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Formulation, Analyses, And Acceptability of Root Crops Puto Pao with Black Rice

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Abstract: This experimental-development research was conducted during school year 2024-2025 aimed to formulate a root crop puto pao with black rice; to describe the sensory qualities of root crop puto pao with black rice flour in terms of appearance, aroma, taste and texture.; to determine which treatment is generally acceptable in sensory qualities; to find out if there are significant differences among treatments in terms of their sensory qualities and general acceptability; and to determine the products' shelf life in room temperature and in chilling temperature. The three (3) treatments were: TA (Cassava puto pao) ; TB (Sweet potato puto pao); and TC (Taro puto pao). The sensory qualities of the product were evaluated by ten semi-trained panellists. While the general acceptability was evaluated by one hundred consumers composed of students and teachers of Dao National High, Dao, Capiz. Mean and ANOVA were the statistical tools used to analyze the data using the Statistical Package for the Social Sciences software. Sweet potato variant was the most preferred product in in all sensory qualities and the generally acceptable among treatments. There were no significant differences in appearance and aroma while there were significant differences in the products taste and texture. There were significant difference in appearance, aroma, taste and texture in the general acceptability. Post Hoc test revealed that these differences were manifested between TC (sweet potato) and TA (cassava) variants. Similarly, TC (Taro) and TB (sweet potato) variants significantly differ in all sensory qualities.

Keywords: Alternative root crops flour source, black rice, puto pao, sensory qualities

I. INTRODUCTION

Baked products are commonly made from wheat flour. Wheat flour is the main ingredient for production of the bakery products such bread, biscuits, pie, cake, and many more. Aside from baked products, there are also steamed food products which are flour-based. Puto Pao (steamed cake) can be considered as one of these.

Producing food products from sweet potato flour are very feasible due to its availability, natural color, high-energy, low-protein, good biological activity in the human diet and low cost, as a result, become a key ingredient for the production of new products in the current global habitation. Sweet potato flours can be used for imparting desired properties, nutritional value, antioxidants, and natural color to processed foods and also used as thickeners and gelling agents. Sweet potato is rich in carbohydrate, dietary fibers, and potassium, low in fat and is an important source of the β-carotene. The sweet potato is becoming increasingly popular for various products production such as chips, drinks (wine, liquor), sugar production, flour, pasta, alcohol, etc. the sweet potato is becoming widely accepted in the daily diet (Truong et al. 2018). Likewise, cassava flour (*Manihot esculenta)* is a good substitute for wheat flour in a variety of recipes. Cassava flour comes from the root vegetable cassava. This is a vegetable that is rich in carbohydrates and contains important vitamins and minerals (Hodgson, 2021).

Moreover Arıcı et al. (2021) found out that higher resistant starch content was observed in GFB samples than WFB. Dietary fiber content increased significantly as taro flour addition was increased in both formulations ($p < .05$). Acceptable sensorial properties were achieved with the substitution level of 12.50% for WFB and 18.70% for GFB.

Various literatures provide information on the functional properties and strength of various root crop flours when used as substitutes for wheat flour. However, no documented studies were found regarding the outcomes of products made by combining black rice flour with root crop flours.

Additionally, the researcher observed that various *puto* variants are sold throughout the province of Capiz. Many of these are made using commercial flour or traditional rice flour. However, at the time this study was conceptualized, no variant of *puto* made with black rice and root crop flours was identified. If such a product existed, it had not yet been documented or widely known. Insights from the literature and the researcher's observations, this study was undertaken to address the identified gap.

The study generally aim to formulate and determine the acceptability root crops puto pao as sweet potato, cassava and taro with black rice. Specifically, it aimed to describe the sensory qualities and the general acceptability of root crop

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puto pao in terms of appearance, aroma, taste and texture. Likewise, the study investigated if there are significant differences among treatments. The shelf like of the product placed in room and in chilling condition were also determined.

