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# Braided Bread Enriched with Cassava-Based Sagip Nutri Powder

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## Abstract

This study developed and evaluated braided bread enriched with Cassava-Based Sagip Nutri Powder fortified with Cacao Pod Husk Powder, malunggay, and turmeric powder in terms of sensory acceptability, nutritive value, shelf-life, production cost, and return on expenses. Guided by the Input–Process–Output model, the study used an experimental product-development design involving five formulations: one control and four treatments with 10%, 20%, 30%, and 40% substitution levels. The study was conducted at Isabela State University, Echague Campus, with 75 randomly selected faculty staff and students as sensory panelists. Data were gathered using a 9-Point Hedonic Scale, proximate analysis, shelf-life observation, and cost-return computation, while mean, descriptive statistics, ANOVA, F-test, and Tukey's HSD were used for analysis. Results showed that Formulation 1, with 10% or 25g Cassava-Based Sagip Nutri Powder, was the most acceptable in color, aroma, taste, texture, and general acceptability. Higher substitution levels improved nutritional components, particularly ash and fiber, but reduced some sensory qualities. All formulations remained acceptable during the seven-day room-temperature shelf-life observation. Cost and return on investment analysis showed that only 3 formulations were financially feasible, with F0 to F3 obtaining positive ROI of 67%,46%,24% and 12% respectively and F4 obtaining -.38% ROI. The study supports SDG 2, SDG 3, SDG 8, and SDG 12 by promoting nutrition improvement, healthier food choices, livelihood potential, and responsible food innovation. Its sustainability impact lies in supporting community nutrition, local crop utilization, bakery product innovation, and value-added use of cassava-based resources.

**Keywords:** Braided Bread, Cassava-Based Sagip Nutri Powder, Cost and Return Analysis, Food Fortification, Functional Bakery Product, Proximate Analysis, Sensory Acceptability, Shelf-Life, Sustainable Food Innovation

## 1. Introduction

This study focuses on the development, acceptability, nutritive value, shelf-life, and economic feasibility of braided bread enriched with Cassava-Based Sagip Nutri Powder fortified with Cacao Pod Husk Powder, malunggay, and turmeric powder. The study is situated within the continuing public health concern of malnutrition, the growing consumer preference for healthier bakery products, and the need for affordable, locally available, and nutrient-dense food innovations. By integrating a research-based nutrition powder into braided bread, the study aims to contribute to food fortification, community nutrition, school-based feeding initiatives, and functional bakery product development.

Bread has been a basic food staple since ancient times, originally prepared through the simple combination of water and wheat. Over time, bread production became increasingly industrialized and mechanized, making bread more affordable and accessible to consumers. However, the commercial refinement of flour, the addition of preservatives and additives, and the use of sugar and fats to improve flavor, texture, shelf life, and appearance have reduced the nutritional quality of many commercially produced breads. This nutritional decline contributes to undernutrition, overnutrition, micronutrient deficiency, and diet-related health risks such as cancer, diabetes, obesity, and cardiovascular diseases. In the Philippines, bread is widely consumed after rice because of its affordability, versatility, and role as a source of energy. Filipinos commonly eat bread for breakfast, snacks, or as an occasional substitute for rice meals. The growing popularity of bread, changing lifestyles, and the influence of social media have increased consumer interest in innovative and nutritious bakery products. As a result, food researchers, small and medium bakery owners, and private individuals have explored functional and nutrient-dense ingredients in bakery product development. Bread enrichment has therefore become a relevant trend, as shown in products such as malunggay pandesal. Cassava (Manihot esculenta) is a locally abundant and globally consumed root crop with potential value in food innovation. According to Borku, A. W. (2025) cassava is underutilized despite its high nutritional value, especially in carbohydrates. At Isabela State University Echague Campus, the College of Education developed Cassava-Based Sagip Nutri Powder as a research output used in ISU-BIDANI extension services. Previous studies have shown the potential of this powder in bakery enrichment. In the study conducted by Tabal, C., & Peñalber, M. (2025), the inclusion of Cacao Pod Husk, Malunggay, Turmeric, and other ingredients in Pandesal Fortified with Cassava Based Sagip Nutri Powder enhanced the nutritional content of the product. De Vera and Peñalber (2025) also found that macaroons fortified with cassava-based Sagip Nutri Powder and turmeric improved energy and nutrient composition, particularly protein, fat, and carbohydrates, while providing functional advantages. Braided bread, known for its twisted and visually appealing form, provides a suitable product base for enrichment. The incorporation of Cassava-Based Sagip Nutri Powder fortified with Cacao Pod Husk Powder, malunggay, and turmeric powder aims to improve the bread's nutritional value, color, texture, aesthetic appeal, and palatability. Through sensory evaluation, proximate analysis, shelf-life observation, and cost and return analysis, the study seeks to determine whether the enriched braided bread can serve as an affordable, acceptable, nutritious, and potentially marketable bakery product.

