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Pigeon Pea (*Cajanus cajan*) Flour-Based Cookies: Fortified with Papaya (*Carica papaya*) and Corn-Based Sagip Nutri Powder

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Abstract

This study aimed to develop and evaluate the sensory acceptability, nutritional composition, shelf life, and economic feasibility of drop cookies formulated using pigeon pea (*Cajanus cajan)* flour, papaya (*Carica papaya),* and Corn-Based SAGIP Nutri Powder as alternative ingredients to address malnutrition and promote food innovation. Grounded in food fortification, functional food development, and sustainable food systems concepts, the study employed an experimental research design with five cookie formulations subjected to sensory evaluation using a 9-point Hedonic Scale. The respondents consisted of 75 randomly selected student panelists aged 18 and above. Data were analyzed using one-way analysis of variance (ANOVA) and Tukey's HSD test to determine significant differences among formulations. Results showed that formulation F1 achieved the highest general acceptability in terms of odor, aroma, taste, and overall preference, while F0 was most preferred in color and appearance and F2 in firmness. Significant differences were observed across all sensory attributes. Nutritional analysis indicated that increasing pigeon pea flour enhanced protein, fiber, and mineral content while reducing moisture, fat, carbohydrate content, and metabolizable energy, with F4 exhibiting the most nutritionally advantageous profile and improved shelf stability. Shelf-life assessment showed that all formulations remained acceptable for seven days without signs of spoilage. Economic analysis revealed that all formulations were profitable despite higher production costs in fortified variants. The study concludes that pigeon pea flour, papaya, and Corn-Based SAGIP Nutri Powder are viable ingredients for producing nutritious and acceptable cookies, with recommendations for further research on shelf life, micronutrient analysis, and market validation. The study supports SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-Being) by promoting nutrient-enriched food alternatives that address malnutrition. It contributes to socio-economic and community sustainability by enhancing food security, supporting local agricultural resources, and encouraging the development of functional food products.

Keywords: Acceptability, Corn-Based SAGIP Nutri Powder, Drop Cookies, Papaya, Pigeon Pea Flour, Proximate Analysis, Sensory Evaluation, Shelf Life, Sustainability

1. Introduction

Food consumption is essential for sustaining human health, productivity, and economic stability, while food sustainability encompasses nutrition, environmental impact, cultural preferences, and safety (Lindgren et al., 2018). This study focuses on developing nutritious drop cookies using pigeon pea *(Cajanus cajan*), papaya *(Carica papaya)*, and Corn-Based SAGIP Nutri Powder as a response to malnutrition, food insecurity, and underutilized agricultural resources. Legumes such as pigeon pea provide a high-protein alternative to animal sources, while papaya contributes medicinal and nutritional benefits. The integration of fortified corn-based powder enhances the nutritional composition of baked products. Given the global rise in food insecurity and malnutrition, innovative food products like fortified cookies offer a practical and sustainable intervention aligned with health, economic, and food security goals.

1.1 Background on Pigeon Pea, Papaya, and Corn-Based SAGIP Nutri Powder in Nutritious Cookie Development

Food plays a critical role in survival, health, and economic productivity, making sustainable food systems vital in addressing global food insecurity (Lindgren et al., 2018). Legumes, particularly pigeon pea *(Cajanus cajan),* are valuable protein sources containing approximately 23–26% protein and serve as affordable alternatives to animal protein (Fasoyiro et al., 2024). Despite its nutritional value, pigeon pea remains underutilized due to processing challenges and limited technological applications (Fasoyiro et al., 2010). Cookies are widely consumed across age groups and present an effective medium for nutritional fortification (Adegbanke et al., 2019). Incorporating pigeon pea flour into cookies increases protein content, though it may affect sensory properties such as taste, texture, and color (Ramashia et al., 2021; Borczak et al., 2022). The addition of fortified ingredients like Corn-Based SAGIP Nutri Powder enhances both nutritional value and acceptability, contributing vitamins and minerals essential for preventing malnutrition (Udachan et al., 2018). The bakery industry's steady growth further supports the viability of fortified cookie products (Soni et al., 2018).