II. METHODS AND MATERIALS

The study was experimental-developmental research. It aimed to develop a nutritious puto pao utilizing different root crops flour substitute such as cassava, sweet potato, and taro. Aside from introducing a tangible product, the study aimed to come up with a standardized recipe based on the taster's evaluation results.
The study employed a Completely Randomized Design (CRD), involving three Treatments A, B, and C, each with three replications. Each treatment consisted of varying proportions of a primary flour source combined with black rice (BR) as an additive. The primary flour sources used were cassava (C), sweet potato (SP), and taro (T). Black rice served as a nutritional and functional supplement to these root crop flours.

The product for each treatment were evaluated by the semi-trained panelists in terms of their sensory attributes to determine which treatment within each product group has the best appearance, aroma, taste and texture. After which, the treatment with the highest score based on the ratings and feedback of the evaluators were mass-produced and were subjected to further evaluation by a separate set of evaluators to assess their overall acceptability.
The materials used in the study were the following frying pan, knife, plastic chopping board, wooden ladle, strainer, bowl, and food container with cover, strainer, measuring cups, puto molders, cupcake paper cups, clean cloth, digital weighing scale, steamer, stove and working table.

Root crops Puto Pao Treatments formulation
Table 1 presents the treatments in preparing the root crops puto pao with black rice flour. After the evaluation of the semi-trained panelist, the chosen products in each treatment were as follows: Treatment A-95g C + 5g BR; Treatment B-95g SP +5g BR; and Treatment C- 90g T +5g BR. These formulations with other ingredients in making the root crop were followed for the products' mass production to be evaluated by 100 consumers.

Table 1. Treatments in preparing root puto pao using root crops flour with black rice flour

Ingredients	Treatments (Cassava)			Treatments (Sweet Potato))			Treatments (Taro)		
	A	B	C	A	B	C	A	B	C
Cassava Flour	95	90	85						
Cassava Flour				95	90	85			
Cassava Flour							95	90	85
Black Rice Flour	5	10	15	5	10	15	15	10	15
Baking Powder	10g	10g	10g	10g	10g	10g	10g	10g	10
Butter	14g	14g	14g	14g	14g	14g	14g	14g	14g
Egg	50g	50g	50g	50g	50g	50g	50g	50g	50g
Fresh milk	90 g	90 g	90 g	90 g	90 g	90 g	90 g	90 g	90 g
Granulated Sugar	80g	80g	80g	80g	80g	80g	80g	80g	80g

Experimental procedure

A. Procedure in Preparing Root Crop Flour and Black Rice flour

1. Procedure in Making a Cassava Flour
First, newly dug out cassava was chosen. The tuber was smooth and intact, free from molds and cracks. The outer skin was brown and rough and the inner flesh was white not black or bluish. It was then peeled and washed in a running water. Next, it was sliced thinly using a sharp knife and dried under the heat of the sun. It was milled until flour-like in texture. Finally, it was placed in a clean and dry container for future use.

2. Procedure in Making a Sweet Potato Flour
First, a good quality of sweet potato was be chosen. That is, the outer skin is free of damaged, vibrant without dark or greenish patches and looks newly harvested. Next, it was washed, peeled and sliced thinly and dried under the heat of the sun. When dried, it was milled until powdered fine. Lastly, it was placed in a clean container and covered tightly for later use.

3. Procedure in Making Taro flour

First, a good quality of taro was chosen. To determine that taro was in good quality, the following were observed: the outer skin was brown and fibrous with minimal discoloration. It was firm and heavy that its size. Next, it was peeled and washed thoroughly in a running water. It was sliced thinly and dried under the heat of the sun. When completely dried, it was milled until becomes flour-liked in texture. Lastly, it was kept in a clean and dry container for future use

4. Procedure in Making Black Rice Flour

First, a good quality of black rice was chosen. The chosen black rice had a consistent dark purple color. The grains were intact with minimal broken kernels. Likewise, these were free stones, dirt, mold and other stuffs. Then, it was cleaned using the winnowing fan. The unnecessary particles were removed and chaffed. It was milled until powdered-fine and was placed and stored in clean and dry container for future use.

