

UTILIZATION AND ORGANOLEPTIC EVALUATION OF PASTRY PRODUCTS MADE FROM ARROWROOT (*Maranta arundinacea*) FLOUR

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ABSTRACT

This study explores the utilization and organoleptic evaluation of pastry products made from arrowroot (*Maranta arundinacea*) flour, aiming to assess their acceptability and nutritional value while examining age-based preferences and shelf-life. Employing an experimental approach, baked products including pies, tarts, and cakes were meticulously developed from arrowroot flour. Sensory evaluations involving 120 participants across various age groups and food experts revealed high acceptability ratings, indicating widespread satisfaction with the products' appearance, aroma, taste, and texture. Statistical analyses further demonstrated no significant differences in acceptability among different age groups, underscoring the broad appeal of arrowroot-based pastries. Additionally, nutritional analyses showcased enhanced protein and fat content in the baked products compared to raw flour, augmenting their dietary value. However, observations on shelf-life delineated varying longevity, with pies and tarts maintaining quality for up to 10 days while cakes exhibited shorter viability. In conclusion, arrowroot flour emerges as a promising ingredient for crafting nutritious and palatable pastry products, suggesting avenues for product diversification and consumer education to capitalize on its culinary and nutritional benefits.

Keywords: *Arrowroot flour, pastry products, organoleptic evaluation, age-based preferences, sensory evaluation, shelf-life*

INTRODUCTION

Food is the most fundamental need in the hierarchy of human requirements. As the human population increased significantly during the 18th century, Thomas Malthus expressed great concern about the sustainability of food availability. Despite the growing human population, a total collapse in the food supply has not yet occurred, primarily due to the periodic emergence of new technologies that boost agricultural productivity and prevent a Malthusian crisis. However, none of these technologies, including the Green Revolution of the 1960s, has been genuinely sustainable, mainly due to their adverse environmental and social impacts (Kesavan & Swaminathan, 2018).

The modern economy is a structured system of activities conducted for financial gain, focusing on individuals pursuing common objectives, which makes modern society possible. A significant aspect of this economy is baking, a process that involves using high heat for an extended period, typically in an oven. Heat transforms batters and dough into baked items with a crisp, dry crust and a soft center. Although baking can be done at home, in bakeries, and in restaurants for daily meals and local consumption, industrialization has automated baking in large factories. Baked foods, especially bread, are frequent and significant from both economic and cultural standpoints, making baking a fundamental skill crucial for nutrition.

Baked goods are widely sold at bakeries, marketplaces, grocery stores, and farmers' markets. However, the regional climate conditions in tropical countries like the Philippines are less favorable for profitable wheat production. Consequently, the Philippines relies entirely on imported wheat for its baked goods.

Arrowroot (*Maranta arundinacea L.*), locally known as “*Sagu*” among Ilocanos and “*Uraru*” among Tagalogs, is a low perennial herb found in rainforest areas, growing to about two feet in height. It has small white flowers and fruits and is primarily cultivated for the starch in its rhizome. This starch can serve as a healthier substitute for cornstarch, being finely ground, white, and powdery. It is the only starch product that contains calcium ash, essential for maintaining the body's acid-alkali balance (Fallon, 2000).

Arrowroot is grown mainly for its starchy tubers, which must be processed within 48 hours of harvest to prevent decay. The tubers are bathed in hot water, peeled to remove the fibrous covering, and then grated into a rough pulp. This process breaks down the stiff cells enclosing the starch. The pulp is washed over screens to separate the starch from the fibrous particles. The settled starch is centrifuged or filtered, promptly dried, and powdered. About 20% of the root's starch is extracted, with the remaining 78% being natural starch (Cecil, 1992; Kay et al., 1987). Arrowroot starch, one of the cleanest natural carbohydrates, has a high maximum viscosity and is used in desserts, pastries, jellies, and various meal preparations. It is particularly suitable for infants and people with special dietary needs due to its high digestibility. Industrial uses include glue and cosmetics, and it has several ethnomedical applications (Göhl, 1982; Ecocrop, 2015; Kay et al., 1987).