The literature emphasizes malnutrition as a persistent public health issue affecting growth, development, and welfare, especially among vulnerable populations and children. In 2021, one in every ten children aged 6 to 23 months met the minimum acceptable diet, while around 26% of Filipino children aged 5 to 10 were stunted and 8.2% were wasted, indicating chronic and severe malnutrition (Department of Science and Technology - Food and Nutrition Research Institute [DOST-FNRI], 2021). The World Health Organization (2024) defined malnutrition as encompassing undernutrition, wasting, stunting, underweight, vitamin and mineral deficiencies, overweight, obesity, and diet-related noncommunicable diseases. Approximately 50% of deaths among children under five are associated with undernutrition, mostly in low- and middle-income countries. In 2022, 149 million children under five were stunted, 45 million were wasted, and 37 million were overweight or obese, while 390 million people were underweight and 2.5 billion were overweight, including 890 million who were obese (World Health Organization 2024). According to the World Health Organization (2025), one in eight people globally were overweight or obese in 2022. The Philippine situation reflects the same nutritional concern. The World Health Organization classified the Philippines' stunting prevalence in 2021 as a very high public health concern because one in four Filipino children under five were stunted. The country was also among those with the largest number of stunted children. According to the Food and Nutrition Research Institute, nearly 10% of children aged 5 to 19 were overweight in 2019, increasing their risk of noncommunicable diseases in adulthood (Hartigan Go et.al). Go et al (2024) further claimed that hunger affects academic performance and that the connection between malnutrition and low academic achievement is often ignored. The literature also identifies bread and bakery products as viable carriers for food fortification. Bread is widely consumed and adaptable to ingredient substitution. Dela Cruz, L. (2021) described bread as a primary energy source, while Garcia et al., 2021 emphasized the importance of developing healthier snack options that are both nutritious and palatable for children. Braided bread also has historical and cultural relevance. Challah bread originated among Ashkenazi Jews and is commonly made with eggs, white flour, water, yeast, sugar, and salt, with a braided appearance (Gutterman's & Gutterman Warheit 2023). Historical accounts trace challah to ancient Israel, where bread was used as an offering, and later developed among diasporic communities before spreading globally (KosherLine n.d.). The braided form later gained symbolic meaning in Jewish culture, representing unity and other ideas (Temple of Miriam, n.d.). Filipino bread culture reflects Spanish, American, and global influences, allowing the development of different bread varieties, including braided breads, in local bakeries ( Xena's Bread and Butter 2024). The Filipino pilipit, whose name means twisted or braided, also reflects the adaptation of European baking techniques into local food traditions (Filipino Pilipit Traditional Twisted Sugar Pastry n.d.).

Functional food innovation in bakery products is another major theme. According to Villarino et al., (2016) bread is among the most popular bakery products, with average per capita consumption of about 250 grams daily. A common strategy for improving baked goods is the partial or total replacement of wheat flour. Composite flour is used in food manufacturing, especially baking, as a method to improve nutritional and technological qualities (Naseha et al., 2025). Eid et al., (2025) reported that biscuit samples made with composite flour from millet flour, wheat, and white sweet potato flour improved nutritional content and functional components while maintaining comparable sensory attributes.
The Cassava-Based Sagip Nutri Powder is a nutritional supplement blend made from cassava, mung bean, and sesame seeds and fortified with Cacao Pod Husk Powder, malunggay, and turmeric powder. It was developed through Isabela State University research initiatives, including Cassava-based Sagip, Corn-based Sagip, and Rice-based Sagip fortified with Cacao Pod Husk Power, a research product of the ISU-Cagayan Valley Cacao Development Center. These products contain nutrients intended to help reduce malnutrition (ISU for Sustainability, 2023). Cassava flour has strong potential as a wheat flour substitute in baking. Lu H. et al (2020) confirmed that cassava flour is used as a substitute for wheat flour because of its quality characteristics and versatility. Its gluten-free nature makes it useful for individuals avoiding gluten, and it is suitable for individuals with celiac disease who follow a gluten-free regimen (Kumari J. et al., 2021). Cassava flour also has potential as a culinary raw material (Nilusha et,al 2021). Li et.al. (2023) noted that several studies demonstrated the feasibility of partially substituting wheat flour with cassava flour in cakes, biscuits, bread, and noodles. Tabal and Peňalber (2025) found that Cassava Based Nutri powder enriched pastries and pancakes increased macronutrients and antioxidants, while flavor profiles were refined to support consumer acceptance. De Vera and Penalber,( 2025) stated that cassava has gained interest as a functional ingredient in bread production because it enhances nutritional content and serves as a locally sourced wheat flour alternative. Tabal & Peñalber, (2025) also reported that hand pan desal enhanced with Cassava-Based Sagip Nutri Powder provides a more nutritious alternative than local pan desal. The nutritional components of the powder are supported by the literature on cassava, mung bean, sesame seed, cacao pod husk, malunggay, and turmeric. Cassava is a major tuber crop cultivated in tropical and subtropical regions and serves as a primary source of nutrition for more than 800 million people globally (Malik & Kongsil et al.,2020). It is believed to have originated in Latin America and was

discovered approximately 4,000 years ago by indigenous peoples of India (McCallum & Anjanappa et.al. 2017). Cassava contains resistant starch and other components that may provide health benefits, although moderation is advised because it contains potentially hazardous substances and relatively high caloric content (Kim Chin,RD, 2023). Cassava is cultivated under diverse rainfall and soil conditions, from tropical semi-arid regions with less than 600 mm annual rainfall De Tafur et al., (1997) to sub-humid and humid tropics exceeding 1000 mm (Pellet and El-Sharkawy, 1997). In 2023, global cassava production reached 333.7 million tons, with Africa producing 63.9%, Asia 27.8%, America 8.2%, and Oceania 0.1% ((Sowcharoensuk, 2025). Cassava has evolved from being viewed as food of the poor into a versatile crop relevant to climate change, economic development, and food security concerns (Food and Agriculture Organization of the United Nations, 2013).