B. Preparation of Asado Filling

Step 1. Preparing of Needed Ingredients

First, the needed ingredients in cooking the asado filling gathered and prepared. Then, the ingredients were weighed based on the set recipe. The ingredients needed were the following: 25 grams cooking oil, 25 ramsg minced onions, 2 grams minced garlic, 500 grams ground pork, 50 grams soy sauce, 50 grams, oyster sauce, 50 grams brown sugar, 25 grams cornstarch and 50ml water. Finally, they were arranged according to their sequence in the recipe.

Step 2. Cooking of Asado Filling

In cooking the asado filling, the procedures were as follows: first, the oil was heated in a pan. Then the minced onions were sautéed until looks translucent. The minced garlic was added and stirred until brown and fragrant. Next, the 500 grams ground seafood was added stirring slowly until the color changes. The soy sauce, oyster sauce, and brown sugar was be added in. The sauteed mixture were stirred once in a while until the ground pork was tendered. In a while, the cornstarch was dissolved in a water by stirring until it looked slurry. It was added to the ground pork to be thickened and was stirred gently until well-combined. Finally, it was too out from the fire, and placed in a clean food container and set aside to cool down.

C. Preparation Root Crop Puto Pao with Black Rice

Step 1. Preparing of Needed Ingredients

The first step in making a root crop puto pao with black rice was the preparation of the required ingredients. Three separate bowls were used. Two of which contained 5 grams of Black Rice flour and the other one contained 10 grams. Additionally, three separate bowls were prepared, each contained 95 grams of cassava flour, 95 grams of sweet potato flour, and 90 grams of taro flour, respectively. Other ingredients included 10 grams baking powder, 90 grams white sugar, 14 grams butter, 90 milliliters fresh milk, and 50 grams grams of egg white. All measured ingredients were then arranged in order according to the recipe's procedure

Step 2 Procedure in making Root Crop Puto Pao with Black Rice

The 95 grams cassava flour, 95 grams sweet potato flour and 90 grams taro flour were weighed separately. Also, two separated bowls each with 5 grams black rice flour and one bowl with 10 grams black rice. These were all sifted to remove the lumps. Then, for treatment A, the 90g CF and 5 grams black were mixed thoroughly along with other dry ingredients such as baking powder and white sugar. Next, the 90 grams fresh milk was poured in and mixed well.

In a while, the egg was beaten and added to the mixture.. The white sugar was added gradually in 3 parts while whipping until stiff. The batter was added to the dry ingredients. A molder lined with paper cups was filled half of the mixture. The asado was also added in the middle and filled up full by the mixture. The filled puto molders was placed in a steamer. The lid of the steamer was covered with a cloth to prevent water from dripping. Finally, it was steamed in an already boiling water for 10 to 12 minutes.

The same ingredients and procedures were followed for the rest of the treatments except for the root crops flour with black rice flour in each treatment.

Collection of Data

To collect the data, the evaluation sheets was used. The product was presented for evaluation to the two groups of evaluators. The first group was the food technology specialists composing of the faculty members of CAPSU Main Campus. Each treatment's samples were presented to them for pre-tasting. The gathered comments and evaluation for the improvement of the product were integrated to the formulation and production of the product.

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The other group of evaluators were the faculty, students and community members of Dao National High School in the Municipality. Each evaluator was given an evaluation sheets during the products' final tasting. Prior to it, the researcher gave a brief rationale and the purpose of the study and that their honest responses are very significant to the realization of the endeavor. Likewise, they were guided on how to rate the sensory qualities of the product using the scale in the evaluation sheet. These include the appearance, aroma, texture, taste. The products were replicated thrice to assure reliable result. The accomplished evaluation sheets were gathered immediately. Finally, it was tabulated, analyzed and interpreted.

