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Cassava (*Manihot Esculenta*) Chips Fortified with Sagip Nutri Powder

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Abstract

This study aimed to develop and evaluate cassava (Manihot esculenta) chips fortified with Sagip Nutri Powder as a nutrient-enhanced snack alternative for college students. Anchored on principles of food fortification, sensory evaluation, and product development, the study employed an experimental research design involving four formulations, including one control and three fortified treatments. Seventy-five randomly selected college students served as respondents, and a 9-point hedonic scale was used to assess sensory attributes such as color/appearance, odor/aroma, taste/flavor, crispiness, and general acceptability. Proximate analysis, shelf-life evaluation, and cost analysis were also conducted. Results showed that all formulations were generally acceptable, with Formulation 1 obtaining the highest sensory ratings. Nutritional analysis revealed improvements in energy, protein, fiber, moisture, and ash content, particularly in higher fortification levels, while carbohydrate content decreased. All formulations maintained acceptable sensory quality for seven days, indicating good shelf stability. Economic analysis demonstrated that while production costs increased with fortification, all treatments remained profitable, with the control and Formulation 1 yielding the highest returns. The study concludes that cassava chips fortified with Sagip Nutri Powder are nutritionally enhanced, acceptable, and economically viable, and recommends their development for commercialization, further research on shelf life and packaging, and wider consumer testing. This study supports SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being) by promoting nutrient-dense food alternatives, as well as SDG 12 (Responsible Consumption and Production) through the use of local resources. It contributes to socio-economic, nutritional, and environmental sustainability by enhancing food value, supporting local agriculture, and encouraging sustainable food production practices.

Keywords: Cassava chips; Economic feasibility; Food fortification; Nutritional value; Sagip Nutri Powder; Sensory acceptability; Shelf life; Sustainability

1. Introduction

Good nutrition during early life is essential for optimal physical development, health, and long-term well-being. However, persistent malnutrition, poor dietary habits, and micronutrient deficiencies remain significant concerns, particularly in developing countries like the Philippines. This study focuses on developing cassava chips fortified with Sagip Nutri Powder as a nutrient-enhanced snack alternative for college students, integrating local agricultural resources, food fortification strategies, and sensory evaluation to address nutritional gaps while ensuring product acceptability and sustainability.

1.1 Nutritional Background and Dietary Challenges among College Students

Healthy eating habits established during childhood contribute to improved well-being and reduced risk of chronic diseases in adulthood (Butte et al., 2005). Physical development involves changes in body systems, including muscle growth, bone development, and motor control (Suhaimi & Mustafa, 2024). In the Philippines, malnutrition remains a major public health issue. The 2023 National Nutrition Survey reported that 31.4% of households experience moderate to severe food insecurity, with 23.6% stunting, 5.6% wasting, and 15.1% underweight prevalence among children (National Nutrition Survey [NNS], 2023). Nutritional inadequacies extend to adolescents and young adults, whose diets are often high in carbohydrates and low in micronutrient-rich foods (Food and Nutrition Research Institute [FNRI], 2023). Micronutrient deficiencies such as iron deficiency anemia, vitamin A deficiency, and iodine deficiency disorders continue to impair growth, cognitive development, and productivity. College students are particularly vulnerable due to financial constraints, time limitations, and reliance on convenience foods, which are typically high in fat and sodium but low in essential nutrients. Cassava (Manihot esculenta), a major carbohydrate source, provides significant energy but lacks sufficient protein and micronutrients (FAO, 2013). Sagip Nutri Powder, developed by Isabela State University, contains nutrient-rich ingredients such as cocoa pod husk, malunggay, and turmeric, offering potential for nutritional enhancement. Previous research demonstrated the acceptability and improved nutrient content of fortified products (De Vera and Peñalber, 2025), but limited studies have explored cassava chip fortification for college students.

