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Exploring the Potential of Shiny Bush *(Peperomia pellucida L.)* in the Development of Nutrient-Dense Ice Cream

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Abstract

Underutilized wild greens like Shiny bush (Peperomia pellucida) hold untapped nutritional potential to combat malnutrition through innovative functional foods, yet their optimal integration into consumer-preferred frozen desserts remains underexplored. This descriptive-experimental study, integrated with Project Development Method, formulated four nutrient-dense ice cream variants using varying levels of P. pellucida aqueous extract. Proximate analysis (AOAC standards) assessed crude protein, crude fiber, crude fat, moisture, and ash, while 75 panelists evaluated sensory attributes through a validated 9-point hedonic scale. Cost-benefit analysis determined return on investment (ROI), with Information, Education, and Communication (IEC) materials developed for community nutrition education. Formulation 4 (F4) excelled nutritionally with highest crude protein (3.44%) and fiber (0.90%), alongside lowest moisture (61.72%), but Formulation 2 (F2) achieved superior sensory acceptance ("like extremely" for texture, creaminess, and overall liking), driven by optimal fat-moisture balance enhancing microstructure stability and mouthfeel. Inferential statistics confirmed texture as the primary preference driver, with moderate aroma/taste differences, all formulations met economic viability (positive ROI), favoring F2 for its sensory-cost trade-off. These patterns align with fortified ice cream literature emphasizing optimization over nutrient maximization. Findings validate P. pellucida as a viable functional ingredient, balancing nutrition and palatability without compromising dairy-like quality. F2 emerges as the lead formulation for commercialization, supporting networks for malnutrition interventions. Accompanying IEC materials bridge research to practice, promoting dietary diversification via evidence-based, culturally attuned education for sustained community health impact.

Keywords: Aqueous Extract, Functional Product, Fortified Ice Cream, Nutrient-Dense Ice Cream, Shiny Bush (*Peperomia pellucida*)

1. Introduction

Peperomia pellucida, commonly known as Shiny Bush or Pansit-pansitan, is an underutilized edible plant with recognized nutritional, medicinal, and functional potential. Although existing studies emphasize its phytochemical and pharmacological properties, its application in processed food products remains limited. This study addresses that gap by exploring the development of nutrient-dense ice cream fortified with Shiny Bush and cassava-based Sagip Nutri-Pack powder. The research situates the product within broader concerns on malnutrition, food insecurity, functional food innovation, and sustainable food systems, while also examining proximate composition, sensory acceptability, commercial potential, and product information dissemination through IEC material.

Shiny Bush is a small herb that thrives in damp and shady environments and is characterized by soft, fleshy, heart-shaped leaves, succulent stems, and shallow roots (Ooi et al., 2012). It has long been recognized in Philippine traditional medicine for its analgesic, anti-inflammatory, and anti-hyperuricemic properties (Philippine Council for Health Research and Development, 2024). Beyond medicinal use, the plant has shown promise in food development, as studies on Shiny Bush-based muffins reported acceptable consumer response and suggested that the plant can enhance nutritional value when incorporated into familiar food products (Canaya, 2024). Peperomia pellucida is nutraceutically rich and possesses antioxidant and bioactive potential, yet it remains largely absent from mainstream food products. Much of the available literature is centered on pharmacological applications and solvent-based extracts, particularly for anti-inflammatory and antigout effects, rather than food-based consumption. As a result, its role as a dietary ingredient remains underdeveloped in the literature (Tuan & Men, 2024). In addition, there is limited evidence on how the plant behaves in processed food systems, especially under conditions such as cooking, baking, storage, and formulation within sensory-sensitive products. There is also a lack of research on flavor acceptability, optimal inclusion levels, and sensory thresholds in various food matrices (Gomes et al., 2022). The present study responds to these limitations by developing nutrient-dense ice cream using

Shiny Bush and evaluating its nutritional and sensory qualities. The product is intended as a more appealing and accessible vehicle for nutrient delivery, particularly in contexts where dietary deficiencies and limited food access remain serious concerns.