Cassava flour is made from dried cassava roots and can function as food, stabilizer, thickening agent, and wheat substitute (Ayetigbo O. et al, 2018). WebMD Editorial Contributor. (2025) stated that it can be used as a grain-based flour alternative or gluten-free flour mixture because of its mild flavor and application in baking, sauces, and patties. Zelman (2025) described cassava flour as low in calories, fat, and sugar, with high water content and lower caloric density than corn, plantain, rice, coconut, sorghum, and wheat flours. Cassava flour's resistant starch may support weight management, gut health, and metabolic markers (Lang A (2022). Cassava also contains flavonoids such as quercetin that help regulate blood sugar and support metabolism (Laya et al., 2022). A 1/4 cup serving of cassava flour contains 130 calories, 31 grams of carbohydrates, and 2 grams of fiber (Lang,2022), while cooked cassava provides carbohydrates, protein, fiber, calcium, magnesium, potassium, vitamin C, thiamine, riboflavin, and niacin (Dresden, D., & Sanghavi, D. (2024). A cup of cassava flour contains approximately 110 grams of carbohydrates, 5 grams of fiber, 4.5 grams of sugar, and vitamin C (WebMD Editorial Contributor. (2025, July 25). Mung bean contributes protein, fiber, and micronutrients. It is widely cultivated in Asia and is rich in dietary fiber, protein, iron, magnesium, potassium, and essential amino acids (Petruzzello,2025). It is an important edible legume cultivated on about 6 million hectares globally and widely consumed in Asia (Dahiya et.al, 2015). Mung bean flour is produced from finely milled mung beans and is a versatile gluten-free flour used in South Central and East Asian cuisines (Jaron, 2018). It is suitable for gluten-free baking and can be used in bread, cakes, and pastries, though liquid adjustment is needed due to its absorption capacity (thecoconutmama.com). Mung beans contain polyphenols, polysaccharides, and polypeptides with antioxidant activity and essential amino acids that may be deficient in many cereals (Hou D.etal,2019). Huzar( 2023) identified possible antioxidant, antifungal, antibacterial, anti-inflammatory, anti-diabetes, anti-hypertension, and anti-cancer properties. According to the US Department of Agriculture (USDA), 100 grams of boiled mung beans contain 7.02 grams of protein, 19.15 grams of carbohydrates, 7.60 grams of dietary fiber, and 159 micrograms of folate. Sesame seed also contributes nutritional and functional value. Sesame (Sesamum indicum) is a short-day subtropical and thermophilic crop cultivated in Central Asia and North Africa (Jakusko,2013). It can be used as oil, flour, or garnish for buns (Robbins 2023). Sesame seeds and oil have antioxidant and anti-inflammatory properties, and oxidative stress and inflammation are key factors in cardiovascular diseases (CVDs). Sesame seeds contain sesamol, which enhances cognitive function and is associated with memory and cognitive ability (Ghosh etal 2023). Three tablespoons of unhulled sesame seeds provide calcium, magnesium, manganese, and zinc, while hulled sesame seeds also provide these nutrients in varying amounts (McCulloch, 2025).

Cacao pod husk, malunggay, and turmeric strengthen the nutritional and functional composition of the powder. Cacao pod husk is the external shell of Theobroma cacao L. and has historically been treated as an agricultural byproduct, although it now receives attention for diverse uses (Campos et.al 2018). Since cacao pod husks account for over 70% of the cacao fruit's weight, they represent a significant byproduct of chocolate production (Mohan et al., 2020). Cocoa pod husk flour contains 6.98% protein, 27.35% fiber, and 0.32% fat, making it a plant protein and fiber source (Banan & Ramos, 2025). Cacao powder provides iron, phosphorus, manganese, magnesium, potassium, and fiber ( WebMD Editorial Contributor. (2025). Malunggay or Moringa oleifera is known as the "miracle tree" and is believed to be indigenous to Afghanistan, Bangladesh, India, and Pakistan while growing widely in tropical and subtropical areas (Pareek et.al, 2023). It grows in slightly acidic to alkaline soil and can produce fruit after six to eight months (Swatia, et.al 2023). Braganza (2023) noted that malunggay can flourish even in adverse conditions. Moringa oleifera is rich in antioxidants and may help cardiovascular and skin health, lower blood sugar, reduce inflammation and cholesterol, and support malnutrition-related interventions, although it may interact with medications and is not recommended during pregnancy (Arnarson 2025). Its leaves contain calories, protein, Vitamin B6, Vitamin C, iron, riboflavin, Vitamin A, and magnesium. Turmeric provides additional functional value. Curcuma longa is cultivated in tropical and subtropical countries and has been used therapeutically for 4,000 years ( Fuloria et.al 2022). Turmeric has been used traditionally in China, India, Thailand, Malaysia, Indonesia, Japan, South Korea, and other countries, and contains diphenylalkanoids, terpenoids, aromatics, steroids, fatty acids, minerals, and nucleosides (Bhowmik et.al nd). Curcumin, the principal bioactive compound in turmeric, is a fat-soluble anti-inflammatory and antioxidant associated with reduced oxidative stress, cardiovascular disease, cancer, and chronic age-related ailments (Arnarson,2023). Turmeric has also been used for digestive ailments, wounds, sore throats, joint inflammation, viral hepatitis, urticaria, and skin allergies (Khan, N. 2021). One tablespoon of ground turmeric powder contains calories, protein, fat, carbohydrates, fiber, sugar, calcium, iron, magnesium, phosphorus, and potassium (MedlinePlus 2022).

At the global level, malnutrition continues to affect both undernourished and overnourished populations, with children among the most vulnerable. The World Health Organization (2024) and World Health Organization (2025) data emphasize that stunting, wasting, underweight, overweight, and obesity coexist as serious public health concerns. These conditions are especially critical in low- and middle-income countries, where undernutrition contributes significantly to child mortality. At the national level, the Philippines faces persistent malnutrition concerns among children and adolescents. DOST-FNRI data show inadequate dietary intake among young children and notable levels of stunting and wasting (Department of Science and Technology - Food and Nutrition Research Institute [DOST-FNRI], 2021). The connection between nutrition and education is also important, as poor nutrition affects school performance and learning outcomes, a concern highlighted in relation to the 2022 PISA results and the need for school reforms (Go et al (2024). The study aligns with the Philippine Plan of Action for Nutrition (PPAN) 2023–2028, launched by the National Nutrition Council as a guiding framework for reducing all forms of malnutrition across life stages. PPAN emphasizes access to affordable, safe, and nutritious food and encourages sustainable nutrition solutions through collaboration among government agencies, civil society, the private sector, and academic institutions. The study also relates to DepEd Order No. 8. Series 2007, which directs school canteens to help address malnutrition and promote healthy eating habits by offering nutrient-rich foods. It also aligns with DO No.13 S.2017, which provides policy guidelines on healthy food and beverage choices in schools and DepEd offices, and Department of Education Order No. 39 series 2017, which supports the School Based Feeding Program using locally sourced ingredients for wasted and severely wasted learners (Department of Education, 2017). Republic Act No. 8976, known as the Philippine Food Fortification Act of 2020, also supports food fortification as a legal strategy to address micronutrient deficiencies. At the local and institutional level, the study is linked to the ISU-BIDANI-PNEA initiative, a community-based participatory strategy aligned with PPAN. Isabela State University's College of Education has used Cassava-Based Sagip Nutri Powder in extension services through BIDANI-PNEA to support nutrition improvement in adopted barangays. The study was conducted at Isabela State University, Echague Campus, College of Education Cafeteria, and focuses on the acceptability, proximate nutritive value, shelf-life, and economic feasibility of braided bread enriched with fortified Cassava-Based Sagip Nutri Powder.