1.2 Food Fortification, Cassava Utilization, and Sensory Acceptability of Fortified Snack Products

Literature emphasizes the importance of sustainable and nutrient-dense diets that are accessible, culturally acceptable, and environmentally responsible. Healthy diets rich in fruits, vegetables, and whole grains are recommended to address malnutrition and chronic diseases. Food fortification is widely recognized as an effective strategy to reduce micronutrient deficiencies and improve public health (Horton, 2006; Prajapati P., 2024). Studies show that plant-based fortification using ingredients such as malunggay, turmeric, and cocoa enhances nutritional value while maintaining sensory acceptability when properly formulated (Ali et al., 2025; Huey et al., 2024). Cassava-based products are important for food security due to their high carbohydrate content and adaptability (Bayata, 2019; Acheampong et al., 2021; Tafesse, 2021; Alamu et al., 2022; Adebayo, 2023). However, their low protein and micronutrient content necessitate fortification. Research highlights that fortified food products can improve nutritional profiles while maintaining consumer acceptance through proper formulation and sensory evaluation (Lawless & Heymann, 2010; Fiorentini M., et al., 2020). Sensory evaluation using tools such as the 9-point hedonic scale remains essential in determining product acceptability (Wichchukit and O'Mahony, 2014). Attributes such as color, aroma, taste, texture, and overall acceptability significantly influence consumer preference (Lawless & Heymann, 2010). Shelf-life studies emphasize the importance of moisture control, packaging, and oxidation prevention in maintaining product quality (Kilcast & Subramaniam, 2000; Choe & Min, 2006; Robertson, 2013). Additionally, economic analyses show that fortified food products can yield higher returns due to their added value and health benefits (Bogue & Sorenson, 2008; Brigham & Ehrhardt, 2017; Kotler & Keller, 2016).

1.3 Philippine and Local Context of Cassava Production and Nutrition Interventions

Globally, malnutrition and micronutrient deficiencies remain critical challenges affecting health and development. The World Health Organization emphasizes food fortification and nutrient-dense diets as key strategies to improve health outcomes (World Health Organization, 2026). In the Philippines, malnutrition persists despite national programs such as the School-Based Feeding Program (Department of Education, DO 39, s. 2017) and policies like the Food Fortification Act of 2000. The BIDANI program integrates nutrition into local development planning, highlighting collaborative efforts in addressing malnutrition. Locally, cassava is a major agricultural commodity in Isabela, providing opportunities for value-added product development. The use of Sagip Nutri Powder developed by Isabela State University demonstrates a localized approach to addressing nutritional gaps while supporting agricultural communities.

1.4 Conceptual Foundations of Food Fortification, Sensory Evaluation, and Product Development

This study is anchored on the principles of food fortification, sensory evaluation, and product development. Food fortification theory emphasizes enhancing nutritional quality without compromising acceptability. Sensory evaluation theory explains consumer acceptance based on measurable attributes such as appearance, aroma, flavor, and texture (Lawless & Heymann, 2010). The use of hedonic scales enables systematic assessment of consumer preference (Wichchukit and O'Mahony, 2014). Additionally, food processing and preservation theories highlight the importance of drying, packaging, and storage conditions in maintaining product quality and shelf life (Fellows, 2009; Robertson, 2013). Economic theories on cost and return analysis support the evaluation of product feasibility and profitability (Brigham & Ehrhardt, 2017).

1.5 Research Gap on Fortified Cassava Chips Using Sagip Nutri Powder for College Students

Despite extensive research on food fortification and cassava utilization, limited studies focus on developing fortified snack products specifically for college students. Existing programs primarily target younger populations, leaving a gap in addressing the nutritional needs of young adults. There is also limited research on the incorporation of Sagip Nutri Powder into cassava chips and its sensory acceptability, shelf life, and economic viability. While previous studies have explored fortified baked products (De Vera and Peñalber, 2025), the application in snack products such as chips remains underexplored. This study addresses these gaps by developing and evaluating cassava chips fortified with Sagip Nutri Powder, focusing on acceptability, nutritional value, shelf life, and economic potential.

1.6 Alignment of Cassava Chip Fortification with Sustainable Development Goals (SDGs)

This study aligns with several Sustainable Development Goals. It supports SDG 2 (Zero Hunger) by promoting nutrient-dense food products to address malnutrition. It contributes to SDG 3 (Good Health and Well-being) by improving dietary quality and reducing micronutrient deficiencies. Furthermore, it aligns with SDG 12 (Responsible Consumption and Production) by utilizing locally available agricultural resources such as cassava and cocoa pod husk, promoting sustainable food production and minimizing waste (United Nations, 2015).

