

**Nutritious muffins utilizing Saba banana (*Musa acuminata* × *balbisiana*)
pseudostem flour**

Angelica M. Bica^d*

Isabela State University, Clarin, Echague, Isabela, Philippines

ABSTRACT

This study aimed to develop nutritionally enhanced muffins by partially or fully substituting all-purpose flour with saba banana pseudostem flour and to evaluate its effects on proximate composition, metabolized energy, and contribution to Recommended Energy and Nutrient Intakes (RENI). The use of banana pseudostem flour produced composite muffins with reduced gluten content and increased dietary fiber, supporting the demand for healthier bakery products. Sensory evaluation was conducted using a 9-point hedonic scale with 50 panelists, assessing color, aroma, taste, firmness, and overall acceptability. The study followed a Randomized Complete Block Design (RCBD), and data were analyzed using Analysis of Variance (ANOVA) with LSD and Tukey's HSD tests for post hoc comparisons. Results showed that muffins with lower levels of pseudostem flour (F1 and F2) achieved higher sensory acceptability, exhibiting better flavor and texture. Higher substitution levels (F3 and F4) resulted in lower acceptability due to denser texture and stronger flavor. Proximate analysis revealed that increasing pseudostem flour reduced calorie and carbohydrate content while significantly increasing fiber and ash content. Fiber contribution reached up to 18% of RENI per serving, indicating potential benefits for digestive health and satiety. Shelf-life evaluation showed that muffins were no longer suitable for consumption after four days due to microbial growth and quality deterioration. Cost and return analysis demonstrated that all formulations were economically viable, with revenues exceeding production costs. Overall, saba banana pseudostem flour is a promising functional ingredient for bakery products, enhancing nutritional value while supporting sustainable utilization of banana by-products.

Keywords: Banana pseudostem flour, composite muffins, sensory evaluation, dietary fiber, proximate composition.

Date Submitted: July 10, 2026

Date Accepted: June 29, 2026

Date Published: August 8, 2026

INTRODUCTION

Banana (*Musa* spp.) is a tropical fruit and is considered one of the most popular fruits in the world. In the Philippines, it is widely cultivated and among the most exported commodity worldwide. From the year 2023-2024, the Philippine Banana exports reached \$1.22 billion mostly to Japan, China, and South Korea (TradeImEX, 2025). Banana is a staple food in many

*Corresponding author / Email: angelicabicad11@gmail.com

DOI: <http://doi.org/10.69651/PIJHSS05031396>

Recommended citation:

Bica^d, A. M. (2026). Nutritious muffins utilizing Saba banana (*Musa acuminata* × *balbisiana*) pseudostem flour. Pantao (International Journal of the Humanities and Social Sciences) 5 (3), 2295-2307.
<http://doi.org/10.69651/PIJHSS05031396>

countries and due to its high nutritive value has a positive effect on the health and well-being of many people. It is packed notably with minerals, such as calcium, magnesium, iron, copper, zinc, manganese phosphorus, sodium, and potassium (Atli Arnarson, 2019). The banana plant is very versatile with almost every part of the plant having uses in food, health, and various industries. Apart from the fruits, the inflorescence, pseudo-stem, rhizome and leaves are also consumed locally and traditionally in several regions (Subagyo & Chafidz, 2020).

One of the major types of banana grown widely in the Philippines is Saba (*Musa acuminata* × *balbisiana*). It is mostly eaten boiled/steamed but may also be eaten raw when ripe. They are commonly used in the preparation of popular Filipino snack foods like banana cue, “turon,” “maruya,” among others. The leaves are used in food wrappings while its male bud or “puso ng saging” is the preferred variety for vegetable dishes like “kare-kare.” Although being the world’s second largest fruit crop, edible bananas are cultivated mainly for their fruits. Thus, banana farms and processing industries tend to generate several tons of under-used by-products and wastes such as pseudo-stems, stalks, leaves, and peels. Collectively, a single banana plant produces waste materials of up to 80% of the total plant mass. Thus, the pseudostem is the largest source of biomass waste from the banana plant, not just 40% of the fresh banana's weight (Pillai et al., 2024).

The banana pseudo-stem is particularly rich in cellulose, hemicellulose, protein, fat and dietary fibres along with other nutritive elements (Rochana, et al., 2016). It has many potential for incorporating as a source of nutrients in the food products. Therefore, consumption of banana pseudostem can be beneficial, and hence, materializing its usage in food products appears noteworthy. Banana pseudostem is known to be beneficial to health, but so far is rarely used by the food industry (Jun et al., 2016). Most research focused on the fruit, leaving a gap in understanding the stem's viability as a food source (Boteju et al., 2026). It has been demonstrated that edible starch made from banana pseudostem pith and green banana culling has a higher resilience to heating and amylase action than commercial maize starch (Z. Li et al. Citation2018). Several food products are prepared from the banana pseudostem like bread, cookies, ready to drink juice, cutlets, fortified juice powder and isotonic drinks (Pillai et al., 2024).