The study is conceptually anchored on the Input–Process–Output (IPO) model. The input includes the materials and ingredients, particularly bread flour, Cassava-Based Sagip Nutri Powder, sugar, yeast, milk, milk powder, butter, salt, water, and the different formulations. The process involves baking procedures such as preparation of ingredients, mixing, kneading, proofing, shaping, cooling, glazing, and packing, as well as sensory evaluation, proximate analysis, shelf-life analysis, cost and return analysis, and statistical analysis using ANOVA. The output includes the degree of acceptability in terms of appearance, odor, taste, texture, and general acceptability; nutrient composition in terms of moisture, ash, fat, protein, crude fiber, and carbohydrates; spoilage indicators; cost and return results; and significant differences in sensory ratings among formulations. This framework provides a systematic structure for examining how the incorporation of Cassava-Based Sagip Nutri Powder affects the quality and acceptability of braided bread. It connects the independent variable, which is the formulation level of the fortified powder, with the experimental procedures and measured outcomes. The process flow also supports product development by showing the preparation, measuring, sifting, mixing, kneading, proofing, punching, shaping, braiding, baking, cooling, glazing, and packing stages needed to produce the enriched braided bread.

The reviewed literature confirms the nutritional potential of cassava, mung bean, sesame seeds, cacao pod husk, malunggay, and turmeric as functional food ingredients. It also shows that cassava flour and composite flour can improve the nutritional value of baked goods without necessarily compromising sensory quality. Existing studies have examined Cassava-Based Sagip Nutri Powder in products such as pandesal, pastries, pancakes, and macaroons, with findings showing improved nutrient content, energy composition, macronutrient levels, antioxidants, and functional benefits (Tabal, C., & Peñalber, M. (2025); De Vera and Peñalber (2025); Tabal and Peňalber (2025); De Vera and Penalber,( 2025); Tabal & Peñalber, (2025). However, there remains limited local research on the incorporation of Cassava-Based Sagip Nutri Powder into braided bread. While functional food innovation and composite flour technology are increasingly studied, the acceptability, nutritional value, shelf-life, and cost-return potential of braided bread enriched with this fortified powder remain underexplored. This study addresses that gap by evaluating different formulations of braided bread enriched with Cassava-Based Sagip Nutri Powder in terms of color/appearance, odor/aroma, taste/flavor, texture/firmness, general acceptability, nutritive value, shelf-life, and return on investment. The rationale of the study rests on the need to develop an affordable, acceptable, nutritious, and locally relevant bakery product that can support nutrition improvement, functional food innovation, school feeding initiatives, community-based nutrition programs, local agriculture, and microenterprise opportunities. By using a locally available crop and an institutionally developed nutrition powder, the study contributes to practical food-based interventions against malnutrition while expanding the application of research outputs into community and market contexts.

The study aligns with SDG 1: No Poverty because the development of an affordable enriched bread product may support low-cost nutrition options and create income-generating opportunities for local bakers, home-based entrepreneurs, and food sectors. It aligns with SDG 2: Zero Hunger because it directly addresses hunger, malnutrition, and micronutrient deficiency through food fortification and nutritious food innovation. It supports SDG 3: Good Health and Well-Being by promoting a healthier bakery product that may contribute to improved dietary intake and reduced nutrition-related health risks. The study also relates to SDG 5 Gender Equality because the product may support equal opportunities for individuals, regardless of gender, to participate in food innovation, entrepreneurship, and nutrition improvement activities. It contributes to SDG 8 Decent Work and Economic Growth by encouraging entrepreneurship, bakery innovation, and potential income generation from an enriched food product. It also supports SDG 10 Reduce Inequalities by promoting access to affordable and nutritious food, particularly for vulnerable populations who may have limited ability to purchase healthier food options. Finally, it aligns with SDG 12 Responsible Consumption and Production by encouraging healthier food choices, responsible food innovation, and the use of locally available nutrient-dense ingredients.

The study contributes to public health sustainability by addressing malnutrition through an accessible and fortified bakery product. It provides a practical food-based approach that may help improve nutrient intake among students, children, consumers, and vulnerable populations. It also contributes to educational sustainability because the enriched braided bread may inform school canteen operations, nutrition education, feeding programs, and health-promoting practices among teachers, school administrators, parents, and learners. The study supports socio-economic sustainability by creating potential livelihood opportunities for local farmers, bakery owners, home-based bakers, and entrepreneurs. Increased use of cassava and other locally available ingredients may stimulate demand for agricultural products and encourage value-adding activities in communities. It contributes to community and institutional sustainability by extending the application of Isabela State University's research output into nutrition advocacy, extension programs, school feeding initiatives, and local nutrition planning. The study also promotes agricultural and food system sustainability through the use of cassava, malunggay, cacao pod husk, mung bean, sesame seed, and turmeric as functional ingredients. By integrating locally available and nutrient-dense materials into an everyday food product, the research supports innovation in responsible consumption and production. Overall, the study is multidisciplinary because it connects food science, nutrition, education, public health, agriculture, entrepreneurship, community extension, and sustainable development through the development and evaluation of braided bread enriched with Cassava-Based Sagip Nutri Powder.