1.7 Multidisciplinary Sustainability Contributions of Fortified Cassava Chips Development

This study contributes to socio-economic sustainability by creating opportunities for local farmers and small-scale entrepreneurs through value-added cassava products. It supports food and nutritional sustainability by providing affordable, nutrient-enhanced snack alternatives for college students. It also promotes educational sustainability by serving as a reference for food technology, nutrition, and entrepreneurship programs, particularly in Technology and Livelihood

Education. Additionally, the study advances environmental and agricultural sustainability by utilizing locally sourced and underutilized materials such as cocoa pod husk, reducing waste and supporting sustainable production systems. Overall, the research integrates nutrition, agriculture, food technology, and economics to contribute to community-based innovation and sustainable development.

2. Material and methods

2.1 Research Design

The study utilized an experimental research design involving four formulations of cassava chips, including one control and three fortified treatments. The formulations varied in the proportion of cassava root and Cassava-Based Sagip Nutri Pack while maintaining constant amounts of water, sugar, and salt. The preparation followed the standard procedure for cassava chips, where cassava roots were grated, mixed with ingredients, flattened, steamed, dehydrated, cut, dried again, and fried before packaging in polyethylene plastic bags. The experimental treatments were randomly assigned to units with replication to ensure reliability. The formulations were coded and presented to panelists in random order to minimize bias during sensory evaluation.

2.2 Locale of the Study

The study was conducted at Isabela State University Echague Campus, particularly at the College of Education for sensory evaluation. Laboratory analyses, including proximate analysis, were conducted at the Quirino State University-Diffun Campus College of Health and Sciences Food Laboratory. Raw materials such as cassava roots were sourced from Bannawag, Jones, Isabela, while Sagip Nutri Powder was obtained from the Isabela State University Cagayan Valley Cacao Development Center, and other ingredients were procured from SM Santiago City.

2.3 Respondents of the Study

The respondents consisted of seventy-five individuals randomly selected from students of the Isabela State University Echague Campus College of Education. The panelists were screened based on specific criteria, including being within the age range of 10 to 40 years old, non-smokers, non-liquor drinkers, and in good health at the time of evaluation.

2.4 Sample and Sampling Procedure

Samples from each formulation were prepared in 10-gram portions, placed in coded sealed plastic packs, and presented to the panelists for evaluation. Random sampling was used in selecting respondents, and random assignment was applied in presenting the formulations to ensure unbiased assessment. Panelists were instructed to rinse their mouths before tasting each sample to maintain accuracy and consistency in sensory evaluation.

2.5 Research Instrument

The study utilized a sensory evaluation score sheet based on the 9-point hedonic scale to measure acceptability in terms of color/appearance, odor/aroma, taste/flavor, crispiness, and general acceptability. The scale ranged from "dislike extremely" to "like extremely," allowing panelists to express their degree of preference for each formulation.

2.6 Data Gathering Procedure

The cassava chips were prepared using standardized procedures, beginning with measuring and mixing ingredients, followed by steaming, drying, cutting, and frying. After preparation, the samples were packaged and distributed to panelists for sensory evaluation. Panelists assessed each sample based on specified sensory attributes using the provided hedonic scale. Shelf-life analysis was conducted through daily observation over seven days under ambient conditions, focusing on changes in sensory attributes and signs of spoilage. Proximate analysis was performed to determine moisture, protein, fat, crude fiber, ash, and carbohydrate content using established laboratory methods. Additionally, cost data were collected to evaluate production expenses and potential returns.

2.7 Data Analysis Techniques

Sensory evaluation results were analyzed using one-way analysis of variance (ANOVA) to determine significant differences among formulations. Statistical measures such as mean, F-test, and descriptive statistics were applied to evaluate differences in sensory attributes. Tukey's Honestly Significant Difference (HSD) test was used to identify specific differences among treatments. Proximate analysis results were interpreted to determine the nutritional composition of the formulations. Shelf-life data were analyzed based on observed changes in sensory quality over time. Cost and return analysis was conducted by calculating unit cost, selling price, total sales, income, and return of expenses to assess economic feasibility.