1.2 Nutritional, Functional, and Sensory Insights on Pigeon Pea, Papaya, and Fortified Cookie Products

Existing literature highlights three major themes: nutritional enhancement through legumes, functional benefits of fruit-based ingredients, and the role of food fortification. Pigeon pea is recognized for its high protein, fiber, and micronutrient content, contributing to disease prevention and improved health outcomes (Hassan et al., 2016; Abdel et al., 2010; Ellong et al., 2015). It also supports agricultural sustainability and food security (Ye & Fan, 2021). Papaya is widely studied for its medicinal and nutritional properties, including antioxidant, antimicrobial, and anti-inflammatory effects (Ahmad et., al 2018; Babalola, 2019). Its natural sugars and enzymes enhance both flavor and nutritional value in food products. Fortification using Corn-based products is emphasized as an effective strategy for addressing nutrient deficiencies. Corn (*Zea mays)* provides essential carbohydrates, vitamins, and minerals and plays a major role in global food systems (Ai & Jane, 2016; World Health Organizations, 2023). Corn-Based SAGIP Nutri Powder, developed through institutional initiatives, demonstrates potential in improving dietary intake and reducing malnutrition (Ahmed et al., 2022).

1.3 Local, National, and Global Context of Food Security, Malnutrition, and Crop Utilization

Globally, food insecurity remains a major concern, with 2.3 billion people experiencing severe food insecurity and 2.6 million unable to afford healthy diets (UNICEF, 2024). In the Philippines, malnutrition persists, contributing to significant health risks, including child mortality (Philippines Statistics Authority, 2022). Pigeon pea is cultivated in over 80 countries and is widely recognized for its role in food security (Varshney et al., 2012; Zhao et al., 2020). In the Philippines, it is locally known as "kadyos" and is promoted through agricultural programs to address nutritional deficiencies. Papaya production is also globally significant, with major producers including India, Brazil, and Mexico (FAOSTAT, 2021). Its widespread availability and nutritional benefits make it a viable component in food innovation. Meanwhile, corn remains a staple crop in the Philippines, supporting both food supply and agricultural livelihoods (Philippines Statistics Authority, 2022).

1.4 Conceptual Basis on Food Fortification, Functional Foods, and Sustainable Ingredient Utilization

This study is grounded in food fortification and functional food development theories, which emphasize enhancing nutritional quality through the integration of nutrient-dense ingredients. Fortification is recognized as a key strategy in combating micronutrient deficiencies and improving public health outcomes (Udachan et al., 2018; World Health Organizations, 2023). The concept of functional foods supports the inclusion of ingredients such as pigeon pea and papaya, which provide both nutritional and medicinal benefits (Ahmad et., al 2018; Babalola, 2019). Additionally, sustainable food systems theory highlights the importance of utilizing underutilized crops and local resources to improve food security and economic resilience (Ye & Fan, 2021).

1.5 Research Gaps in the Development and Evaluation of Fortified Pigeon Pea–Papaya Cookies

Despite the recognized nutritional benefits of pigeon pea, papaya, and fortified corn products, their combined application in bakery products remains limited. Pigeon pea is underutilized due to processing challenges (Fasoyiro et al., 2024), while papaya by-products are often wasted despite their nutritional potential. There is also limited research on the sensory acceptability, shelf life, and economic viability of fortified cookies using these combined ingredients. Furthermore, gaps exist in promoting affordable, nutrient-rich food products that address both malnutrition and consumer preferences. This study aims to bridge these gaps by developing and evaluating fortified drop cookies as a sustainable and marketable food solution.

1.6 Alignment of Fortified Pigeon Pea–Papaya Cookie Development with Sustainable Development Goals (SDGs)

This study aligns with several Sustainable Development Goals. SDG 2 (Zero Hunger) is addressed through the development of nutrient-rich cookies that contribute to food security and reduce malnutrition. SDG 3 (Good Health and Well-Being) is supported by enhancing dietary intake through fortified food products that provide essential nutrients and prevent diseases. SDG 8 (Decent Work and Economic Growth) is promoted by creating opportunities for local farmers and small businesses through value-added food production. SDG 17 (Partnerships for the Goals) is reflected in collaborations such as BIDANI and institutional research initiatives that support community nutrition programs.