Flour is an essential food item. It is the primary component of bread and other bakery goods that are staples for human consumption. This nutrient-dense, gluten-free substitute for regular wheat flour is a popular choice among consumers with dietary limitations and those who are health-conscious (Soberano et al., 2022). For centuries, cereals have been major food stuffs used all around the world; because of that, there are many different kinds of breads produced from different types of flours. Despite the variety of flours available, there are still many challenges to produce ingredients which maximize nutrient components, and with which healthier breads and other products can be produced. As studies have shown, traditional wheat flour has some nutritional deficiencies (although this is a matter of perspective), which depend on the level of consumption (Pourafshar et al., 2010). Rice flour is the most commonly used wheat flour substitute in cookies, Amaranth, quinoa, sorghum, and banana flours are also viable alternatives, with amaranth noted for its high protein and fiber, good sensory acceptance, and cost-effectiveness when mixed with starch. Banana flour increases fiber content and sensory acceptance in gluten-free cookies. Studies suggest utilizing co-products can reduce waste, and consumer acceptance among healthy individuals is confirmed (Almeida et al., 2025). Despite various gluten-free options, investment in industry and large-scale processing remains essential for production facilitation. The nutritional value of breads can be enhanced through the use of a variety of alternative flours.

The resultant banana flour is a healthier substitute for regular flours and may be used in several recipes, such as bread, muffins, and pancakes. Studies report that composite flours also

enable development of gluten reduced or gluten free products and support use of underutilized resources like banana pseudostem flour to enhance dietary fiber (Kumar et al., 2023).

This study addresses multiple global challenges by supporting several United Nations Sustainable Development Goals. The Saba banana pseudostem flour muffins initiative contributes to ending poverty (SDG 1), combats hunger and promotes food security, improved nutrition, and sustainable agriculture (SDG 2), and helps ensure healthy lives and well-being for people of all ages (SDG 3). It also promotes sustained, inclusive economic growth and productive, decent employment (SDG 8), while encouraging sustainable consumption and production practices (SDG 12).

This study aimed to develop and test the acceptability level of Nutritious Muffins utilizing Saba Banana (*Musa acuminata* x *balbisiana*) Pseudostem Flour. The primary objective of this study includes assessing the sensory attributes of the muffins, such as color, aroma, taste and texture compared to traditional flour-based muffins. Additionally, the study seeks to evaluate consumer preferences and acceptance through sensory evaluation and provide insight into the potential for Saba Banana Pseudostem flour as a viable ingredient in baked goods. The research also aims to promote healthier dietary choices and encourage the use of alternative flours in everyday baking practices. Furthermore, the effective utilization of Saba banana pseudostem can reduce waste disposal problem. This approach not only addresses food waste reduction but also offers an innovative solution to improve dietary quality and sustainability. Ultimately, integrating Saba Banana Pseudostem flour into muffin production could serve as a sustainable food security strategy with socio-economic and environmental advantages.

Statement of the problem

This study generally aimed to produce and determine the acceptability of Nutritious Muffins utilizing Saba Banana (*Musa acuminata* x *balbisiana*) Pseudostem Flour and its potential benefits. Specifically, it sought to determine the acceptability of the developed muffins based on selected sensory attributes, their nutritive value, storage duration while maintaining acceptable sensory quality and perceived safety, and their potential return on expenses when sold in the market. The study aimed to answer the following questions:

1. What is the level of acceptability among the four formulations in terms of color or appearance, odor or aroma, taste or flavor, firmness, and general acceptability?
2. What is the nutritive value of Nutritious Muffins utilizing Saba Banana Pseudostem Flour?
3. How long can Nutritious Muffins made from Saba Banana Pseudostem Flour be stored while maintaining acceptable sensory quality and perceived safety?
4. What is the Return on Expenses (ROE) if the product is sold in the market?

METHODOLOGY

The preparation of the Saba Banana (*Musa acuminata* x *balbisiana*) Pseudostem Flour began with the banana trunk obtained after harvesting the fruit, which was stripped of leaves and corm, leaving only the main stem. The outer sheaths of the pseudostem section were peeled away to reveal the inner central core, which had a diameter of less than 6 cm. The inner central core of the Saba Banana Pseudostem was collected and washed, then sliced into thin pieces and soaked in brine solution for fifteen minutes to prevent browning. After soaking, the pseudostem slices were dropped in boiling water and boiled for twenty minutes to remove the cyanogenic glycosides present in the pseudostem. The pseudostem pieces were then pressed in cheesecloth

to remove excess water. The banana pseudostem slices were placed on baking trays and dried in a hot air oven at 150° Celsius for about thirty to forty minutes, or until light brown. The dried pieces were cooled and pulverized using a grinder to a fine powder, after which the coarse particles were removed by sieving. The quality of the flour was checked, and it was then packed in airtight, moisture proof containers, labeled, and stored in a cool, dry place. Hygiene and food safety rules were followed throughout the process.

The nutritious muffins were prepared following a standard recipe, using varying proportions of All-purpose flour and Saba Banana Pseudostem Flour across five formulations, while the quantities of the other ingredients remained constant across all formulations. Formulation 0, which served as the control, consisted of 0g Banana Pseudostem Flour (BPSF) and 240g All-purpose flour (APF). Formulation 1 consisted of 60g BPSF and 180g APF. Formulation 2 consisted of 120g BPSF and 120g APF. Formulation 3 consisted of 180g BPSF and 60g APF. Formulation 4 consisted of 240g BPSF and 0g APF. Across all five formulations, the granulated sugar used was 80g, the baking powder was 14g, the salt was 6g, the unsalted butter was 50g, the milk was 80g, and the egg was 50g.