The reviewed literature establishes several recurring themes. First, Shiny Bush is botanically and geographically widespread, especially across tropical and subtropical regions, and is ecologically resilient in disturbed habitats (The Institute for Regional Conservation, n.d.; Piperaceae, n.d.; Abere et al., 2012; Deane, 2020; Communications, n.d.; Anonim, 2015). In the Philippines, it is also culturally familiar as Pansit-pansitan and is associated with traditional and alternative healing practices. Second, the literature consistently highlights its nutritional and medicinal value. Peperomia pellucida is reported to contain protein and essential minerals such as potassium, calcium, and iron, and has been used traditionally for headaches, fever, gout, rheumatism, kidney problems, and other ailments. It also exhibits antihypertensive, antidiabetic, antibacterial, analgesic, antioxidant, and osteogenic properties, with these benefits linked to compounds such as flavonoids and Peperochromen-A (Silalahi, 2022). Its mineral composition further suggests its dietary value, particularly its potassium, calcium, iron, zinc, and copper content, and its favorable zinc-to-copper ratio supports its promise as a nutritional source (Ooi et al., 2012). Third, literature from both Eastern and Western traditions shows that Peperomia pellucida has long been used not only medicinally but also, in some contexts, as a food ingredient. However, its culinary use remains less developed in the Philippines despite reports of its use in salads, tisanes, and other preparations elsewhere (Ho et al., 2022; Silalahi 2022; Sauvain, 2007; Susaya-Garcia et al., 2018; Philippine Herbal Medicine, 2005-17; Minh, 2019). Fourth, the literature on functional ice cream supports the use of frozen dairy products as carriers of plant-based bioactive compounds. Functional ice cream development has emerged as a promising approach for enhancing nutritional value while maintaining sensory appeal. Ice cream can preserve heat-sensitive phenolics and antioxidants due to cold storage, and its matrix can help distribute plant extracts while reducing bitterness. Previous studies on herbal-fortified ice cream show that optimal formulation can improve antioxidant properties and shelf stability without compromising acceptability (Rad et al., 2021; Kandyliari et al., 2023; Genovese et al., 2022).

At the global level, food insecurity remains a pressing concern, particularly as populations grow and as many communities continue to lack stable access to sufficient and nutritious food. Food insecurity is not only a nutritional issue but also a social, cultural, and biological concern (Hadley, 2014). At the national level, the Philippines continues to face serious nutritional challenges. National nutrition data indicate widespread malnutrition among vulnerable groups, including infants, preschool children, pregnant women, and breastfeeding mothers. These include protein-energy malnutrition (PEM), iron-deficiency anemia (IDA), vitamin A deficiency (VAD), and iodine deficiency disorders (IDD) (Balatibat, n.d.). At the same time, the country also faces the double burden of malnutrition, where undernutrition coexists with obesity and chronic disease, driven by dietary, lifestyle, and socioeconomic factors (Gaupholm et al., 2023). At the local level, the study is linked to a BIDANI initiative of Isabela State University – Echague Campus intended to help reduce malnutrition in 14 barangays. Records from the National Nutrition Council show notable cases of underweight, stunting, moderate wasting, and severe wasting among children in several barangays, including Angolluan, Bacradal, Buneg, and Pangal Norte (National Nutrition Council). These local data provide a concrete basis for developing a functional food product that is nutritious, acceptable, and potentially useful in nutrition intervention efforts. Conceptually, the study is grounded in the idea that underutilized indigenous plants with proven nutritional and bioactive properties can be transformed into acceptable and potentially marketable functional food products. In this case, Peperomia pellucida serves as the core novel ingredient, while cassava-based Sagip Nutri-Pack functions as a fortifying component that enhances macro- and micronutrient content. The resulting product is assessed through proximate analysis, sensory evaluation, projected Return-on-Investment, and IEC development, reflecting an integrated food innovation process centered on nutritional optimization and consumer acceptability. The literature on functional ice cream development further supports this conceptual basis by showing that frozen dairy systems can act as effective carriers of plant-derived bioactive compounds while preserving sensory quality and nutritional functionality (Rad et al., 2021; Kandyliari et al., 2023; Genovese et al., 2022). The principal research gap lies in the limited translation of Peperomia pellucida from medicinal and ethnobotanical contexts into processed food applications. Although the plant has established nutritional, antioxidant, and therapeutic value, most studies have focused on extracts and pharmacological outcomes rather than ordinary food consumption (Tuan & Men, 2024). Likewise, there is insufficient evidence on its performance in actual food systems, particularly in relation to thermal stability, sensory thresholds, formulation levels, and consumer acceptability in processed products (Gomes et al., 2022). The study is therefore justified by the need to develop an innovative, nutrient-dense, and acceptable food product that responds to malnutrition and food insecurity while also creating opportunities for food innovation and commercialization. Specifically, the study aims to determine the proximate analysis of four formulations, assess acceptability in terms of color/appearance, odor/aroma, taste/flavor, texture, and general acceptability, identify the most acceptable formulation, estimate projected Return on Investment, and present the process and composition of the product through IEC material.