1.7 Multidisciplinary Sustainability Contributions of Pigeon Pea, Papaya, and Corn-Based SAGIP Nutri Cookie Innovation

This study contributes to socio-economic, health, agricultural, and community sustainability. It promotes socio-economic sustainability by providing income opportunities for farmers and food entrepreneurs. It supports public health sustainability by addressing malnutrition through fortified food products. Agricultural sustainability is enhanced through the utilization of underused crops like pigeon pea and papaya. Additionally, the study contributes to innovation and community sustainability by developing accessible, nutritious food products that meet consumer preferences while addressing food insecurity. Through interdisciplinary integration of nutrition, agriculture, and food technology, the research supports long-term sustainable development and improved quality of life.

2. Material and methods

2.1 Research Design

The study employed an experimental design involving five formulations of drop cookies with varying proportions of pigeon pea flour and all-purpose flour, while maintaining constant amounts of other ingredients such as papaya and Corn-Based SAGIP Nutri Powder. These formulations were randomly assigned and evaluated to determine differences in sensory attributes, nutritional composition, shelf life, and economic feasibility.

2.2 Locale of the Study

The study was conducted at the College of Education, Isabela State University, Echague, Isabela, where the preparation, sensory evaluation, and related procedures were carried out. Proximate analysis was performed at the Quirino State University-Diffun Campus College of Health Science Food Laboratory.

2.3 Respondents of the Study

The respondents consisted of 75 student panelists from Isabela State University – Echague, College of Education. Both male and female participants aged 18 years and above were randomly selected. All panelists were provided with consent forms to ensure confidentiality and ethical handling of their personal information during the sensory evaluation process.

2.4 Sample and Sampling Procedure

Five formulations of pigeon pea flour drop cookies were prepared and coded as F0, F1, F2, F3, and F4, with corresponding numerical codes randomly assigned to experimental units. Samples were presented to panelists in coded form to eliminate bias. Each panelist evaluated all formulations, ensuring consistent comparison across samples.

2.5 Research Instrument

The primary instrument used for data collection was a score sheet based on the 9-Point Hedonic Scale, which measured the level of acceptability in terms of color/appearance, odor/aroma, taste/flavor, firmness, and general acceptability. The scale ranged from "Dislike Extremely" to "Like Extremely," allowing panelists to quantitatively assess their preferences.

2.6 Data Gathering Procedure

Ingredients were prepared by sourcing pigeon pea, papaya, and Corn-Based SAGIP Nutri Powder. Pigeon pea seeds were cleaned, sorted, and processed into flour, while ripe papaya was washed, peeled, shredded, and blended, ensuring removal of seeds and spoiled portions. Corn-Based SAGIP Nutri Powder was obtained from Isabela State University. All tools and equipment were prepared, sanitized, and arranged prior to processing. Ingredients were measured accurately, and dry components were sifted to remove impurities. Butter, sugar, and vanilla were mixed, followed by the incorporation of pigeon pea flour, all-purpose flour, Corn-Based SAGIP Nutri Powder, cornstarch, and baking powder. Papaya and chocolate chips were then added, and the mixture was gently combined. The dough was portioned into 25-gram circular shapes and baked in a preheated oven for approximately 30–50 minutes. After baking, the cookies were cooled for 20 minutes and packaged properly. Shelf-life analysis was conducted over seven days by observing changes in appearance, odor, taste, and firmness. Proximate analysis of selected formulations included moisture, protein, fat, crude fiber, ash, and carbohydrate content. For sensory evaluation, coded samples were presented to panelists, who rated each formulation after rinsing their mouths between samples to avoid bias. Cost and return analysis was also conducted by calculating production costs, unit cost, selling price, total sales, and income based on standard formulas.