All needed ingredients, tools, and equipment were prepared through a mise en place procedure, and the oven was preheated to 375° F or 190°C. Muffin molders were greased and lined with paper cups. In a mixing bowl, the sifted Saba Banana Pseudostem Flour was mixed with the granulated sugar, baking powder, and salt to combine the dry ingredients. In another mixing bowl, the wet ingredients, namely the milk, melted butter, and eggs, were combined together by whisking. The wet ingredients were then poured into the dry ingredients and stirred until well blended but not overmixed. The batter was divided evenly into the muffin cups, filling each about two thirds full, and baked for 18 to 20 minutes until golden brown or until a toothpick inserted came out clean. The muffins were allowed to cool in the pan for a few minutes before being transferred to a wire rack to cool completely. They were then packed and stored in an airtight container at room temperature until needed for sensory evaluation.

The varying proportions of Banana Pseudostem (*Musa* spp) flour and All-purpose flour described above served as the treatments of the study, consisting of Formulation 0 (control) at 0g Saba Banana Pseudostem Flour to 240g All-purpose flour, Formulation 1 at 60g Saba Banana Pseudostem Flour to 180g All-purpose flour, Formulation 2 at 120g Saba Banana Pseudostem Flour to 120g All-purpose flour, Formulation 3 at 180g Saba Banana Pseudostem Flour to 60g All-purpose flour, and Formulation 4 at 240g Saba Banana Pseudostem Flour to 0g All-purpose flour.

The Banana Pseudostem muffin samples were subjected to proximate analysis conducted at the College of Health Sciences Laboratory, Quirino State University, Andres Bonifacio, Diffun, Quirino. The nutrients analyzed were %moisture, %crude protein, %fat, %crude fiber, %ash, and %carbohydrate. The samples were analyzed using standard laboratory procedures, including the Moisture Analyzer, the Raghuramalu method, Folch extraction, the Biuret method, and the Randive metabolizable energy computation.

Sensory evaluation was conducted at the Isabela State University-Echague Campus to identify the potential areas of improvement and market appeal of the muffins and to determine the acceptability of the experimental products in terms of appearance/color, aroma/odor, taste/flavor, firmness/texture, and general acceptability of the Nutritious Muffins using Saba Banana Pseudostem Flour. The instrument used for data gathering was a scoresheet employing the Nine Point Hedonic Scale, one of the most widely used scales for measuring food acceptability, which has been quickly adopted by the food industry and is now used for measuring the acceptability of foods and beverages. A sensory panel composed of fifty (50) individuals was randomly selected from among students, professionals, faculty, and staff of the Isabela State University-Echague Campus. The panelists chosen were those in healthy condition, non-smokers, non-alcoholic, and with ages ranging from 18 to 50 years old. The

treatment samples were prepared and coded using 3 digit random numbers, with five (5) treatments of the study assigned randomly to the experimental units. Each panelist was given a set of coded samples placed on a plate and was requested to evaluate keenly and rate each treatment sample according to their acceptability of color/appearance, taste/flavor, odor/aroma, texture, and general acceptability of the prepared muffins. The respondents were required to rinse their mouths before tasting each sample, a procedure that was strictly observed as a standard measure to ensure the credibility and validity of the results of the study.

The Nine Point Hedonic Scale used in the sensory evaluation was interpreted as follows: a scale of 9, with a range of 8.50 to 9.00, was described as Like extremely; a scale of 8, with a range of 7.50 to 8.49, was described as Like very much; a scale of 7, with a range of 6.50 to 7.49, was described as Like moderately; a scale of 6, with a range of 5.50 to 6.49, was described as Like slightly; a scale of 5, with a range of 4.50 to 5.49, was described as Neither like nor dislike; a scale of 4, with a range of 3.50 to 4.49, was described as Dislike slightly; a scale of 3, with a range of 2.50 to 3.49, was described as Dislike moderately; a scale of 2, with a range of 1.50 to 2.49, was described as Dislike very much; and a scale of 1, with a range of 1.00 to 1.49, was described as Dislike extremely. To ensure the outcome of the sensory evaluation and to retain the trust and cooperation of the participants, ethical procedures were put in place, including safety and hygiene, informed consent, confidentiality, respect for diversity, and professional conduct.

In the data analysis of the study, descriptive statistics, including mean and standard deviation, were employed to provide a clear summary of the central deviation in sensory attribute scores for each sample. In addition, inferential statistics and One way Analysis of Variance (ANOVA) were applied. Least Significant Difference (LSD) was used as a post hoc test for the sensory evaluation, and Honestly Significant Difference (HSD) was used for the nutrient analysis.

The formulated products of the Nutritious Muffins utilizing Saba Banana (*Musa acuminata* x *balbisiana*) Pseudostem Flour were subjected to shelf life analysis using traditional methods of shelf life estimation by sensory evaluation to determine how long the product could be stored while maintaining acceptable quality and safety. Fourteen small samples (10 grams each) from each treatment were packed and sealed in small plastic bags. Seven samples from each treatment were stored at room temperature, and five samples were stored in the refrigerator. One sample from each treatment was opened and evaluated for appearance, aroma, taste, and texture, and this was done every day for one week. The day by which the appearance of molds and other unusual characteristics of the sample occurred was carefully noted, and all observations over time were recorded and analyzed.