## 2. Material and methods

### 2.1 Research Design

The study used an experimental product-development design to determine the acceptability and quality of braided bread enriched with Cassava-Based Sagip Nutri Powder. Five formulations were prepared, consisting of a control formulation with no Cassava-Based Sagip Nutri Powder and four experimental formulations with increasing substitution levels. The bread flour was progressively replaced with Cassava-Based Sagip Nutri Powder using 0g, 25g, 50g, 75g, and 100g of the powder, corresponding to 0%, 10%, 20%, 30%, and 40% substitution levels. The formulations were evaluated based on sensory acceptability, proximate nutrient composition, shelf-life, production cost, and return on investment.

### 2.2 Locale of the Study

The preparation and sensory evaluation of the enriched braided bread were conducted at the College of Education Cafeteria, Isabela State University, Echague Campus. The Fortified Cassava-Based Sagip Nutri Powder was obtained from the College of Education Cafeteria through Dr. Martina Delos Reyes-Peňalber, a research extensionist of Isabela State University, Main Campus, Echague, Isabela. The proximate analysis of the product samples was conducted at the College of Health Sciences Food and Nutrition Research Laboratory of Quirino State University, Diffun Campus.

### 2.3 Respondents of the Study

The respondents of the sensory evaluation were 75 randomly selected male and female faculty staff and students. The panelists were selected based on the required age range of 18 to 50 years old. They were also screened to ensure that they were non-smokers, non-liquor drinkers, and in good health during the conduct of the sensory evaluation.

### 2.4 Sample and Sampling Procedure

The study used five coded formulations of braided bread to prevent bias during sensory evaluation. The samples were coded as F0-721, F1-628, F2-563, F3-480, and F4-125 and were randomly assigned to the experimental units per block within each replication. Each panelist evaluated one slice of bread from each treatment. Random selection was applied in choosing the sensory panel, while random coding and assignment of samples were used to maintain impartiality in the evaluation process.

### 2.5 Research Instrument

The primary instrument used for data gathering was a sensory evaluation score sheet based on the 9-Point Hedonic Scale. The panelists rated the samples in terms of color/appearance, odor/aroma, taste/flavor, texture, and general acceptability. The scale ranged from 9, interpreted as "Like Extremely," to 1, interpreted as "Dislike Extremely." A shelf-life observation tool was also used to record the daily quality condition of each formulation for seven days, with results classified as acceptable, marginal, or unacceptable. Proximate analysis was used to determine the moisture content, protein, fat, crude fiber, ash, and carbohydrate content of the developed products. Cost and return computations were also used to determine the economic feasibility of the different formulations.

### 2.6 Data Gathering Procedure

The preparation of the braided bread began with the measurement and weighing of all ingredients, including bread flour, Cassava-Based Sagip Nutri Powder, sugar, yeast, salt, milk powder, butter, milk, egg, water, vanilla essence, powdered sugar, and warm water. The dry ingredients were combined, while the salt, sugar, egg, milk, and water were mixed separately before being added to the flour mixture. The mixtures were combined to form dough, after which butter and oil were gradually added while kneading until the dough became smooth and elastic. The windowpane test was performed to check dough development. The dough was then formed into a ball, placed in a lightly greased bowl, covered, and allowed to proof until doubled in size. After the first proofing, the dough was punched down, divided into 15-gram portions, rolled into 16-inch ropes, twisted and braided, and sealed at the ends. The shaped dough pieces were placed on a parchment-lined baking tray, covered, and allowed to undergo second proofing. The oven was preheated for 15 minutes and set at 180–200 degrees centigrade or 350–380 degrees Fahrenheit. The dough was baked for 15 minutes or until golden brown. After baking, the bread was cooled, dipped in glaze made from powdered sugar and hot water, placed on a cooling rack to allow excess glaze to settle, and packed in clean zip lock bags to maintain freshness. For the proximate analysis, all treatment products were submitted to the Food and Nutrition Research Laboratory of Quirino State University, Diffun Campus, to determine their nutrient components. For the shelf-life analysis, the samples were securely packed in zip lock bags and stored at room temperature. The appearance, aroma, texture, taste, and acceptability of each formulation were observed daily for seven days. For the sensory evaluation, coded bread samples were served to the panelists. Each panelist tasted one slice from every formulation and rated the samples using the 9-Point Hedonic Scale. The respondents were required to rinse their mouth before tasting each sample, and mineral water was provided to maintain the validity and credibility of the sensory evaluation.

### 2.7 Data Analysis Techniques

The completed score sheets were gathered, tabulated, analyzed, and interpreted. Mean and descriptive statistics were used to summarize the sensory ratings of the five formulations in terms of color/appearance, taste/flavor, odor/aroma, texture, and general acceptability. One-way Analysis of Variance (ANOVA) and the F-test were used to determine whether significant differences existed among the formulations. Tukey’s HSD (Honestly Significant Difference) was also used to identify the differences among treatments. The shelf-life data were analyzed based on daily observations of product quality, while the proximate analysis results were interpreted according to the measured nutrient components. Cost and return analysis were conducted by computing the unit cost, selling price, total sales, income, and return on investment of each formulation.

### 2.8 Ethical Considerations

The study was conducted in compliance with established ethical standards. Before implementation, the research protocol was reviewed and approved by the Institutional Ethics and Review Board of Isabela State University. The researcher submitted a formal request letter and completed the required ethics review documents, including the proposal protocol, study design, methodology, statistical plan, and criteria for participant inclusion and exclusion in the sensory evaluation. Proximate analysis was conducted in a reputable Food and Nutrition Research Laboratory by qualified experts before the sensory evaluation to ensure sample accuracy and safety. Informed consent was obtained from all participants, and the purpose of the study was clearly explained. Participation was voluntary, and no coercion was involved. Participants with known allergies to cassava or other ingredients in the product samples were informed of possible risks, and all participants were advised that they could withdraw at any time without penalty. Confidentiality and anonymity were maintained, and all responses were used only for academic purposes and presented in consolidated form. The researcher also upheld academic integrity through proper paraphrasing and plagiarism prevention. No personal, financial, or professional conflict of interest influenced the design, implementation, or interpretation of the study.