Roots and tubers undergo preparation and cooking before consumption, ranging from simple boiling to complex fermentation, drying, and baking. These crops are crucial for the nutrition of millions of people living in temperate zones, the tropics, and subtropics, where most of the world's population resides, often in undernourishment (FAO, 1990). Compared to cereals and legumes, root and tuber crops generally require less maintenance, fewer production inputs, and are less susceptible to pests and diseases. They are often farmed for subsistence, with only the surplus sold. Most are consumed fresh after boiling or roasting. Processing these crops yields various products, reduces post-harvest losses, improves flavor, and removes anti-nutritional elements like cyanide (Akaroda, 1992). Utilizing indigenous root crops in baked goods can reduce the cost of wheat flour importation and boost the local economy. Incorporating native root crops like arrowroot flour in baking can make inexpensive and nutrient-dense baked goods accessible and affordable to a large population, thereby reducing malnutrition in the nation.

This study aimed to examine the viability of using arrowroot flour as a versatile ingredient in baking. It assessed its effect on the final product's texture, taste, and overall quality through a series of controlled experiments and sensory evaluations. The researcher hopes to provide insightful information about the opportunities and challenges of incorporating arrowroot flour into baked goods, potentially closing the gap in sustainable and local food production.

Research Questions

This study aimed to develop pastry products (Pie and Tart) made from arrowroot flour and determine its acceptability.

Specifically, it sought to answer the following questions:

1. What are the processes involved in developing baked products (*Pie, Tart, and Cake*) using arrowroot flour?
2. What is the acceptability level of pastry products (*Pie, Tart, and Cake*) made from arrowroot flour in terms of:
 - a. appearance/ color;
 - b. aroma;
 - c. taste, and
 - d. texture?
3. What is the general level of acceptability of pastry products such as pie, tart, and cake made from arrowroot flour as evaluated by different age groups of respondents?
 - a. children;
 - b. teenagers;
 - c. adults; and
 - d. food experts
4. Is there a significant difference in the general level of acceptability of pie, tart, and cake made from arrowroot flour as perceived by the evaluators according to their age groups?
5. What is the nutritive value of pie, tart, and cake made from arrowroot flour?

6. What is the shelf-life of baked products made from arrowroot flour at room temperature?

METHODOLOGY

To conduct the study, tools, supplies, equipment, and materials were used.

1. Tools and Equipment

Preparation tools, measuring tools, mixing tools, cutting tools, baking pans, and equipment used in the conduct of the study are shown below.

Table 1. Tools and equipment needed in the preparation of Arrowroot pie, tart, and cake.

Preparatory Tools	Measuring Tools	Mixing Tools	Cutting Tools	Cooking Tools	Equipment
Flour Sifter	Measuring Spoons	Wire Whisk	Knife	Pie Pan	Oven
Utility Tray	Measuring Cups	Spoon	Dough Cutter	Gas Range	Dough Roller
Rolling Pin	Weighing Scale	Mixing Bowls	Chopping Board	Casserole	Blender
Bowl				Frying Pan	
Plate					
Kneading Table					
Grater					
Spatula					

The table shows the ingredients used in the production of baked products using arrowroot flour.

Table 2. Proportion of ingredients used in the preparation of Pie from arrowroot flour

Ingredients	Measurement
Arrowroot flour	1 ¼ C
Salt	½ tsp
Unsalted Butter	½ C
Sugar	¼ C
Cold water	¼ C
Arrow Root Pie Filling	
Egg whites	3 pcs.
Egg yolks	3 pcs.
Condensed Milk	396 G
Coconut Cream	396 G
Arrow root Halaya	½ C

Salt	$\frac{1}{4}$ tsp.
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Legend: C- Cup pc – Piece tsp – teaspoon G- grams

No. of Yields: 4 pcs. Small Sizes = 250 grams

Table 3. Proportion of ingredients used in the preparation of tart from arrowroot flour.

Ingredients	Measurement
Arrowroot flour	1 $\frac{1}{4}$ C
Salt	$\frac{1}{2}$ tsp
Unsalted Butter	$\frac{1}{2}$ C
Sugar	$\frac{1}{4}$ C
Arrow Root Tart Filling	
Egg whites	3 pcs.
Egg yolks	3 pcs.
Condensed Milk	396 G
Coconut Cream	396 G
Arrow root Halaya	$\frac{1}{2}$ C
Salt	$\frac{1}{4}$ tsp.