Cost analysis was performed to determine the economic feasibility of the product if it were to be sold in the market. This was done by listing down all the costs incurred in producing the different formulations of the Banana Pseudostem muffins and computing the unit cost and the return on expenses (ROEx) per treatment.

The researcher declares that no conflict of interest existed in the conduct of this study. The study was self-funded and was not influenced by any financial or personal considerations, and the research was undertaken solely for academic purposes. The researcher hereby declares that the utilization of artificial intelligence (AI) tools, including QuillBot, Grammarly, Paraphraser, ChatGPT, and AI detection software, was undertaken in a limited and responsible manner throughout the conduct of this study. All outputs generated through these tools were subjected to review, evaluation, and necessary revisions by the researcher to ensure their accuracy, coherence, and full compliance with established academic standards and ethical guidelines.

RESULTS AND DISCUSSION

This study evaluated the sensory quality, nutritional composition, shelf life, and economic feasibility of nutritious muffins formulated with varying proportions of saba banana pseudostem flour (BPSF) and All-purpose flour (APF). Five formulations were developed and subjected to sensory evaluation by a panel of raters using a structured evaluation instrument assessing color, odor/aroma, taste, firmness, and general acceptability on a hedonic scale, with descriptive ratings ranging from like slightly to like very much. The formulations consisted of F0 with 0g BPSF and 240g APF, F1 with 60g BPSF and 180g APF, F2 with 120g BPSF and 120g APF, F3 with 180g BPSF and 60g APF, and F4 with 240g BPSF and 0g APF. Data were analyzed using Analysis of Variance (ANOVA) to determine significant differences among treatments, and the results are interpreted in direct relation to the objectives of developing and assessing a nutritionally enhanced muffin product using an underutilized agricultural byproduct.

In terms of color, the Analysis of Variance revealed a highly significant difference among treatments, confirming that formulation significantly influenced this attribute. Treatment F0 obtained the highest mean score of 7.82, verbally interpreted as like very much, which was not statistically different from F1 with a mean score of 7.42. Treatment F4 obtained the lowest mean score of 6.06, interpreted as like slightly, while the overall mean score across all treatments was 6.86, interpreted as like moderately, indicating that respondents generally accepted the color of the banana pseudostem muffins at a moderate level. Color analysis presents an important criterion for the overall acceptability of baked products for consumption (Chakraborty, et al., 2021). The high variability in color scores may be attributed to differences in ingredient composition and pigmentation, which are influenced by the content of reducing sugar, proteins, and amino acids present on the surface as well as baking temperature and time. Enzymatic browning of the banana pseudostem flour, resulting from the oxidation of phenolics by polyphenol oxidase, may have also contributed to the browning observed in the baked products (Mahloko, et al., 2019), which likely explains why muffins with higher amounts of BPSF received lower acceptability scores in terms of color.

With respect to odor and aroma, ANOVA confirmed highly significant differences among treatments, with a coefficient of variation of 18.14%, indicating acceptable panel consistency. Treatment F1 registered the highest aroma score, closely followed by F0, both interpreted as like very much, suggesting that lower treatment levels better retained the desirable aroma associated with muffins. An increase in mean values was noted as the amount of BPSF increased, a pattern that appeared contrasting since even the control treatment without BPSF was perceived by raters as having a similar odor to the treatments containing BPSF. This suggests that the incorporation of BPSF alongside other ingredients such as butter, eggs, milk, and sugar produced a masking effect that made it difficult for panelists to distinguish the specific pseudostem odor across the varied treatments (Go, et al., 2021).

For taste, descriptive statistics indicate that F0 and F1 were the most preferred, with mean scores of 7.38 and 7.42 respectively, both interpreted as like moderately, while F3 and F4 received the lowest taste scores of 6.16 and 6.22 respectively, corresponding to like slightly. The overall mean of 6.76 suggests that panelists moderately liked the taste of the banana pseudostem muffins across all formulations, indicating that higher inclusion levels in F3 and F4 may have slightly altered the flavor balance, rendering them less preferred relative to the control and lower level treatments. The ANOVA results indicate a highly significant difference in taste among treatments ($F = 8.26$, $p = 0.0000$, $p < 0.01$), confirming that variation in formulation levels significantly influenced taste perception. The relatively high coefficient of variation of 22.17% reflects some variability in panelist responses, which is expected for

sensory attributes such as taste given individual differences in perception; nevertheless, the significant F value demonstrates that the observed differences are primarily attributable to treatment effects rather than random variation. Higher levels of BPSF can lead to a more pronounced banana pseudostem like flavor or odor that may not align with the intended flavor profile of the product (Chakraborty et al., 2021), suggesting that the original or lower level formulations, F0 and F1, are the most optimal for maintaining a favorable taste profile.

