredients, significantly enhances the acceptability of traditional puto. These findings support the potential of *Eleusine indica* as a functional ingredient in the development of culturally relevant and nutritionally improved food products (Granato *et al.*, 2020).

Table 3: Sensory evaluation of paragis-enriched puto (steamed cake) formulations.

Sensory attributes	Scores based on 9-point hedonic scale			
	T_0	T_1	T_2	T_3
Appearance	7.50±0.44^{d}	7.80±0.45^{c}	8.10±0.38^{b}	8.35±0.40^{a}
Aroma	7.40±0.48^{c}	7.65±0.50^{c}	8.05±0.42^{b}	8.20±0.37^{a}
Taste	7.45±0.46^{c}	7.70±0.48^{c}	8.15±0.36^{b}	8.40±0.35^{a}
Texture	7.60±0.42^{c}	7.85±0.40^{c}	8.10±0.39^{b}	8.30±0.33^{a}
Overall acceptability	7.50±0.45^{c}	7.75±0.46^{c}	8.10±0.37^{b}	8.35±0.36^{a}

*Values are expressed as mean ± standard deviation of sensory scores obtained from panelists using a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely). Means within the same row followed by different superscript letters are significantly different ($p<0.05$) based on one-way ANOVA with Tukey’s post hoc test.

CONCLUSION

The findings of this study demonstrated that Eleusine indica (Paragis) contains bioactive phytochemicals, including alkaloids, saponins, tannins and cardiac glycosides, which support its potential as a functional food ingredient. Incorporating Paragis into traditional Filipino puto significantly improved its nutritional profile, as evidenced by increased mineral content and a more balanced macronutrient composition compared with the control formulation. Notably, Paragis-enriched variants, particularly the leche flan formulation, exhibited higher levels of calcium, potassium and crude fat while maintaining acceptable moisture and protein levels. Sensory evaluation further revealed that all formulations were well accepted, with significant improvements ($p<0.05$) in appearance, taste, texture and overall acceptability in enriched samples compared with the control.

Hence, the study confirms that Paragis can be effectively used as a functional ingredient in the development of nutritionally enhanced and culturally relevant food products without compromising sensory quality. These results highlight the potential of Eleusine indica to promote food innovation and the use of indigenous plant resources. Future research should focus on evaluating the antioxidant activity, shelf-life stability and large-scale consumer acceptability of Paragis-based products, as well as exploring its application in other food systems to further establish its role in functional food development.

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Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this research. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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