2.8 Ethical Considerations

Informed consent was obtained from all participants prior to the study. Participants were informed about the purpose, procedures, and potential risks, and confidentiality and anonymity were ensured through proper data handling. Participation was voluntary, and respondents were allowed to withdraw at any time without penalty. The study adhered to ethical standards for research involving human participants and obtained appropriate institutional approval.

3. Results and Discussion

3.1 Sensory Acceptability of Cassava Chips Fortified with Sagip Nutri Powder

3.1.1 Color or Appearance

All formulations of cassava chips were rated "Like Very Much" in terms of color or appearance, with mean scores ranging from 7.65 to 7.93. Formulation 1 obtained the highest mean score, followed by Formulations 2 and 3, while the control had the lowest mean. Statistical analysis revealed no significant difference among the formulations, as indicated by an F-value of 0.90 and a p-value of 0.4402. These findings indicate that the addition of Sagip Nutri Powder did not negatively affect the visual quality of the product. Color and appearance are critical sensory attributes that influence consumer perception and purchasing decisions, as emphasized by Harry T. Lawless and Hildegarde Heymann and supported by Herbert Stone and Joel L. Sidel (2020). The consistent acceptability across formulations suggests that fortification maintained desirable visual characteristics without compromising product appeal.

3.1.2 Odor or Aroma

The aroma of the cassava chips was generally rated highly, with mean scores ranging from 8.16 to 8.56. Formulation 1 achieved the highest rating, followed closely by the control and Formulation 3, while Formulation 2 obtained the lowest mean. Statistical results showed a significant difference among formulations, with an F-value of 8.88 and a p-value of 0.000. This suggests that varying levels of Sagip Nutri Powder influenced the aroma of the product. Aroma plays a crucial role in food acceptability as it contributes to perceived freshness and flavor. The results support findings that plant-based additives can alter aroma profiles and influence sensory perception (Posidio & Peñalber, 2025). Despite the variation, all formulations remained within acceptable levels, indicating successful integration of the fortifying ingredients.

3.1.3 Taste or Flavor

All formulations were rated "Like Very Much" in terms of taste or flavor, with mean values ranging from 7.73 to 8.01. Formulation 1 again received the highest score, followed by Formulations 3 and 2, while the control had the lowest. Statistical analysis indicated no significant difference among treatments, with an F-value of 0.89 and a p-value of 0.4477. These results imply that the addition of Sagip Nutri Powder did not significantly alter the taste of the cassava chips. Taste is a major determinant of consumer acceptance, and the findings align with studies showing that ingredients such as turmeric and Moringa can enhance flavor without negatively affecting acceptability when properly formulated (Sun, 2023). The uniform acceptance suggests that the formulations were well-balanced in flavor.

3.1.4 Crispiness

The crispiness of the cassava chips was also highly rated, with all formulations receiving "Like Very Much" ratings and mean scores ranging from 7.95 to 8.17. Formulation 1 recorded the highest mean, followed by Formulations 3 and 2, while the control had the lowest score. Statistical analysis showed no significant difference among formulations, with an F-value of 0.54 and a p-value of 0.6582. This indicates that fortification did not significantly affect the texture of the chips. Crispiness is an essential attribute in snack products, influencing overall eating quality. According to Lawless and Heymann, texture plays a key role in consumer satisfaction, and the results demonstrate that the processing method maintained the desired structural quality despite the addition of fortifying ingredients.

3.1.5 General Acceptability

All formulations were rated "Like Very Much" in terms of general acceptability, with mean scores ranging from 7.84 to 8.13. Formulation 1 obtained the highest overall rating, followed by Formulations 2 and 3, while the control had the lowest mean. Statistical analysis indicated no significant difference among formulations, with an F-value of 1.06 and a p-value of 0.3645. These findings suggest that the overall quality of the cassava chips remained highly acceptable regardless of fortification level. General acceptability reflects the combined evaluation of sensory attributes, and previous studies have shown that plant-based fortification can enhance nutritional value without compromising consumer preference (Gopalakrishnan et al., 2016; Prasad, 2014; Afoakwa et al., 2013). The results confirm that the fortified product achieved both nutritional enhancement and sensory acceptability.