The study aligns directly with SDG 2 – Zero Hunger because it promotes the use of an underutilized plant resource to diversify food sources and enhance food security. It also aligns with SDG 3 – Good Health and Well-being by aiming to improve nutrition and dietary diversity through a nutrient-dense and potentially accessible food product. In addition, the

study supports SDG 12 – Responsible Consumption and Production through the use of underutilized local plant resources and food product innovation that encourages more sustainable production pathways. It contributes to public health sustainability by proposing a supplementary food product that may help address micronutrient deficiencies and undernutrition among vulnerable populations. It contributes to food and nutritional sustainability by expanding the range of locally available nutrient-dense food options and by integrating an indigenous plant into a familiar and acceptable food form. It supports economic sustainability by opening possible livelihood and commercialization opportunities for farmers, plant growers, food entrepreneurs, and SMEs through increased demand for Shiny Bush and value-added food production. It also contributes to institutional and policy sustainability by providing evidence that may inform nutrition-sensitive programs, food innovation initiatives, and research priorities among policy makers and agencies such as the Department of Science and Technology. Finally, it supports environmental sustainability by encouraging the productive use of an underutilized plant species and potentially promoting biodiversity conservation and sustainable agricultural practices.

The study is delimited to the development of Shiny Bush Nutrient-Dense Ice Cream and to the evaluation of four formulations supplemented with shiny bush and cassava-based sagip. It is further limited to proximate analysis, sensory acceptability, identification of the most acceptable formulation, projected Return-on-Investment, and the development of an IEC material describing the product's process and composition. The study involved seventy-five (75) respondents and was conducted from January to March 2026 during the second semester of School Year 2025–2026.

2. Material and methods

2.1 Research Design

The study used an experimental descriptive method integrated with the Project Development Method. This combined approach provided a systematic and iterative process for food product innovation, beginning with concept development and proceeding through formulation, evaluation, refinement, and potential community-level application. The Project Development Method served as the organizing framework that guided the sequential stages of the study, allowing the researchers to define objectives, establish product standards, develop and revise prototypes, and improve the product based on documented results. In combination with the experimental descriptive method, this approach ensured that the product development process was not confined to laboratory testing alone but was also oriented toward practical usability, scalability, and impact. The study also tested two hypotheses concerning significant differences in proximate analyses and sensory acceptability among the developed formulations of Shiny Bush Nutrient-Dense Ice Cream products.

2.2 Locale of the Study

The study was conducted at Isabela State University – Angadanan Campus, Centro 3, Angadanan, Isabela. The time and place identified in the manuscript indicate that the research implementation occurred in January 2026, while the broader conduct of the research extended from January to March 2026 during the second semester of School Year 2025–2026.

2.3 Respondents of the Study

The respondents of the study were seventy-five individuals who served as sensory evaluators of the developed nutrient-dense ice cream. These panelists were randomly selected from among Food and Service Management students and untrained Food Technology experts of Isabela State University – Angadanan Campus. The panelists were screened based on overall health condition, healthy lifestyle practices, and physical well-being during data collection to reduce possible bias associated with illness or reduced sensory acuity. They were informed of the objectives and procedures of the study and of their roles as evaluators, and possible conflicts of interest such as institutional affiliation and familiarity with the researchers or product concept were disclosed in support of transparency and ethical integrity.