## 3. Results and Discussion

### 3.1 Sensory Acceptability of Braided Bread Enhanced with Cassava-Based Sagip Nutri Powder

#### 3.1.1 Color or Appearance

The results showed that Formulation 1 obtained the highest mean score of 7.64, described as like very much, followed by Formulation 2 with a mean of 7.32, described as like moderately. Formulations 3 and 4 obtained means of 6.81 and 6.60, respectively, both described as like moderately, while the control formulation obtained the lowest mean of 6.17, described as like slightly. The grand mean of 6.91 indicated that the color or appearance of the product was generally liked moderately. Statistical analysis showed a significant difference among formulations, with an F-value of 13.22 and a p-value of 0.000. The findings indicate that moderate incorporation of Cassava-Based Sagip Nutri Pack Powder improved the color development and visual appeal of the braided bread, possibly due to enhanced browning reactions during baking. Formulation 1 was the most acceptable in color and appearance because its substitution level produced the ideal visual quality. This finding is consistent with the claim that color is the most essential determinant influencing consumer acceptance (Zhang et al. (2021).

#### 3.1.2 Odor or Aroma

The results showed that Formulation 1 obtained the highest mean score of 7.87, described as like very much, and was significantly higher than the other formulations. Formulation 2 followed with a mean of 7.35, while Formulations 3, 0, and 4 obtained means of 6.81, 6.51, and 6.20, respectively, all within the like moderately range. The grand mean of 6.95 showed that the odor or aroma of the product was generally liked moderately. The F-value of 14.84 and p-value of 0.000 confirmed a significant difference among formulations. The result suggests that the quantity of Cassava-Based Sagip Nutri Powder in Formulation 1 produced the most favorable aroma because it maintained a balanced interaction between bread flour and cassava-based powder during baking. In contrast, the lower rating of Formulation 4 suggests that excessive substitution may reduce desirable flour-derived aroma or produce less favorable aromatic compounds. Aroma is a critical criterion influencing consumer approval among several sensory aspects (Pico, J., Bernal, J., & Gómez, M. 2017).

#### 3.1.3 Taste or Flavor

The results revealed that Formulation 1 obtained the highest mean score of 8.12, described as like very much, followed by Formulation 2 with a mean of 7.71, also described as like very much. Formulations 3 and 0 obtained means of 6.93 and 6.53, respectively, both described as like moderately, while Formulation 4 obtained the lowest mean of 6.41, described as like slightly. The grand mean of 7.27 indicated that the taste or flavor of the braided bread was generally liked moderately. The F-value of 38.55 and p-value of 0.000 showed significant differences among formulations. The findings suggest that the 10% substitution level in Formulation 1 improved the taste or flavor of the bread, possibly by adding mild sweetness and enhancing the bread flour flavor. However, higher levels of Cassava-Based Sagip Nutri Powder appeared to reduce flavor acceptability because of possible masking of bread flour flavor or imbalance in taste compounds. According to Pu et al. (2021) Flavor, comprising of aroma and taste, is a fundamental attribute of bread products which is th main influencing factor for consumer acceptability.

#### 3.1.4 Texture or Firmness

The results showed that Formulation 1 had the highest mean score of 8.27, described as like very much, followed by Formulation 2 with a mean of 7.62, also described as like very much. Formulation 3 obtained a mean of 7.15, while the control formulation obtained 6.59, both described as like moderately. Formulation 4 obtained the lowest mean of 6.46, described as like slightly. The grand mean of 7.35 indicated that the product's texture was generally liked moderately. The F-value of 47.10 and p-value of 0.000 confirmed statistically significant differences among formulations. The results indicate that Formulation 1 produced the best balance of softness and structural integrity, allowing the bread to hold its shape while remaining convenient to eat. Formulation 4's lower rating suggests that excessive cassava substitution resulted in a denser and less cohesive crumb structure due to the lower gluten content of cassava flour. According to Guiné, R. P. F. (2022) texture comprises various product attributes and is crucial for consumer acceptance. Texture influences consumer perception and the value attributed to the products.

#### 3.1.5 General Acceptability

The results showed that Formulation 1 obtained the highest mean of 8.05, followed by Formulation 2 with a mean of 7.68, both described as like very much and not significantly different from each other. Formulation 3 obtained a mean of 7.11, while Formulations 4 and 0 obtained means of 6.63 and 6.61, respectively, all described as like moderately. The grand mean of 7.22 showed that the panelists generally liked the braided bread moderately. The F-value of 21.03 and p-value of 0.000 indicated significant differences among formulations. The findings suggest that Formulations 1 and 2 had the best substitution levels because they produced a more balanced combination of aroma, flavor, and texture. The lower acceptability of the control and Formulation 4 suggests that too little or excessive cassava substitution may reduce overall sensory appeal. A fundamental aspect of functional food development is customer acceptance, which is influenced by visual and sensory impressions of the food (Nakov et al., 2020).

### 3.2 Proximate Nutrient Composition of Braided Bread Enhanced with Cassava-Based Sagip Nutri Powder

#### 3.2.1 Moisture Content

The results showed that moisture content decreased gradually as the level of Cassava-Based Sagip Nutri Powder increased. Formulation 1 recorded 11.00%, followed by Formulation 2 with 10.63%, Formulation 3 with 10.31%, and Formulation 4 with 9.78%. This indicates that higher substitution levels reduced the moisture content of the bread. The decrease in moisture content suggests that Cassava-Based Sagip Nutri Powder reduced the moisture retention capacity of the bread matrix. This may be attributed to the lower gluten-forming capacity and lower water-binding ability of cassava-based ingredients compared with bread flour. According to Srikaeo, K., & Sangkhiaw, J. (2024), the impact of integrating cassava flour and ginger powder into bread, indicated that increasing the ratio of cassava flour in bread recipes resulted in a notable decrease in moisture content.