3.2 Nutritional Composition of Fortified Cassava Chips

The proximate analysis showed that increasing levels of Sagip Nutri Powder resulted in higher moisture, ash, lipid, protein, and fiber content, while carbohydrate content decreased. Moisture increased from 3.69% to 6.18%, ash content increased, lipid content slightly rose, and protein content significantly improved from 1.80% to 7.87%. Fiber content also increased, while carbohydrate content decreased from 76.80% to 62.63%. Additionally, metabolized energy increased from 378.30 to 431.70 kcal/100 g. These results indicate that fortification enhanced the nutritional profile of cassava chips. The increase in protein, fiber, and minerals can be attributed to the nutrient-rich components of Sagip Nutri Powder. Similar findings have been reported where moringa-based fortification improves nutrient content (Anwar et al., 2007; Gopalakrishnan et al., 2016). The improved nutrient composition supports the role of fortified foods in addressing dietary deficiencies, consistent with recommendations to enhance food nutrient content for better public health outcomes (WHO, 2026).

3.3 Shelf-Life Stability of Fortified Cassava Chips

All formulations maintained acceptable sensory quality throughout the seven-day storage period under ambient conditions. No signs of spoilage, discoloration, or off-flavors were observed, and the chips retained their crispiness and overall acceptability. This stability can be attributed to the low moisture content of fried products, which limits microbial growth. The use of sealed polyethylene packaging further preserved product quality by reducing exposure to air and moisture. These findings are consistent with previous studies indicating that low-moisture fried snacks have extended shelf life and maintain sensory quality when properly packaged (Peter J. Fellows, 2009).

3.4 Economic Feasibility and Cost Analysis

The production cost increased with higher levels of Sagip Nutri Powder, with the control formulation having the lowest cost and the highest fortified formulation having the highest cost. Despite this, all formulations generated income when sold at a fixed price. The control recorded the highest income and return on expenses (380%), followed by Formulation 1 (142%), Formulation 2 (101%), and Formulation 3 (76%). These results indicate that while fortification increases production cost, it can still yield profitable returns. The lower return on expenses in higher formulations is due to increased ingredient costs. Return on investment is a key measure of profitability, reflecting the efficiency of production (Brigham & Ehrhardt, 2017). The findings highlight the importance of balancing cost and product value, supporting the idea that effective cost management is essential in developing profitable value-added food products (Kotler & Keller, 2016).

4. Conclusion & Recommendations

The study found that cassava (Manihot esculenta) chips fortified with Sagip Nutri Powder were generally acceptable in terms of color/appearance, odor/aroma, taste/flavor, crispiness, and general acceptability, with Formulation 1 (F1) being the most preferred due to its balanced composition. Nutritional analysis showed that fortification improved the nutritive value of the chips, particularly in terms of energy, protein, fiber, moisture, and ash content, with Formulation 3 showing the highest nutritional enhancement. All formulations maintained acceptable sensory quality for up to seven days, indicating good shelf stability. In terms of economic feasibility, all formulations were profitable, although profitability decreased as production costs increased, with the control formulation yielding the highest return on expenses, followed by F1, demonstrating that the product is both nutritionally beneficial and economically viable.

The study recommends the development of cassava chips fortified with Sagip Nutri Powder as a nutritious snack alternative, particularly Formulation 1 due to its high acceptability and improved nutritional value. The product may be utilized by food entrepreneurs and small-scale producers for production and commercialization, while the agricultural sector may increase the cultivation of cassava and related ingredients to support potential demand. Government and community-based programs may consider incorporating such fortified products to improve dietary intake, and educational institutions may use the findings as reference material for food technology and entrepreneurship. Future research is encouraged to further examine extended shelf life, improved packaging, broader consumer acceptability, and large-scale production feasibility.

The study was limited to selected respondents from one academic institution, which may restrict the generalizability of the findings to a wider population. The shelf-life evaluation was conducted only for seven days under ambient conditions, limiting the assessment of long-term product stability. Additionally, the analysis focused on specific sensory, nutritional, and economic parameters, and did not include broader market testing or large-scale production conditions.

Compliance with ethical standards

This study adhered to ethical standards for research involving human participants. Participants were informed about the purpose, procedures, and potential risks of the study, and confidentiality and anonymity were ensured through appropriate data handling and coding of responses. Participation was voluntary, and respondents were allowed to withdraw at any time without penalty. Ethical approval was obtained from the relevant institutional authority.

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