2.4 Sample and Sampling Procedure

The study focused on five formulations of Shiny Bush Nutrient-Dense Ice Cream, identified as F0, F1, F2, F3, and F4. The formulations varied according to the amount of aqueous Shiny Bush extract and Cassava-based Sagip Nutri-Pack added, while the base ingredients such as heavy cream, egg yolk, and refined sugar were kept constant. Fresh milk was slightly reduced in the treatment formulations to accommodate the added functional ingredients. The experimental design used five blocks, and within each block the five formulations were randomly assigned to the experimental units to minimize bias and ensure comparability of treatment conditions. For sensory evaluation, the product samples were presented to the seventy-five panelists, who were instructed to evaluate the samples objectively. They were also required to rinse and clean their palates before tasting each sample, and standard procedures were strictly observed to support the credibility and validity of the results.

2.5 Research Instrument

The instrument used for data gathering was the 9-Point Hedonic Scale. This instrument was used to assess the acceptability of the developed ice cream in terms of appearance or color, aroma or odor, taste or flavor, texture, and general acceptability.

The respondents rated the samples according to the established scale continuum from dislike extremely to like extremely. The structured sensory evaluation instrument formed part of the overall assessment of product quality together with laboratory-based nutrient analysis.

2.6 Data Gathering Procedure

The study began with the preparation of the Shiny Bush Nutrient-Dense Ice Cream using aqueous Shiny Bush extract, heavy cream, fresh milk, egg yolk, refined sugar, and Cassava-based Sagip Nutri-Pack. Ingredient quantities for each formulation were measured in grams. After formulation and preparation, the product underwent evaluation through sensory testing and laboratory analysis. In the sensory phase, the samples were presented to the selected panelists for assessment using the 9-Point Hedonic Scale. The evaluators were instructed to rate each formulation objectively according to color or appearance, aroma or odor, taste or flavor, texture, and general acceptability. Proper tasting procedure, including palate cleansing before each sample, was observed. In addition to sensory evaluation, the study examined the proximate composition of the formulations, projected Return-on-Investment if commercialized, and the process and composition of the product as presented in the developed Information, Education, and Communication material.

2.7 Data Analysis Techniques

The study analyzed the product in terms of proximate composition and sensory acceptability. Proximate analysis was used to determine the laboratory results for moisture, crude fat, crude fiber, ash, and crude protein. Sensory data were gathered through the 9-Point Hedonic Scale and were analyzed using appropriate statistical methods to establish product quality and acceptability. The manuscript also indicates that the study sought to determine whether significant differences existed among formulations in both proximate analyses and sensory acceptability, consistent with the hypotheses tested. In addition, the economic aspect of the product was examined through projected Return-on-Investment analysis.

2.8 Ethical Considerations

Ethical safeguards were reflected in the selection and handling of the sensory panel. Prospective evaluators were screened to ensure they were physically fit to participate in the sensory activity, and they were informed of the study objectives, procedures, and expected roles. Disclosure of possible conflicts of interest, particularly institutional affiliation and prior familiarity with the researchers or product concept, was also made to promote transparency and uphold the ethical integrity of the sensory evaluation.

3. Results and Discussion

3.1 Nutritional and Sensory Findings

3.1.1 Proximate Composition of the Developed Formulations

The proximate analysis showed clear nutritional differences across the four formulations. Formulation 4 obtained the highest crude protein content at 3.44%, followed by Formulation 3 at 3.27%, Formulation 2 at 2.56%, and Formulation 1 at 2.21%. In crude fiber, Formulation 4 also ranked highest at 0.90%, followed by Formulation 3 at 0.86%, Formulation 2 at 0.73%, and Formulation 1 at 0.67%. For crude fat, Formulation 1 had the highest value at 10.48%, followed by Formulation 2 at 9.53%, Formulation 4 at 9.15%, and Formulation 3 at 9.12%. In moisture content, Formulation 2 had the highest level at 64.55%, followed by Formulation 1 at 63.44%, Formulation 3 at 63.12%, and Formulation 4 at 61.72%. In ash content, Formulation 1 registered the highest value at 0.81%, followed by Formulation 4 at 0.77%, while Formulations 2 and 3 both had 0.73%. These results support the view that increasing levels of shiny bush contributed to improved nutritional enhancement, particularly in protein and fiber. The findings are consistent with Ooi et al. (2012), whose work established the nutritional richness of Peperomia pellucida, and they also support the pattern noted in Matabura et al. (2023), especially in relation to the superior nutrient values observed in Formulation 4. The increase in protein and fiber, alongside lower moisture in the most fortified treatment, indicates that P. pellucida can be effectively incorporated into a high-moisture dairy matrix without undermining the basic composition of the product.