Statistical Tools

Mean and Analysis of Variance (ANOVA) were the statistical tools used in the analysis and interpretation of the data gathered. Mean was used to describe the sensory qualities and to determine the general acceptability of black rice puto pao using three treatments. On the other hand, ANOVA set at 0.01 alpha was used to determine the significant differences among treatments in terms of appearance, aroma, texture, and taste. Least Square Difference (LSD) was used to identify which treatments differ in the sensory qualities among treatments.

III. RESULTS AND DISCUSSIONS

Sensory Qualities of Root Crop Puto Pao With Black Rice

Table 2 presents the sensory evaluation of root crops puto pao variants in terms of appearance, aroma, taste and texture. There were three variants such as Treatment A (95g Cassava and 5g Black Rice), Treatment B (95g Sweet Potato and 5g Black Rice), and Treatment C (90g Taro and 10g Black Rice).

Among the three variants, the sweet potato puto pao (treatment A) obtained the highest mean score for appearance (M=8.20), described as extremely attractive. This may be attributed to the natural vibrant color of sweet potato, which is enhanced when steamed, offering a visually appealing golden hue. Previous studies by Sun (2022) and Tan et al. (2019) emphasized that sweet potato flour enhances the visual quality of baked and steamed goods due to its pigmentation and moisture retention properties. Cassava puto pao (Treatment B) got a score of (M=8.10), described as very much attractive. Cassava's neutral color and its ability to blend well with black rice resulted in a consistent and clean finish. This aligns with the findings of Apea-Bah et al. (2016), who noted cassava's good compatibility in composite flour blends, yielding acceptable visual outcomes. On the other hand, the taro and black rice variant received the lowest appearance rating (M=7.70), or moderately attractive. While taro can contribute to a rich texture and unique color, its darker tone, especially when combined with a higher proportion of black rice, may have affected the uniformity and brightness of the product. Rachmayanti et al. (2023) also observed that taro's appeal in visual aspects depends heavily on variety and proportion used in formulations.

In terms of aroma, the sweet potato variant obtained a highest mean score of (M=8.20), interpreted as extremely pleasant. This result confirms the findings of Focbit et al. (2025), where sweet potato-based puto was highly rated for its natural, sweet, and inviting aroma. The natural sugars and bioactive compounds in sweet potato likely contributed to this pleasing scent. Cassava and black rice variant was slightly behind with a score of (M=7.90), or very moderately pleasant. While cassava has a mild aroma, its neutral scent blended well with the black rice, producing a subtle but acceptable smell. Taro and black rice, with a mean of (M=7.70), also achieved a very moderately pleasant rating, yet it was perceived to have a more earthy or root-like aroma. This is supported by Zubair (2023), who noted that the earthy aroma of taro could influence sensory perception, and sometimes necessitates adjustments in formulation to be more appealing.

Taste is an important factor for product acceptability, and the sweet potato variant once again received the most favorable rating (M=8.10), described as very moderately desirable. The sweet potato's inherent sweetness and rich starch composition enhanced the overall flavor of the puto pao, finding in the studies of Pradhanang & Yu (2022) and Sun (2022), highlighted that sweet potato flour contributes positively to flavor in steamed cakes. Cassava with black rice scored a lower taste rating of (M=7.10), described as moderately desirable. Cassava's taste is typically bland and requires enhancement, as noted by Aidoo (2022). Taro and black rice variant achieved a taste rating of (M=7.30), moderately very desirable, suggesting that while it was generally acceptable, the distinctive earthy flavor of taro may not be favored by all consumers. Findings from Mohamed et al. (2018) indicated that taro flour-based products often require flavor enhancement to meet consumer expectations.