Legend: C- Cup Tbsp – Tablespoon pc – Piece tsp – teaspoon g- grams

No. of Yields: 6 pcs. small sizes = 250 grams

Table 4. Proportion of Ingredients used in the preparation of Cake from arrowroot flour

Ingredients	Measurement
Arrowroot flour	1 $\frac{1}{2}$ C
Cocoa Powder	1 C
Baking Powder	1 tsp
Baking Soda	1 tsp
White Sugar	1 C
Brown Sugar	$\frac{3}{4}$ C
Salt	$\frac{1}{2}$ tsp
Oil	$\frac{3}{4}$ C
Milk	1 C
Egg	1 Large Pc.
Vanilla	1 tsp
Coffee	1 tsp
Hot Water	$\frac{3}{4}$ C

Legend: C- Cup Tbsp – Tablespoon pc – Piece tsp – teaspoon

Method Used in the Study

The study utilized an experimental research design to develop baked products (Pie and Tart) made from arrowroot flour. Furthermore, it used a survey method to determine the acceptability of the developed products in terms of appearance/color, aroma, taste, and texture.

Developmental Procedures

This study used arrowroot flour. The developmental procedures began with selecting the arrowroot crops, which were then dried, finely ground, and sifted to become arrowroot flour. After the preparation of the arrowroot flour, the preparation of baked products followed.

Preparation of Arrowroot Flour

The preparation for arrowroot flour began with selecting and washing the local root crops. After ensuring they were clean, the crops were dried completely. Once dried, they were finely ground using a food processor until they reached a powdery consistency. The ground root crops were then sifted to remove any coarse particles, resulting in a smooth, fine flour.

Preparation of Pie, Tart, and Cake Products

The preparation of baked products from arrowroot flour began with sifting to remove dirt, and insects, and to separate and break up coarse particles. Next, the ingredients were measured exactly according to the standard recipe. Selecting the best quality ingredients was essential to ensure the final product's quality. Following this, the ingredients were mixed and combined into a homogenous mass to form the product.

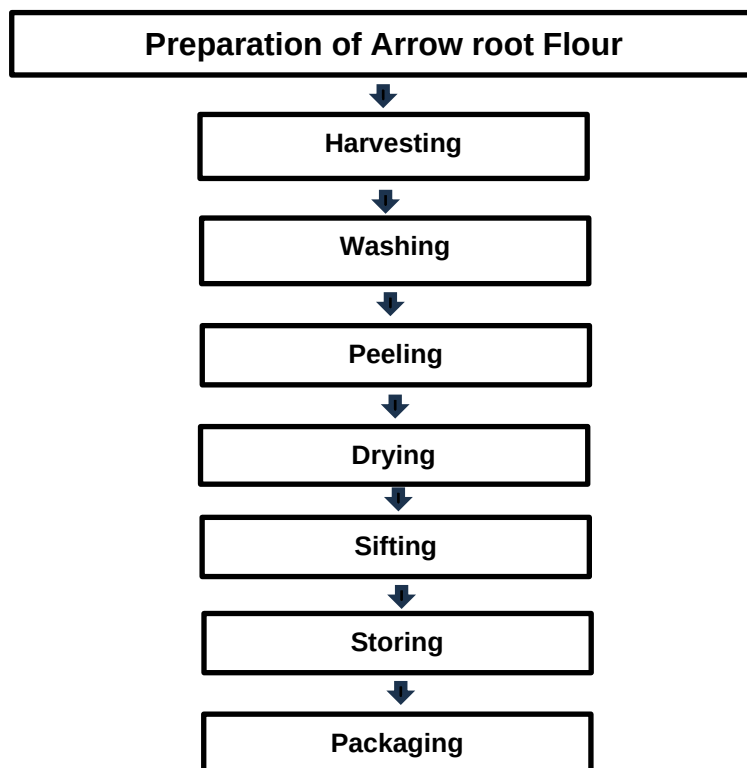


Figure 2. Process Diagram of the Preparation of Arrowroot Flour for Pastry Products