#### 3.2.2 Ash Content

The results showed that total ash content increased progressively from 2.43% in Formulation 1 to 2.71% in Formulation 2, 3.01% in Formulation 3, and 3.46% in Formulation 4. This indicates that higher levels of Cassava-Based Sagip Nutri Powder increased the mineral content of the braided bread. The increasing ash content suggests that the Cassava-Based Sagip Nutri Powder contributed mineral components to the product. This is nutritionally favorable because ash content reflects inorganic mineral residue and total mineral availability. Studies revealed ideal blending proportions for nutritional benefit and sensory appeal, comprising 49–71% wheat, 10.6–29% cassava, and 18.2–22.0% soybean flour. Composite breads within these ranges can provide superior protein quality, enhanced antioxidant qualities, and satisfactory sensory attributes, facilitating the creation of healthier, nutrient-dense bread products that promote customer well-being (Alemu, T. T., & Kuyu, C. G. 2025).

#### 3.2.3 Lipid Content

The results showed that lipid content slightly decreased from 8.57% in Formulation 1 to 8.34% in Formulation 2 and 8.12% in Formulation 3, then slightly increased to 8.21% in Formulation 4. Although the values varied, the differences were relatively small across formulations. The slight reduction suggests that increasing Cassava-Based Sagip Nutri Powder may have lowered the fat concentration of the product because cassava-based ingredients generally contribute less lipid than other bread ingredients. However, the lipid values remained relatively stable because other lipid-contributing ingredients such as milk, egg, and fat remained constant across formulations. The findings indicate that an elevation in CF resulted in a reduction of moisture, protein, fat, and b* values in W-CF (Li et al., 2023).

#### 3.2.4 Protein Content

The results showed that protein content decreased from 11.09% in Formulation 1 to 10.79% in Formulation 2 and 10.47% in Formulation 3, but increased to 13.78% in Formulation 4. This indicates minor variation across formulations, with Formulation 4 having the highest protein value. The initial decrease may be linked to the reduction of bread flour, which contains gluten-forming proteins that support bread structure. The higher value in Formulation 4 may be associated with sample preparation, analytical variation, lower moisture concentration, or uneven distribution of protein-containing ingredients. In proximate analysis, small changes may occur when moisture decreases because nutrients may appear proportionally higher on a weight basis.

#### 3.2.5 Fiber Content

The results showed that fiber content consistently increased from 3.93% in Formulation 1 to 4.62% in Formulation 2, 5.50% in Formulation 3, and 6.74% in Formulation 4. This indicates that higher substitution levels substantially improved the dietary fiber content of the braided bread. The increase in fiber content demonstrates the potential of Cassava-Based Sagip Nutri Powder as a functional ingredient for bakery fortification. This is nutritionally important because dietary fiber supports digestive health, satiety, and regulation of blood glucose and lipid metabolism. In the study Tabal, C., & Peñalber, M. (2025) as stated the treatment formulations of Pan de Sal were created, integrating different quantities of turmeric powder and Cassava-Based Sagip Nutri Powder. The nutritional research indicated that the fortified Pan de Sal possessed greater energy, dietary fiber, and protein levels than the bread flour.

#### 3.2.6 Carbohydrate Content

The results showed that carbohydrate content remained the major nutrient fraction in all formulations but decreased from 62.98% in Formulation 1 to 62.91% in Formulation 2, 62.59% in Formulation 3, and 58.03% in Formulation 4. This indicates that the product remained carbohydrate-rich despite increasing substitution levels. The findings suggest that both bread flour and cassava-based ingredients contributed to the carbohydrate profile of the product. According to Tabal, C., & Peñalber, M. (2025) the marginal rise indicates that flour substitution enhanced the starch content in the product. Cassava-based substances, such as Sagip Nutri Powder, possess a carbohydrate content of 81% to 87%, and studies suggest that processing or integration into food products may elevate carbohydrate levels further. This indicates that cassava-based Sagip Nutri Powder can substantially enhance the energy content of fortified foods (Frontiers in Sustainable Food Systems, 2025).

#### 3.2.7 Metabolized Energy

The results showed that metabolized energy decreased from 373.13 kcal in Formulation 1 to 369.02 kcal in Formulation 2, 364.04 kcal in Formulation 3, and 361.53 kcal in Formulation 4. This indicates that higher levels of Cassava-Based Sagip Nutri Powder reduced the caloric density of the product. The decline in metabolized energy may be associated with the slight reduction in lipid content and the altered nutritional balance caused by substitution. Since lipids provide higher energy per gram than carbohydrates and proteins, even small decreases in fat content can affect total caloric value. This suggests that higher substitution levels may produce a bread product suitable for calorie-conscious consumers while still maintaining nutritional value.

#### 3.2.8 Statistical Analysis of Proximate Nutrient Composition

The ANOVA results showed significant differences among formulations in moisture content, total ash, total protein, total fiber, total carbohydrate, and metabolized energy, with p-values below 0.05. Moisture content had an F-value of 18.45 and p-value of 0.002; total ash had an F-value of 22.31 and p-value of 0.001; total protein had an F-value of 9.87 and p-value of 0.010; total fiber had an F-value of 25.76 and p-value of 0.000; total carbohydrate had an F-value of 6.54 and p-value of 0.021; and metabolized energy had an F-value of 8.91 and p-value of 0.012. Total lipid was not significant, with an F-value of 1.12 and p-value of 0.389. These findings indicate that increasing Cassava-Based Sagip Nutri Powder significantly altered most nutrient parameters of the braided bread. The strongest effect was observed in fiber content, confirming the role of the powder in dietary fiber enrichment. The significant changes in moisture, ash, carbohydrate, and metabolized energy further demonstrate that cassava-based substitution influenced the physicochemical and nutritional characteristics of the product. However, lipid content did not significantly differ, suggesting that the substitution did not substantially affect fat composition.