Regarding firmness, a similar trend was observed, with F0 receiving the highest score of 7.58, interpreted as like very much, followed by F1 with a mean score of 7.44, interpreted as like moderately. Treatments F3 and F4 obtained the lowest scores of 6.08 and 5.84 respectively, interpreted as like slightly, indicating that these formulations were perceived as softer or less firm. The texture of baked products is influenced by the gluten present in wheat flour, a group of structural proteins, primarily gliadin and glutenin, found in wheat, barley, rye, and triticale, which provides elasticity and structure to baked goods and acts as a binding agent that traps air within the tissue of the baked product. This principle is evident in the results, as F0, composed of pure APF, obtained the highest firmness score, while F1, in which wheat flour was partially substituted with BPSF, obtained the second highest score. Treatments with increasing amounts of BPSF resulted in progressively lower acceptability due to softer texture associated with reduced wheat flour content, with F4, composed entirely of BPSF, obtaining the lowest mean score because of its softest texture. Higher treatment levels of BPSF may have compromised firmness possibly due to higher moisture content or ingredient interaction affecting texture, and as the amount of pseudostem flour increased, the texture score decreased, which may be attributed to a tougher texture and cracks on the crust (Sangroula, 2018). The overall mean firmness score of 6.79 suggests that, on average, the banana pseudostem muffins exhibited moderate firmness, implying that lower formulation levels of BPSF maintained structural integrity more effectively due to the presence of gluten in All-purpose flour.

For general acceptability, F0 achieved the highest overall score of 7.90, interpreted as like very much, closely followed by F1 with a score of 7.52, with both treatments not significantly different from one another. Treatments F2, F3, and F4 scored lower, indicating moderate to slight acceptance, and the overall mean of 7.06 confirms that panelists generally liked the banana pseudostem muffins moderately, consistent with the earlier sensory results in which F0 and F1 consistently demonstrated higher ratings across individual attributes, suggesting that these formulations achieved the most balanced sensory profile. ANOVA confirmed a significant difference in general acceptability among treatments ($F = 11.56$, $p < 0.01$), with a moderate coefficient of variation of 18.38% reflecting reasonable consistency in panelist responses. This significant result indicates that formulation levels strongly influenced overall product acceptability, likely through their combined effect on color, aroma, taste, and firmness, and confirms that the combination of sensory attributes present in F0 and F1 created the most favorable product experience, with lower formulation levels optimizing the overall quality of the banana pseudostem muffins.

The proximate analysis of the nutritious muffins demonstrated clear nutritional shifts as the proportion of BPSF increased across formulations. Moisture content increased progressively from 28.3% in F0 to 29.43% in F1, 42.79% in F2, 40.48% in F3, and 50.89% in F4, with ANOVA results indicating a significant difference among treatments. This trend indicates that saba banana pseudostem flour possesses strong water holding capacity attributable to its fibrous cellular structure, as plant pseudostem tissues are known to contain hydrophilic polysaccharides capable of binding large amounts of water during baking. The high moisture retention observed in F4 suggests that complete substitution with pseudostem flour substantially increases product hydration, which may influence softness, shelf life, and

microbial susceptibility, and since moisture content is responsible for product spoilage, the inclusion of BPSF in the muffin formulation may extend shelf life relative to the control formulation (Ho, et al., 2017).

Total ash content, which was significantly different among treatments according to ANOVA, increased from 1.6% in F0 to 1.73% in F1, 2.47% in F2, 2.37% in F3, and 3.33% in F4, indicating greater mineral concentration as the proportion of pseudostem flour increased. This finding is consistent with reports that banana pseudostem flour possesses a very high ash content (Miando, et al., 2012). Since ash represents the total inorganic mineral residue remaining after combustion, the higher ash values suggest that banana pseudostem contributes additional minerals such as potassium, calcium, and magnesium; ash content also affects the color of the flour, with higher ash content resulting in a darker color of the baked product (Wheat Marketing Center, 2018), which further confirms the potential of banana pseudostem flour as a mineral enriching ingredient in bakery formulations.

Total lipid content remained relatively stable across treatments, ranging from 14.03% to 14.43%, with ANOVA indicating no significant difference among formulations. This minimal variation is expected because unsalted butter, which served as the principal fat source, was maintained at a constant quantity across all formulations, and since pseudostem flour contributes negligible lipid, flour substitution did not meaningfully affect fat concentration. The low lipid and high dietary fiber content of BPSF make it an ideal and healthy alternative for strengthening the nutrient profile of wheat based products (Chakraborty, et al., 2021).

Total protein values, which differed significantly among treatments according to ANOVA, ranged from 5.43% to 7.13%, with F2 recording the highest protein value of 7.13% and F4 showing the lowest at 5.43%, while F0 and F1 registered 6.2% and 7.10% respectively, and F3 registered 6.13%. The current international Recommended Dietary Allowance for protein is 0.8 grams per kilogram of body weight regardless of age, a recommendation based on the minimum level required to maintain nitrogen balance rather than one optimized for physical activity levels (Lonnie, et al., 2018), and based on this allowance, consumption of the formulated muffins may supply required nutrients to the body. The banana pseudostem muffins exhibited relatively low protein levels overall because the initial protein concentration of wheat flour is higher than that of banana pseudostem flour, which affects the overall protein content of the product (Aziz, et al., 2011). The reduction observed in F4 may be attributed to the complete removal of All-purpose flour, which contains gluten proteins that contribute substantially to total protein content, while the slight increase observed in F3 relative to F4 suggests that balanced substitution may help preserve protein content while incorporating functional plant material.

Total fiber content, which differed significantly among treatments, increased markedly from 0.9% in F0 to 4.00% in F1, 5.77% in F2, 7.07% in F3, and 8.80% in F4. This confirms that saba banana pseudostem serves as one of the best sources of fiber (Chandrasekaran, et al., 2012), and that BPSF is rich in non-starch polysaccharides or dietary fibers, including cellulose, hemicellulose, and lignin (Cordeiro, et al., 2024). Fiber is among the most nutritionally valuable components contributed by pseudostem flour because it supports digestive health, promotes satiety, and may help regulate blood glucose absorption, with F4 demonstrating the strongest functional food potential based on fiber enrichment.