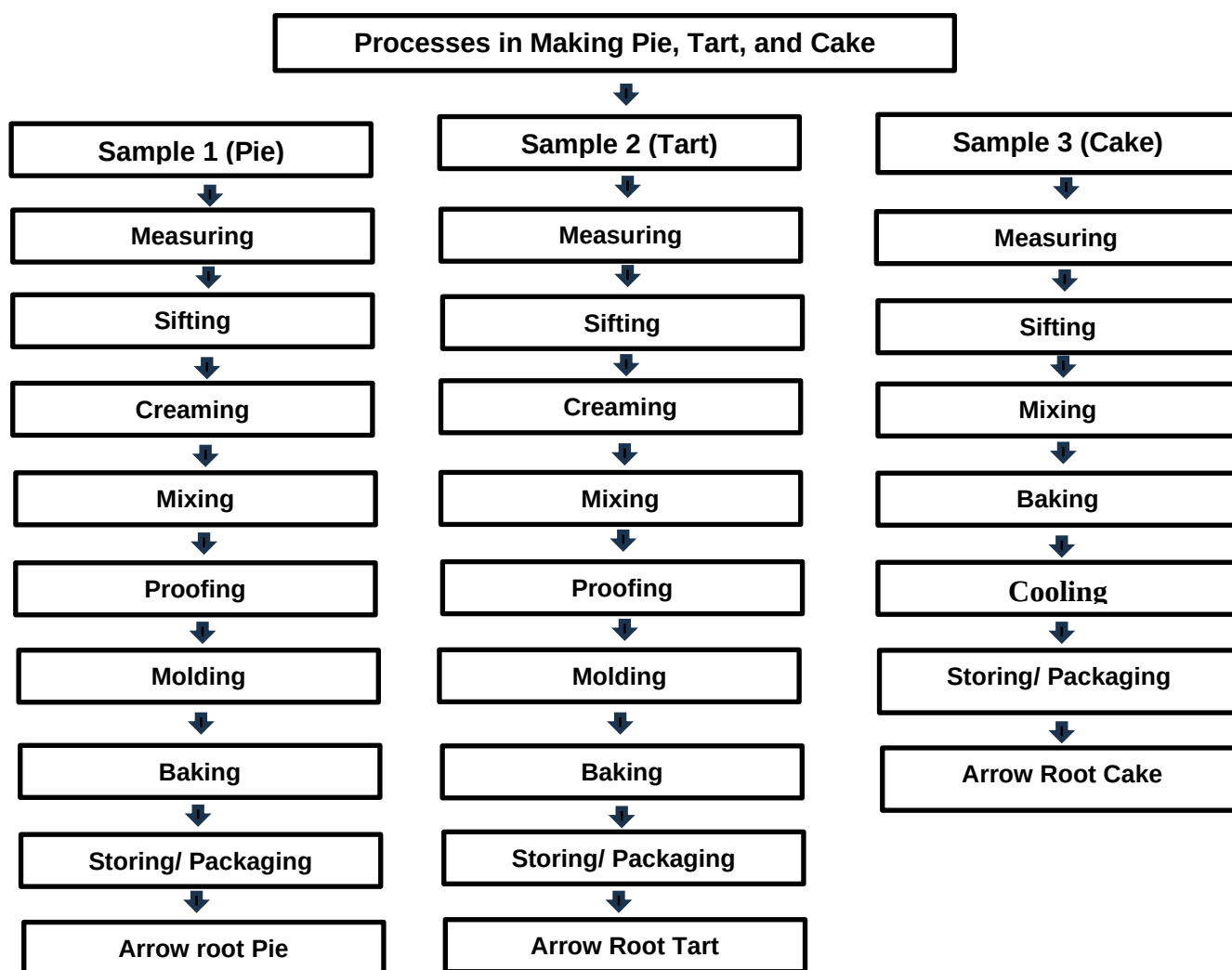


Fig. 2. Flow Diagram in the Making of Pastry Products from Arrow Root Flour

Data Gathering Instrument

The conducted study employed rubrics for evaluation, as well as a questionnaire, which respondents used to rate the treatment. These rubrics were chosen due to their suitability in measuring the acceptability of the products across various dimensions, including aroma, appearance, taste, texture, and overall acceptability.

Data Gathering Procedure

The respondents, including children, teenagers, adults, and food experts, were asked to perform a sensory evaluation of the developed products. After obtaining permission, the questionnaires were distributed. The researchers explained the directions for completing the questionnaires to the evaluators. Once completed, the questionnaire

checklists were retrieved by the researchers. The sensory assessment questionnaire checklist was used to compile data on the acceptability of arrowroot pie, tart, and cake.

Sensory Evaluation

The finished products were subjected to organoleptic/sensory evaluation. One hundred twenty (120) participants from varied age groups were purposely selected and oriented on how to evaluate the products using an evaluation form. The evaluators included children and adults from the Municipality of San Mariano, Isabela, as well as teenagers, adults, and Food Technology teachers from the Municipality of Cabatuan, Isabela, along with selected bakeshops in both municipalities. The study was conducted during the second semester of the 2023-2024 school year.