2.7 Data Analysis Techniques

Data were analyzed using one-way analysis of variance (ANOVA) to determine significant differences among the five formulations in terms of sensory attributes. An F-test was applied to assess variability, and Tukey's Honestly Significant Difference (HSD) test was used to identify specific differences between formulations. Economic analysis was computed using formulas for unit cost, selling price, total sales, and income to evaluate the product's financial viability.

3. Results and Discussion

3.1 Sensory Acceptability of Pigeon Pea–Papaya Fortified Cookies

3.1.1 Color and Appearance

The results showed that all formulations were generally well accepted in terms of color and appearance, with a grand mean indicating "like very much." The control formulation obtained the highest mean, followed closely by F1, F2, and F3, while F4 received the lowest rating, described as "like moderately." Statistical analysis revealed a significant difference among formulations, indicating that variations in ingredient proportions affected visual appeal. These findings suggest that increasing levels of pigeon pea flour influenced the color characteristics of the cookies, potentially making them less visually appealing at higher substitution levels. Color plays a crucial role in consumer preference and serves as an indicator of product quality and baking completion, as emphasized by Ureta et al. (2014). Thus, maintaining an appealing color is essential in enhancing consumer acceptance of baked products.

3.1.2 Odor and Aroma

The results indicated that F1 achieved the highest acceptability in terms of odor and aroma, followed by F2 and F3, all described as "like very much." The control and F4 received lower ratings, described as "like moderately." Statistical analysis showed a significant difference among formulations, confirming that ingredient variations affected aroma perception. This implies that the incorporation of pigeon pea, papaya, and Corn-Based SAGIP Nutri Powder enhanced the aromatic qualities of the cookies, particularly at moderate substitution levels. Odor is a key factor influencing taste perception and overall food enjoyment, as supported by Lundstrom et al. (2012). The findings also align with Martino et al. (2017), who noted that balanced flavor and aroma fortification can increase consumer interest and acceptance.

3.1.3 Taste and Flavor

The findings revealed that F1 obtained the highest mean for taste and flavor, followed by F2, while F0, F3, and F4 had slightly lower ratings, with F4 receiving the lowest and described as "like moderately." Statistical results indicated a significant difference among formulations, demonstrating that ingredient composition influenced taste acceptability. These results indicate that moderate incorporation of pigeon pea flour and papaya produced a more desirable flavor profile, while higher substitution levels may have affected taste negatively. Taste is a critical determinant of food acceptance, and balanced flavor enhancement plays a significant role in consumer preference, as emphasized by Martino et al. (2017).

3.1.4 Firmness

The results showed that F2 achieved the highest acceptability in terms of firmness, followed by F3 and F1, while the control had a lower rating and F4 was the least preferred. All formulations except F4 were described as "like very much," with significant differences observed among treatments. This suggests that the inclusion of pigeon pea flour improved the structural properties of the cookies, contributing to desirable firmness at optimal levels. However, excessive substitution may reduce acceptability. Firmness in baked products is influenced by flour type and fiber content, as noted by Duta and Culetu (2015), supporting the observed effects of pigeon pea flour on texture.

3.1.5 General Acceptability

The results indicated that F1 had the highest overall acceptability, followed by F2 and F3, while F4 had the lowest rating. All formulations were generally rated as "like very much," except F4, which was "like moderately." Statistical analysis confirmed significant differences among formulations. These findings demonstrate that moderate incorporation of pigeon pea flour, papaya, and Corn-Based SAGIP Nutri Powder produced the most acceptable product. General acceptability reflects combined sensory attributes and is crucial in determining consumer preference, as highlighted by Kumar et al. (2019). The results confirm that the selected ingredients effectively enhanced product quality when properly balanced.

3.2 Nutritional Characteristics of the Developed Cookies

The results showed that increasing pigeon pea flour led to decreased moisture, lipid, carbohydrate, and energy content, while protein, fiber, and ash content increased. The highest substitution level exhibited the lowest moisture and carbohydrate content but the highest protein, fiber, and mineral content. These findings indicate that pigeon pea flour significantly improved the nutritional profile of the cookies by enhancing protein and fiber while reducing fat and carbohydrate content. Lower moisture content also suggests improved shelf stability, while increased ash content reflects higher mineral composition. The improved nutrient balance demonstrates the potential of pigeon pea flour as a functional ingredient for developing healthier baked products.