Total carbohydrate content decreased steadily and significantly from 48.5% in F0 to 43.31% in F1, 27.47% in F2, 29.92% in F3, and 17.45% in F4. This reduction occurred because All-purpose flour, which is rich in digestible starch, was progressively replaced by pseudostem flour, which contains more non-digestible fiber than available carbohydrate. The Institute of Medicine established a carbohydrate distribution range of 40 to 65 percent of total calories as an acceptable macronutrient distribution range (Go, et al., 2021), and the observed carbohydrate concentrations suggest that high pseudostem muffins may be suitable for calorie

conscious consumers, indicating that the formulated muffins remain a good source of carbohydrates.

Metabolizable energy also showed a significant decreasing trend, from 349 kilocalories in F0 to 331 kilocalories in F1, 267 kilocalories in F2, 270 kilocalories in F3, and 218 kilocalories in F4. This pattern reflects the combined reduction in carbohydrate content and the slight reduction in protein content across treatments. Energy values were computed using Atwater conversion factors, in which protein and carbohydrate contribute 4 kilocalories per gram and lipid contributes 9 kilocalories per gram. The lower energy density observed in F4 indicates that higher pseudostem flour substitution can produce muffins with reduced caloric content, suggesting that banana pseudostem flour can also be used as an energy supplement in low calorie foods (Kiran, et al., 2021). Overall, the incorporation of banana pseudostem flour into food products serves as a functional ingredient that enhances nutritional value while utilizing agricultural waste (Zou et al., 2022), with the results demonstrating that increasing banana pseudostem flour significantly enhances moisture, mineral content, and dietary fiber while reducing carbohydrate concentration and metabolizable energy. Among the treatments, F4 exhibited the highest fiber and mineral content, whereas F2 provided a more balanced nutritional profile between protein retention and fiber enhancement.

The nutrient content per 50 gram muffin serving and its corresponding contribution to the Recommended Energy and Nutrient Intakes (RENI) for adults were also examined across four treatments labeled T1 through T4. Energy content per serving was 166 kilocalories in T1, 134 kilocalories in T2, 135 kilocalories in T3, and 109 kilocalories in T4, representing 8.3%, 6.7%, 6.75%, and 5.45% of the daily energy requirement of 2000 kilocalories respectively. This trend aligns with the reduced carbohydrate content, which decreased from 21.7 grams in T1 to 13.7 grams in T2, 15.0 grams in T3, and 8.7 grams in T4, reflecting the replacement of starch rich All-purpose flour with fiber rich banana pseudostem flour. Protein content ranged from 2.7 to 3.6 grams per serving, with T1 and T2 both recording 3.6 grams, T3 recording 3.1 grams, and T4 recording 2.7 grams, contributing 7%, 7%, 6%, and 5% of the daily protein requirement of 50 grams respectively. Total fat content remained fairly stable across treatments at 7.2 grams in T1, 7.2 grams in T2, 7.0 grams in T3, and 7.1 grams in T4, since the fat source, butter, was kept constant across all formulations. These results indicate that the muffins are moderate in calories, suitable as a light snack or functional food, and that their macronutrient profiles can be tailored through pseudostem flour substitution without compromising overall energy contribution.

Dietary fiber per serving increased with higher pseudostem flour content, from 2.0 grams in T1 to 2.9 grams in T2, 3.5 grams in T3, and 4.4 grams in T4, corresponding to 8%, 12%, 14%, and 18% of the recommended daily intake of 25 grams per day respectively. This significant increase highlights the functional benefit of banana pseudostem flour in improving fiber content, which can support digestive health, enhance satiety, and regulate postprandial blood glucose levels, with T4, representing full pseudostem flour substitution, providing the highest fiber contribution and making it particularly suitable for health conscious consumers. Ash content, representing total mineral content, increased with higher pseudostem flour levels from 0.87 grams in T1 to 1.23 grams in T2, 1.18 grams in T3, and 1.65 grams in T4. Correspondingly, estimated calcium content increased from 87 milligrams in T1 to 123 milligrams in T2, 118 milligrams in T3, and 165 milligrams in T4, contributing 8% to 16% of daily calcium needs, while estimated iron content increased from 1.3 milligrams in T1 to 1.9 milligrams in T2, 1.8 milligrams in T3, and 2.6 milligrams in T4, contributing 7% to 14% of daily iron needs. These values indicate that muffins formulated with banana pseudostem flour

serve as a valuable source of essential minerals, supporting bone health and hemoglobin synthesis.