Each participant was asked to taste the baked products made from arrowroot flour. The data collection involved using a score sheet to determine the acceptability level of these baked products. Participants' responses were gathered using a Nine (9) point Hedonic Scale, as shown in Table 5, to assess the level of acceptability of the baked products made from arrowroot flour.

Table 5. The Range of Numerical Rating and its Descriptive Equivalent

SCALE	NUMERICAL RATING	DESCRIPTIVE RATING
9	8.50 – 9.00	Like Extremely
8	7.50 – 8.00	Like Very Much
7	6.50- 7.00	Like Moderately
6	5.50- 6.00	Like Slightly
5	4.50 – 5.00	Neither Like nor Dislike
4	3.50 – 4.00	Dislike Slightly
3	2.50 – 3.00	Dislike Moderately
2	1.50 – 2.00	Dislike Very Much
1	0.50- 1.00	Dislike Extremely

RESULTS

Product Development

The following were the procedures followed by the researcher in the making of the pastry products (Pie, Tart, and Cake).

Procedure for the Flakey Pie and Tart Crust

The procedure for making the flaky pie and tart crust began by measuring all the necessary ingredients. The dry ingredients were combined in a mixing bowl, and then

unsalted butter, cut into small pieces, was added to the mixture. A little water was gradually incorporated into the mix. Care was taken not to over-mix the dough. Once all the ingredients were mixed, the dough was formed into an oval or circle shape, wrapped in clean, clear plastic wrap, and placed in the refrigerator for about 30 minutes. After the chilling period, the dough was taken out, and a rolling pin dusted with flour was used to flatten it. The dough was then divided according to the required sizes and placed into pie and tart molds, making it ready for baking.

For the Arrowroot Pie and Tart Filling

The procedure for making the arrowroot pie and tart filling began by preparing and combining all the necessary ingredients for the filling. Arrowroot was then added to the mixture, and all the ingredients were thoroughly mixed. The filling was spooned into the prepared pie and tart crusts. The oven was preheated for about 20 minutes at 200 degrees Celsius. After preheating, the pies and tarts were baked for up to 30 minutes, or until the desired texture was achieved.



Figure 3. Materials and ingredients for the pastry products made from Arrowroot flour are carefully prepared

For the Arrow Root Cake

To prepare the arrowroot cake, the first step involved preparing and measuring all the required materials and ingredients. Once measured, both the dry and wet ingredients were combined in a mixing bowl. Carefully, the dry and wet ingredients were mixed until they formed a homogeneous mixture. Meanwhile, the baking pan was prepared by lining it with parchment paper, ensuring the inside was well-covered to prevent sticking. As the mixed ingredients were sifted into the baking pan, they were evenly spread to create a uniform layer. Following this preparation, the oven was preheated for approximately 20 minutes to reach the required temperature. Once the oven was properly preheated, the

filled baking pan was placed inside for the baking process. The cake was baked until it reached the desired level of doneness. After baking, the cake was removed from the oven and allowed to cool. Finally, once cooled, the arrowroot cake was carefully packed for storage or serving, ready to be enjoyed.



Figure 4. The Arrowroot Tart as a Final Product

Acceptability of Baked Products (Pie, Tart, and Cake) made from Arrowroot Flour

Table 6. Acceptability level of baked products (Pie, Tart, and Cake) made from arrowroot flour in terms of appearance/ color, aroma, taste, and texture

Variant	Criteria	Mean	Standard Deviation	Description
Pie	Appearance/Color	8.20	0.74	Like Very Much
	Aroma	8.24	0.73	Like Very Much
	Taste	8.34	0.85	Like Very Much
	Texture	8.15	0.84	Like Very Much
	Overall Rating	8.23	0.63	Like Very Much
Tart	Appearance/Color	8.24	0.62	Like Very Much
	Aroma	8.29	0.57	Like Very Much
	Taste	8.30	0.70	Like Very Much
	Texture	8.25	0.66	Like Very Much
	Overall Rating	8.2708	0.51	Like Very Much
Cake	Appearance/Color	8.37	0.72	Like Very Much

	Aroma	8.35	0.70	Like Very Much
	Taste	8.46	0.71	Like Very Much
	Texture	8.33	0.77	Like Very Much
	Overall Rating	8.3771	.60893	Like Very Much

The table presents the acceptability levels of baked products, namely pies, tarts, and cakes, made from arrowroot flour, evaluated across various criteria including appearance/color, aroma, taste, texture, and overall rating.