3.1.2 Sensory Acceptability of the Control and Treatment Formulations

The control formulation was rated “Like very much” across all sensory attributes. It received mean scores of 8.08 for appearance, 8.21 for aroma, 8.29 for taste, 7.64 for texture, and 8.24 for general acceptability. Formulation 1 was likewise rated “Like very much” in all criteria, with 8.16 for appearance, 7.65 for aroma, 8.17 for taste, 8.15 for texture, and 8.27 for general acceptability. Formulation 3 also received consistently favorable ratings, with 8.35 for appearance, 7.96 for aroma, 8.16 for taste, 8.15 for texture, and 8.20 for general acceptability. Formulation 4 remained highly acceptable as well, with 8.25 for appearance, 7.87 for aroma, 8.01 for taste, 8.11 for texture, and 8.28 for general acceptability. Across the formulations, all mean scores remained above the “Like moderately” range, indicating broad panelist acceptance. The strong ratings across all treatments show that shiny bush fortification did not substantially reduce consumer acceptance. The control formulation reflects the familiar sensory benchmark of conventional dairy ice cream, which Genovese et al. (2022) described as having stable microstructure, balanced flavor release, and strong creaminess. Meanwhile, the consistently favorable ratings for the fortified samples indicate that moderate incorporation of Peperomia pellucida can

preserve desirable sensory qualities while enhancing functionality. This supports the observations of Gabbi et al. (2024) that intermediate levels of plant-based fortification tend to maintain strong consumer acceptability in frozen desserts.

3.1.3 Most Acceptable Formulation Based on Sensory Attributes

Among the formulations, Formulation 2 emerged as the most acceptable overall. The data states that Formulation 2 achieved the highest scores, particularly in texture, followed by appearance, aroma, taste/flavor, and general acceptability. The inferential analysis further confirmed this pattern. For aroma, Formulation 2 obtained the highest mean of 8.29 and was significantly higher than Formulation 1. For taste, Formulation 2 recorded the highest mean of 8.44, while Formulation 4 had the lowest at 8.01. For texture, Formulation 2 posted the highest score at 8.65 and was significantly higher than all other formulations, while the control recorded the lowest score at 7.64. For general acceptability, Formulation 2 again had the highest mean at 8.53, exceeding Formulations 1 and 3. Overall, formulation effects ranged from small-to-moderate for taste and general acceptability to large for texture, and the statistical pattern consistently identified Formulation 2 as the standout treatment. These findings indicate that the best-performing formulation was not the most fortified one, but the one that achieved the best balance between nutrient enrichment and sensory quality. This agrees with Genovese et al. (2022) and Chang et al. (2025), who noted that plant enrichment can improve functionality but may also introduce textural or flavor drawbacks if levels become excessive. The strong performance of Formulation 2, especially in texture, supports the idea that minor formulation adjustments can improve microstructural stability and cause meaningful gains in consumer preference, as also noted by Chen et al. (2019). The results further align with Akbari et al. (2019), Akalın et al. (2018), Tolve et al. (2024), Liu et al. (2024), and Alvi & Martinez-Monteagudo (2024), all of whom emphasized the major role of texture, viscosity, fat–water interactions, and melting behavior in frozen dessert acceptability.

3.2 Economic Feasibility and Product Viability

The study found that all formulations were economically feasible, with only minimal differences in return on investment. Although the detailed cost computation was based on unit cost, selling price, total sales, income, and ROI formulas, the chapter's synthesized findings indicate that profitability margins across treatments were closely comparable. In this context, Formulation 2 was identified as the most commercially balanced option because it combined strong sensory performance with relatively lower production cost than the most fortified treatment. This suggests that, when profitability differences are minimal, consumer preference becomes the decisive factor for commercialization. The findings reinforce the principle that a successful functional product is not simply the one with the highest fortification level, but the one that best optimizes nutrition, cost, and sensory experience. In this study, that balance was best represented by Formulation 2, which achieved strong market promise without relying on maximum nutrient loading.