The shelf life of the nutritious muffin formulated with saba banana pseudostem flour was assessed through detailed observation carried out by the researcher, with the muffins stored in a sealed container at room temperature and examined over a period of five days. On the first day of storage, the muffins displayed their best sensory qualities, including a soft and moist texture, pleasant aroma, and acceptable taste. On the second day, only slight changes were noted, with a minor loss of moisture while overall quality remained pleasing. By the third day, clear staling was apparent, indicated by a firmer texture and a decrease in aroma and freshness. On the fourth day, further deterioration in quality was observed, characterized by increased dryness and a decline in palatability. On the fifth day, clear signs of spoilage were evident, including the development of off-odors and the initial presence of mold growth, rendering the product unfit for consumption. Products stored at room temperature generally exhibit a shelf life of approximately three days due to moisture loss and decline in palatability (Food and Agriculture Organization, 2011), and based on the results of the observation, muffins produced using saba banana pseudostem flour were found to be unsuitable for consumption by the fifth day of storage, a finding attributable to spoilage factors such as microbial growth, changes in texture, and the development of off-odor. This finding is consistent with previous studies indicating that homemade muffins generally have a shelf life of 2 to 4 days at room temperature when stored in an airtight container, and up to one week under refrigeration (Braddock, 2024).

The cost analysis and computation of return on expenses (ROE) further demonstrated the economic feasibility of the formulated muffins. Total production cost increased progressively with higher proportions of saba pseudostem flour, from 104.80 pesos in F0 to 105.80 pesos in F1, 107.80 pesos in F2, 109.80 pesos in F3, and 110.80 pesos in F4, based on ingredient costs including saba pseudostem flour priced at 0, 5, 10, 15, and 20 pesos respectively across formulations, all-purpose flour priced at 14, 10, 7, 4, and 0 pesos respectively, and constant costs for granulated sugar at 6.8 pesos, baking powder at 7 pesos, salt at 2 pesos, unsalted butter at 15 pesos, milk at 5 pesos, egg at 10 pesos, paper cups at 15 pesos, fuel at 10 pesos, and labor at 20 pesos. With an output of 12 pieces per formulation, the unit cost increased from 8.73 pesos in F0 to 9.23 pesos in F1, 9.40 pesos in F2, 9.57 pesos in F3, and 9.65 pesos in F4, while the selling price was maintained at 12.00 pesos per piece across all formulations, yielding a total sale of 144 pesos for each formulation. The resulting income, computed as total sale minus total production cost, was 39.20 pesos for F0, 38.20 pesos for F1, 36.20 pesos for F2, 34.20 pesos for F3, and 33.20 pesos for F4, corresponding to a percentage return on expenses of 37.40% for F0, 36.11% for F1, 33.58% for F2, 31.15% for F3, and 29.96% for F4. The Return on Expenses per production of the nutritious muffin utilizing saba banana pseudostem flour therefore ranged from 29.96% to 37.40%, calculated as the ratio of net profit to total production cost, indicating that for every peso spent, a return equivalent to the computed percentage profit was obtained, and suggesting that the product provides a favorable profit margin across all formulations. It was observed that F0 generated the highest return on expenses, closely followed by F1, while F4, which made use of pure banana pseudostem flour, had the lowest ROE among the formulations, although the values did not differ substantially from one another. The cost and return analysis showed that total revenue exceeded total production cost for all formulations, indicating financial feasibility, and further suggests that the use of saba banana pseudostem flour in muffin production is both economically feasible and capable of increasing nutritional content without adversely affecting financial returns, making it especially useful for developing functional and high fiber foods since it improves nutritional profiles while offering a sustainable substitute for wheat flour (Go et al., 2021).

Taken together, these findings address the primary objectives of the study by demonstrating that saba banana pseudostem flour can be successfully incorporated into muffin formulations to enhance nutritional value, particularly in terms of moisture retention, mineral content, and dietary fiber, while maintaining acceptable sensory qualities and economic viability. The sensory evaluation results consistently favored the control and lower substitution formulations, F0 and F1, across color, odor and aroma, taste, firmness, and general acceptability, indicating that partial rather than complete substitution of all-purpose flour with BPSF achieves the most balanced sensory profile. The proximate analysis and RENI contribution results reveal that increasing BPSF substitution progressively enhances fiber and mineral content while reducing carbohydrate concentration and caloric density, positioning higher substitution formulations, particularly F4, as viable options for fiber enrichment and calorie reduction. The shelf life assessment confirms that the product remains suitable for consumption for approximately four days under room temperature storage before the onset of spoilage, while the cost and return on expenses analysis affirms that all formulations remain financially feasible, with returns ranging from 29.96% to 37.40%. Collectively, these results affirm that saba banana pseudostem flour, an agricultural byproduct that is often discarded, holds significant potential as a functional and sustainable ingredient for developing nutritionally improved, economically viable bakery products, thereby contributing to waste utilization, food security, and the diversification of fiber rich food alternatives. These findings provide the empirical foundation for the succeeding chapter, which presents the summary, conclusions, and recommendations derived from the study.

CONCLUSION

The findings of this study demonstrate that formulations F0 and F1 consistently obtained the highest mean scores across color, odor and aroma, taste, firmness, and general acceptability, indicating that these two formulations were the most preferred by the panelists among the five treatments evaluated. This outcome suggests that lower levels of banana pseudostem flour substitution allow the muffins to retain sensory qualities most closely aligned with conventional preferences, while higher substitution levels progressively diminish overall acceptability. These results underscore the importance of controlled ingredient incorporation in achieving a balance between innovation in ingredient use and the maintenance of desirable sensory attributes.