For pies, the mean scores for appearance/color, aroma, taste, texture, and overall rating are 8.20, 8.24, 8.34, 8.15, and 8.23 respectively, with standard deviations ranging from 0.63 to 0.85.

Similarly, the mean scores for tarts are slightly higher, with appearance/color at 8.24, aroma at 8.29, taste at 8.30, texture at 8.25, and overall rating at 8.2708, with standard deviations ranging from 0.51 to 0.70.

Cakes received the highest mean scores, with appearance/color at 8.37, aroma at 8.35, taste at 8.46, texture at 8.33, an overall rating at 8.3771, and standard deviations from 0.60893 to 0.77.

All three types of baked products made from arrowroot flour received high acceptability ratings, with mean scores indicating that the respondents "Like Very Much" across all criteria. The standard deviations suggest relatively consistent agreement among respondents regarding the quality of the baked products. In general, it can be concluded that baked products made from arrowroot flour, including pies, tarts, and cakes, are highly acceptable in terms of appearance, aroma, taste, texture, and overall satisfaction among consumers.

Hence, this finding is similar to the study of Singh & Iraj (2023) that the experimental preserved had the greatest average score for overall acceptability and largely approved by the panelists, products were organoleptically evaluated using the nine-point scorecard method or Hedonic Rating System.

General Acceptability of Baked Products (Pie, Tart, and Cake) made from Arrowroot Flour across Age Groups

Table 7. General level of acceptability of baked products such as pie, tart, and cake made from arrowroot flour as evaluated by different age groups of respondents

Variant	Respondents	Mean	Standard Deviation	Description
Pie	Children	8.11	0.71	Like very much
	Teenagers	8.28	0.66	Like very much
	Adults	8.33	0.53	Like very much
	Food Experts	8.21	0.63	Like very much

Tart	Children	8.19	0.51	Like very much
	Teenagers	8.34	0.64	Like very much
	Adults	8.25	0.42	Like very much
	Food Experts	8.30	0.45	Like very much
Cake				
	Children	8.25	0.73	Like very much
	Teenagers	8.35	0.67	Like very much
	Adults	8.56	0.48	Like extremely
	Food Experts	8.34	0.50	Like very much

The table presents the general level of acceptability of baked products, specifically pies, tarts, and cakes made from arrowroot flour, as evaluated by different age groups of respondents, including children, teenagers, adults, and food experts. For pies, the mean scores for children, teenagers, adults, and food experts are 8.11, 8.28, 8.33, and 8.21 respectively, with standard deviations ranging from 0.53 to 0.71. Similarly, for tarts, the mean scores are 8.19 for children, 8.34 for teenagers, 8.25 for adults, and 8.30 for food experts, with standard deviations ranging from 0.42 to 0.64. For cakes, children rated them at 8.25, teenagers at 8.35, adults at 8.56, and food experts at 8.34, with standard deviations ranging from 0.48 to 0.73.

Overall, across all age groups and baked product types, the mean scores indicate a high level of acceptability, with respondents consistently rating the products as "Like very much" or even "Like extremely" in the case of adult respondents evaluating cakes. The standard deviations suggest relatively consistent agreement among different age groups and food experts regarding the quality and acceptability of baked products made from arrowroot flour. Therefore, it can be concluded that these products are generally well-received across various age groups and among food experts, indicating their broad appeal and quality.

This finding is similar to the study conducted by (Gonzales & Mariano, 2022) in terms of its appearance, aroma, texture, color, and overall acceptability.

Comparison in the Level of Acceptability of Pie and Tart made from Arrowroot as Perceived by the Groups of Respondents

Table 8. Comparison in the level of acceptability of pie and tart made from arrowroot flour as perceived by the evaluators according to their age groups

Variant	F-value	p-value	Comparison	Decision	Remark
Pie	0.71	0.55	p-value > 0.05	Accept Ho	No significant difference
Tart	0.48	0.69	p-value > 0.05	Accept Ho	No significant difference
Cake	1.33	0.27	p-value > 0.05	Accept Ho	No significant difference

The analysis suggests that there is no significant difference in the general level of acceptability of pie and tart made from arrowroot flour among different age groups of evaluators. For pies, the F-value is 0.71 with a p-value of 0.55, indicating that the p-value is greater than 0.05. Similarly, for tarts, the F-value is 0.48 with a p-value of 0.69. Lastly, for cakes, the F-value is 1.33 with a p-value of 0.27. In all cases, the p-values are greater than the commonly used significance level of 0.05. Therefore, the null hypothesis (H_0) is accepted, indicating that there is no significant difference in the general level of acceptability of these baked products among different age groups of evaluators. This implies that regardless of age, respondents perceive pies, tarts, and cakes made from arrowroot flour similarly in terms of acceptability.