### 3.3 Shelf-Life Evaluation

The shelf-life evaluation showed that all formulations remained acceptable in terms of color or appearance, odor or aroma, taste or flavor, firmness or texture, and general acceptability throughout the seven-day storage period at room temperature. The samples were packed in sealed zip lock bags, and no signs of spoilage were noted during the observation period. The findings indicate that the developed braided bread maintained acceptable quality for at least seven days under room conditions when properly packed. Breads made with cassava starch exhibited greater softness after 7 days of storage compared to those made with wheat flour. Moreover, their crumbs exhibited greater cohesion and reduced dryness in the mouth, particularly with sour starch. Cassava starches and, to a lesser degree, cassava flour can enhance the quality of gluten-free loaves (Sigüenza-Andrés, T., Gallego, C., & Gómez, M. 2021). On the other hand, adding sugar glazing to cassava in moderation can keep it at an acceptable quality for at least seven days, which is a good balance between function and customer satisfaction. The glazing kept the moisture in, which stopped the food from going bad (Zhou & Therdthai 2022).

### 3.4 Cost of Production and Return on Investment

#### 3.4.1 Cost of Production

The results showed that total production cost increased as the level of Cassava-Based Sagip Nutri Powder increased. The control formulation had a total cost of Php 139.70, while Formulations 1, 2, 3, and 4 had total costs of Php 171.23, Php 192.85, Php 214.40, and Php 235.90, respectively. Operating expenses remained constant at Php 88.00 across all formulations, while ingredient costs increased from Php 83.23 in Formulation 1 to Php 147.90 in Formulation 4. The findings indicate a direct relationship between nutritional enhancement and production cost. As the proportion of Cassava-Based Sagip Nutri Powder increased, the total cost also increased because the enriched formulation required higher-cost ingredients. This implies that producing braided bread with enhanced nutritional value is more expensive than producing the control formulation, although the increase may be justified by the improved nutritional profile.

#### 3.4.2 Return on Investment

The return-on-investment results showed that the control formulation and Formulations 1, 2, and 3 each obtained a decreasing ROI of 46%,24% and 12% respectively while Formulation 4 obtained an ROI of -.38%%. With the same selling price of Php 5 across formulations F1 got the highest income of Php 78.77 and Php -.90 for F4. The number of pieces decreased from 50 pieces in the control and Formulation 1 to 48 pieces in Formulations 2 and 3, and 47 pieces in Formulation 4. The results suggest that replacing bread flour with Cassava-Based Sagip Nutri Powder with the same selling price will result to a decreasing financial return from Formulation 1 to Formulation 3 and even negative return for F4. The negative ROI of Formulation 4 may be associated with reduced yield caused by the lower gluten content of cassava-based ingredients and increase in production cost. Despite this, 3 formulations remained financially profitable, indicating that braided bread enhanced with Cassava-Based Sagip Nutri Powder has economic potential as a value-added bakery product.

### 3.5 Overall Interpretation of Findings

Overall, Formulation 1 was the most acceptable formulation in terms of color or appearance, odor or aroma, taste or flavor, texture or firmness, and general acceptability. Its 10% substitution level provided the best sensory balance because it improved the product without overpowering the usual qualities of braided bread. However, Formulation 4 showed the strongest nutritional profile because it had the highest ash, fiber, and protein content, the lowest moisture content, and the lowest metabolized energy. The findings demonstrate a clear trade-off between sensory acceptability, nutritional enhancement, and production cost. Lower substitution levels produced better sensory acceptance, while higher substitution levels improved nutritional composition but increased production cost resulting to a reduced yield and income if selling price remained constant across all formulations. Therefore, Cassava-Based Sagip Nutri Powder can function as a fortifying ingredient in braided bread, with potential application in local food innovation, nutrition improvement, and value-added use of cassava resources.

## 4. Conclusion & Recommendations

The study concludes that braided bread enhanced with Cassava-Based Sagip Nutri Powder is generally acceptable, nutritionally improved, shelf-stable within the observed period, and economically feasible as a value-added bakery product. Among the formulations, F1 with 10% or 25g Cassava-Based Sagip Nutri Powder was the most preferred in terms of color/appearance, odor/aroma, taste/flavor, texture/firmness, and general acceptability, while higher substitution levels increased nutritional components such as ash and fiber but reduced some sensory qualities due to changes in flavor, aroma, and texture. The product remained acceptable during the seven-day shelf-life observation, and the cost and return analysis showed that with the same selling across formulations only 4 formulations were financially profitable, with F0 to F3 obtaining 67% , 46%, 24% and 12% ROI respectively while F4 obtaining -.38% ROI. Overall, the findings validate that braided bread enhanced with Cassava-Based Sagip Nutri Powder may serve as a nutritious and viable bakery product for local food innovation, nutrition improvement, and value-added use of cassava resources.

Based on the findings and conclusions, future researchers may conduct longer shelf-life observation, perform microbial shelf-life analysis, examine micronutrient composition such as calcium, iron, potassium, and phosphorus, assess large-scale production feasibility, and explore the incorporation of Sagip Nutri Powder with other local nutrient-rich ingredients for further fortification. Parents may consider enhanced braided bread as a snack or breakfast option for children, while nutrition and health sections may explore its inclusion in feeding or extension services. Food entrepreneurs and bakery owners may assess its income-generating potential and possible use in other bakery products, while school administrators, community coordinators, and extension program coordinators may evaluate its suitability for school canteens, feeding programs, and community nutrition interventions.

The study was limited to the development and evaluation of braided bread enhanced with Cassava-Based Sagip Nutri Powder using selected formulations and sensory evaluation conducted at Isabela State University, Echague Campus, College of Education. Its nutritive value was limited to proximate analysis, while shelf-life was observed only for seven days under room-temperature storage. Therefore, the findings are confined to the tested formulations, respondents, sensory attributes, proximate nutrient parameters, shelf-life observation period, and cost-return conditions used in the study.

## Compliance with ethical standards

The study was conducted in accordance with institutional ethical standards, with voluntary participation, informed consent, confidentiality of respondents' information, and ethical approval properly observed. The authors declare that there was no conflict of interest in the conduct of the study, all relevant contributions were duly acknowledged, and copyright ownership and authorship responsibilities were properly upheld.

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