Beyond sensory considerations, the incorporation of saba banana pseudostem flour was found to significantly influence the nutritional composition of the muffins, particularly with respect to moisture, ash, protein, fiber, carbohydrate, and metabolizable energy content. As the level of substitution increased, the muffins exhibited higher moisture and ash content, reflecting the fibrous polysaccharide composition and mineral contribution of the pseudostem flour, while carbohydrate content and metabolizable energy declined, pointing to a reduction in overall energy density. Protein content varied across treatments, with partial substitution retaining comparatively higher protein levels than full substitution, which is attributed to the inherently low protein content of the pseudostem flour itself. Notably, muffins formulated with full pseudostem flour substitution demonstrated markedly higher dietary fiber content and lower caloric value, positioning them as a potentially suitable option for consumers seeking high fiber, low calorie food alternatives. Taken together, these nutritional shifts indicate that while increasing pseudostem flour content enhances certain functional and nutritional benefits, it simultaneously introduces tradeoffs in sensory quality and energy content that must be carefully weighed in product development.

In terms of product stability, muffins produced using saba banana pseudostem flour were found to have a shelf life of three days following processing, a finding that is consistent with the elevated moisture levels observed in the higher substitution treatments and that carries direct implications for storage, handling, and distribution. From an economic standpoint, the Return on Expenses analysis revealed that F1 emerged as the treatment yielding the most favorable profit margin among the formulations incorporating banana pseudostem flour, suggesting that this particular formulation offers the most viable balance between ingredient cost, acceptability, and profitability for potential commercial production.

Taken collectively, these findings affirm that the utilization of saba banana pseudostem flour in muffin production is a viable approach for developing a nutritious, fiber enriched food product, provided that formulation levels are carefully calibrated to preserve consumer acceptability while maximizing nutritional and economic benefits. In light of these conclusions, it is recommended that further studies explore the addition of natural preservatives or other functional ingredients to enhance nutritional value and extend shelf life without compromising sensory quality. Future research should also evaluate the shelf life and microbial stability of muffins with higher pseudostem flour content in view of their increased moisture levels, as well as conduct additional nutritional analyses, including vitamin content, antioxidant activity, and mineral profiling, to more fully characterize the health benefits associated with banana pseudostem flour. Finally, government agencies and community nutrition programs are encouraged to consider promoting products that utilize banana pseudostem as part of broader food security and sustainable nutrition initiatives, thereby extending the practical value of this research beyond the laboratory setting and into wider public health and agricultural applications.

REFERENCES

- Acosta, K., Cavender, G., & Kerr, W. L. (2011). Sensory and physical properties of muffins made with waxy whole wheat flour. *Journal of Food Quality*, 34(5), 343–351. <https://doi.org/10.1111/j.1745-4557.2011.00401.x>
- Badanayak, P., Jose, S., & Bose, G. (2023). Banana pseudostem fiber: A critical review on fiber extraction, characterization, and surface modification. *Journal of Natural Fibers*, 20(1), 2168821. <https://doi.org/10.1080/15440478.2023.2168821>
- Chakraborty, R., Sabruna, S., Roy, R., & Majumdar, S. (2021). Banana pseudostem substitution in wheat flour biscuits enriches the nutritional and antioxidative properties with considerable acceptability. *SN Applied Sciences*, 3, 75. <https://doi.org/10.1007/s42452-020-03988-1>
- Go, M. B., Golbin, R. A., Jr., Velos, S. P., Literatus, J. V., Sambrana, M. M., & Baird, J. C. (2021). The effects of incorporation of banana pseudostem flour at different proportions on the sensory properties, proximate, and mineral composition and microbial quality of baked brownies. *Food Science and Technology*, 9(4), 87–95. <https://doi.org/10.13189/fst.2021.090403>
- Harastani, R., James, L. J., Ghosh, S., & Woolley, E. (2021). Reformulation of muffins using inulin and green banana flour: Physical, sensory, nutritional and shelf-life properties. *Foods*, 10(8), 1883. <https://doi.org/10.3390/foods10081883>

Kandasamy, S., Ramu, S., & Aradhya, S. M. (2016). In vitro functional properties of crude extracts and isolated compounds from banana pseudostem and rhizome. *Journal of the Science of Food and Agriculture*, 96(4), 1347–1355. <https://doi.org/10.1002/jsfa.7229>

Lonnie, M., Hooker, E., Brunstrom, J. M., Corfe, B. M., Green, M. A., Watson, A. W., Williams, E. A., Stevenson, E. J., Penson, S., & Johnstone, A. M. (2018). Protein for life: Review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults. *Nutrients*, 10(3), 360. <https://doi.org/10.3390/nu10030360>

Padam, B. S., Tin, H. S., Chye, F. Y., & Abdullah, M. I. (2014). Banana by-products: An under-utilized renewable food biomass with great potential. *Journal of Food Science and Technology*, 51(12), 3527–3545. <https://doi.org/10.1007/s13197-012-0861-2>

Sangpueak, R., Saengchan, C., Laemchiab, K., Kiddeejing, D., Siriwong, S., Thumanu, K., Hoang, N. H., Phansak, P., & Buensanteai, K. (2022). Flour on gluten-free muffins from different edible cassava varieties in Thailand. *Foods*, 11(24), 4053. <https://doi.org/10.3390/foods11244053>

Subagyo, A., & Chafidz, A. (2018). Banana pseudo-stem fiber: Preparation, characteristics, and applications. In A. I. O. Jideani & T. A. Anyasi (Eds.), *Banana nutrition: Function and processing kinetics*. IntechOpen. <https://doi.org/10.5772/intechopen.82204>