The findings above are similar to the findings of Claros & Palomar (1998) who found that arrowroot flour can be used as an ingredient in baked products.

Nutritive Value of Pie, Tart, and Cake Made from Arrowroot Flour

Arrowroot flour and baked goods made from it, such as pies, tarts, and cakes, have different nutritional profiles. Arrowroot flour itself is quite low in nutrients, containing 0.72% crude protein, 0.18% crude fiber, 0.48% crude fat, 12.08% moisture content, and 0.39% crude ash. In contrast, the baked products made from arrowroot flour show significantly higher nutritional values. They contain 2.15% crude protein, 0.22% crude fiber, 18.44% crude fat, 27.82% moisture content, and 1.33% crude ash.

Shelf-life of Pastry Products (Pie, Tart, and Cake) Made from Arrowroot Flour

The shelf-life of pastry products made from arrowroot flour, including pies, tarts, and cakes, varied in terms of their appearance, aroma, taste, and texture over time.

Arrowroot Pies and Tarts

On day 1, the products maintained their freshness, with no noticeable changes in appearance, aroma, taste, or texture. From day 2 to day 3, the products remained consistent in all aspects. From day 4 to day 10, the products continued to maintain their quality without significant changes. By day 11, the appearance began to change, showing signs of inflated filling. From day 12 to day 13, although the products were still edible, there were noticeable changes in appearance, with the filling showing signs of inflation. From day 15 to day 20, the texture of the filling became wet, making it less appetizing. While the crust remained compact, the filling was no longer edible. And, by day 21 to day 22, the pies and tarts were no longer edible due to mold growth in the filling.

Arrowroot Cakes

On day 1 and day 2, the cakes maintained their freshness, appearance, color, taste, and texture similar to freshly baked products. From day 3 to day 5, the cakes began

to show signs of moisture, with the appearance becoming wet. Additionally, mold growth started to develop, rendering the arrowroot cake inedible beyond this point.

Conclusions

The study confirms that arrowroot flour is an excellent ingredient for pies, tarts, and cakes, achieving high acceptability across all sensory criteria and age groups. The products made from arrowroot flour also show enhanced nutritional value. Despite a limited shelf-life, arrowroot-based baked goods offer a nutritious and appealing alternative for health-conscious consumers and the food industry.

Recommendations

In view of the findings and conclusions of the study, the following are recommended:

1. Given the high acceptability of arrowroot-based pies, tarts, and cakes, it is recommended for food technologists, food teachers, and students to experiment with other pastry products using arrowroot flour, such as cookies, muffins, and bread, to broaden the product range.
2. Methods to extend the shelf-life of arrowroot-based baked goods, such as incorporating natural preservatives or optimizing packaging techniques, to maintain product quality for a longer duration should be investigated.
3. The researcher should market the nutritional benefits of arrowroot flour products to health-conscious consumers, emphasizing the higher protein and fat content in baked goods compared to raw flour.
4. Educational campaigns highlighting the benefits of arrowroot flour, its nutritional advantages, and the sensory appeal of the products made from it, to increase consumer awareness and demand be conducted.
5. There should be a collaboration with food teachers, culinary experts, and nutritionists to develop new recipes and enhance the quality of existing products, ensuring they meet both culinary standards and consumer preferences.
6. The researcher is encouraged to collaborate with government agencies like the Department of Science and Technology (DOST) and the Department of Trade and Industry (DTI) for the promotion of arrowroot flour as a sustainable ingredient,

highlighting its environmental benefits compared to other conventional flours, to appeal to environmentally-conscious consumers.

Compliance with Ethical Standards

The author hereby declares that this study was conducted in full compliance with ethical standards, including obtaining informed consent from all respondents. Respondents were given the freedom to withdraw from the study at any time without any consequences. The anonymity of the respondents was strictly maintained throughout the research process, and their well-being was safeguarded at all times. He affirms that there is no conflict of interest in the conduct of this study. Furthermore, plagiarism was strictly avoided, and the study's findings were interpreted without any bias. The results of this study are used purely for research purposes.

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