3.3 Process and Composition as Reflected in IEC Material

The chapter also emphasized the importance of the developed Information, Education, and Communication material in presenting the process and composition of the shiny bush nutrient-dense ice cream. The IEC material was described as a strategic tool for nutrition education, designed to communicate evidence-based and culturally relevant information that can improve awareness, attitudes, and healthy eating behavior. It highlights nutritional benefits, preparation methods, safety considerations, and adoption strategies for introducing shiny bush into mainstream food consumption. This shows that the value of the developed product extends beyond laboratory validation and sensory testing. The IEC material helps bridge scientific research and community practice by translating technical findings into accessible guidance for users and potential adopters. In this way, the product is positioned not only as a functional food innovation but also as a community-oriented nutrition intervention supported by effective communication.

3.4 Overall Synthesis of the Results

Taken together, the results show that the developed formulations differed in both nutritional composition and sensory behavior. Formulation 4 provided the strongest nutritional enhancement, especially in protein and fiber, while Formulation 2 achieved the highest sensory preference, most notably in texture. All formulations were generally well accepted and economically feasible, but Formulation 2 emerged as the most balanced and commercially promising option. These findings indicate that product development for functional frozen desserts should focus on optimization rather than maximum fortification, since consumer acceptance depends heavily on preserving structural and sensory quality while still achieving meaningful nutritional gains.

4. Conclusion & Recommendations

The study concludes that the development of shiny bush (Peperomia pellucida) nutrient-dense ice cream is both nutritionally promising and practically viable. The proximate analysis confirmed that the four formulations differed in nutritional composition, with Formulation 4 providing the strongest nutrient enhancement, particularly in crude protein and crude fiber, while also showing reduced moisture content. In terms of sensory evaluation, all formulations were rated favorably by the respondents, with acceptability levels remaining above "like moderately" across the evaluated attributes. Among the treatments, Formulation 2 obtained the highest overall sensory performance, especially in texture, which

emerged as the most influential attribute in consumer preference. Although all formulations were found to be economically feasible with only slight differences in return on investment, Formulation 2 was identified as the most balanced option because it combined strong sensory acceptability with competitive production cost. The study further concludes that the developed IEC materials are important support tools for product promotion and nutrition education because they present the process, nutritional value, and adoption potential of the product in a manner that connects research findings with community use.

Based on the results of the study, it is recommended that the developed product be subjected to further evaluation through microbial analysis, shelf-life assessment, and comprehensive physicochemical testing in order to ensure its safety, stability, and overall product quality. The study also recommends that future scale-up trials give particular attention to texture as the primary sensory driver of acceptability. Specifically, targeted meltdown and viscosity tests across the four formulations should be undertaken to better reproduce the creaminess advantage observed in Formulation 2 and to help maintain high ratings in appearance, aroma, taste, and general acceptability. These recommendations remain consistent with the study's conclusion that successful product development depends not merely on increasing fortification, but on optimizing nutritional enhancement together with desirable sensory performance.

The study was limited to the development and evaluation of four fortified formulations together with one control formulation of shiny bush nutrient-dense ice cream. Its assessment focused only on proximate analysis, sensory acceptability, projected return on investment, and the presentation of process and composition through IEC material. The sensory evaluation was based on the responses of seventy-five respondents from Isabela State University – Angadanan Campus during the second semester of School Year 2025–2026, which means the findings reflect the perceptions of that specific group under the conditions of the study. Accordingly, the scope of the research did not yet include broader commercial testing or additional laboratory evaluations such as microbial, shelf-life, and physicochemical analyses, which were instead identified in the recommendations for future work.

Compliance with ethical standards

The study adhered to institutional ethical standards and observed voluntary participation, informed consent, confidentiality of information, ethical approval, proper acknowledgement of contributions, declaration of conflict of interest, copyright responsibility, and all other relevant ethical considerations in the conduct of the research.

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