3.3 Nutritional Contribution of the Best Formulation (F4)

The results showed that the best-performing formulation provided moderate energy, high protein, and significant fiber content per serving, contributing to recommended nutrient intake levels. It also contained balanced fat and carbohydrate levels suitable for snack consumption. These findings suggest that the formulation can serve as a functional food product that supports dietary needs, particularly for populations requiring improved protein and fiber intake. Its nutrient density makes it suitable for supplementary feeding programs and community nutrition initiatives, highlighting its role in addressing malnutrition and promoting health.

3.4 Shelf Life of Developed Cookies

The results indicated that all formulations remained acceptable over a seven-day observation period, maintaining acceptable appearance, aroma, taste, and firmness. Slight changes such as reduced aroma and softer texture were observed over time, but no signs of spoilage, mold, or contamination were detected. This suggests that the developed cookies possess good storage stability and remain safe for consumption within the observed period. Shelf life is a critical factor influencing consumer acceptance and product quality, as noted by Fauzia, Farooq, & Farooq (2012). The findings also support the importance of proper storage and formulation in extending product shelf life (Hernández-García, Vargas, & Torres-Giner, S., 2022).

3.5 Economic Feasibility and Return on Expenses

The results showed that the control formulation had the lowest production cost and highest return on expenses, while formulations with higher pigeon pea flour content had higher production costs and lower returns. However, all formulations generated positive income, indicating profitability. These findings suggest that although fortified cookies require higher production costs, they still present viable business opportunities. The use of pigeon pea, papaya, and Corn-Based SAGIP Nutri Powder enhances product value and market potential. Effective cost management is essential for profitability, as emphasized by Wulandari & Suardana (2020). The results highlight the economic potential of developing nutritious, value-added food products that can contribute to income generation and food security.

4. Conclusion & Recommendations

The study concludes that drop cookies developed using pigeon pea (*Cajanus cajan*), papaya *(Carica papaya*), and fortified Corn-Based SAGIP Nutri Powder are nutritionally beneficial and generally acceptable as an alternative dessert. The control formulation (F0) was most preferred in terms of color and appearance, while formulation F1 showed the highest acceptability in odor, aroma, taste, and overall acceptability, indicating that moderate substitution of pigeon pea flour enhances sensory qualities. In terms of firmness, F2 performed best among the formulations. Nutritional analysis revealed that increasing pigeon pea flour significantly improved protein, fiber, and mineral content while reducing moisture, fat, carbohydrate content, and metabolizable energy, with formulation F4 demonstrating the most nutritionally advantageous profile and improved storage stability. Overall, the findings confirm the effectiveness of pigeon pea flour as a high-quality alternative flour and highlight the combined value of papaya and Corn-Based SAGIP Nutri Powder in enhancing both the nutritional composition and acceptability of baked products.

The study recommends further research to validate and expand the findings, including extended shelf-life evaluation under varying storage conditions, detailed micronutrient analysis, and assessment of glycemic response and digestibility. Additional studies may explore the use of other locally available nutrient-rich ingredients to further improve functional value. For industry application, thorough market acceptability assessment is necessary to support commercialization and distribution, while promoting sustainability efforts aligned with food security and health goals. Consumers and food processors are encouraged to adopt pigeon pea flour and papaya as alternative ingredients in bakery products, and educational institutions may integrate these ingredients into feeding programs and food preparation to enhance nutritional intake and support the development of healthier food products.

The study is limited to sensory evaluation using selected panelists and proximate analysis focusing on moisture, protein, fat, fiber, ash, and carbohydrate content. The shelf-life assessment was conducted only for seven days under observed conditions, which may not fully represent long-term storage stability. Additionally, the study did not include detailed micronutrient analysis or broader population testing, which may limit the generalizability of the findings.

Compliance with ethical standards

The study adhered to ethical standards in the conduct of research involving human participants. Respondents were selected students aged 18 and above from Isabela State University, and ethical considerations were observed throughout the study to ensure the confidentiality and proper handling of all personal information.

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