Considering texture, the sweet potato and black rice variant earned the highest score (M=8.30), interpreted as extremely soft and smooth. This superior texture quality can be attributed to sweet potato's high starch content and gelatinization

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properties, which contribute to a moist, tender crumb in steamed products (Santiago et al., 2020). These qualities make it particularly suitable for steamed delicacies like puto pao. Cassava puto pao variant followed with a rating of (M=7.30), described as very moderately soft and smooth. This is consistent with cassava's water-binding capacity and elasticity, as highlighted by Charles et al. (2021). Meanwhile, the taro and black rice variant got the lowest texture score (M=7.20), or moderately soft and spongy. Although taro has good cooking qualities that help make food soft and moist, it also has a thick, sticky substance and more starch, which may have made the puto pao feel heavier or stickier than the other versions. This characteristic was also observed in the study by Zubair (2023)."

The sweet potato and black rice variant consistently gained the highest mean among others across all sensory qualities, indicating its strong potential as the most acceptable and marketable version of root crop puto pao. Cassava, while effective in delivering texture and visual consistency, may benefit from the addition of flavor-enhancing ingredients to improve taste appeal. Taro, with its distinct flavor and texture, may suit niche markets but might require formulation refinement to achieve broader consumer acceptability.

The integration of black rice across all variants contributes not only to sensory attributes such as appearance and texture but also to nutritional enhancement, aligning with findings by Kumari and Gupta (2024), who emphasized its functional health benefits. The study supports the potential of combining indigenous root crops with black rice to create innovative, healthful, and sensory-pleasing local delicacies like puto pao.

Table 2. Sensory qualities of root crop puto pao with black rice in terms of appearance, aroma, taste and texture

Sensory Qualities	**Treatment A**		**Treatment B**		**Treatment C**	
	Mean	AD	Mean	AD	Mean	AD
Appearance	8.10	VMA	8.20	EA	7.70	MA
Aroma	7.90	VMP	8.20	EP	7.70	VMP
Taste	7.10	MD	8.10	VMD	7.30	MVD
Texture	7.30	VMSS	8.30	ESS	7.20	MSS
Sensory Qualities	**7.60**		**8.20**		**7.48**	

Legend: *EA- Extremely Appealing* *VMP - Very Much Pleasant* *VMS – Moderately Soft and Spongy*
EP - Extremely Pleasant *VMS - Very Much Delicious* *MD – Moderately Delicious*
ESS - Extremely Soft and Spong *VMA -Very Much Appealing* *MA - Moderately Appealing*
VMSS-Very Much Soft and Spongy

General Acceptability of Root Crops Puto Pao in terms of Appearance, Aroma, Taste and Texture

Data in Table 3 reflect the general acceptability of root crops puto pao such as cassava, sweet potato and taro with black rice. The appearance of the root crop puto pao variants revealed that the sweet potato formulation (Treatment B) received the highest score (M=9.00), described as "liked extremely." This superior visual appeal can be attributed to the vibrant natural color of sweet potato and its ability to retain brightness and structure during steaming. This finding aligns with Sun (2022), who found that sweet potato enhances the color of steamed products, making them more visually attractive. The taro-based puto pao (Treatment C) followed with a score of (M=8.11), described as "liked very much." Although taro contributes a unique tone to the steamed product, its combination with black rice may have resulted in a darker and less uniform appearance. Cassava (Treatment A) obtained a slightly lower score (M=8.02), also described as "liked very much." While cassava blends well in composite flours and contributes to a smooth finish (Apea-Bah et al., 2016), it lacks the bright coloration found in sweet potato, which may explain the difference in appearance ratings.

Considering aroma, the sweet potato variant (Treatment B) again got the highest score (M=9.00), described as "liked extremely." The natural sweetness and pleasing scent of sweet potato contributed significantly to this result. The study by Focbit et al. (2025) supports this finding, as sweet potato flour was reported to be highly rated for aroma in steamed delicacies. The taro variant (Treatment C) gained a rating of (M=8.49), also described as "liked extremely," indicating that despite its earthy smell, it was still appealing when combined with black rice. Cassava (Treatment A) had a slightly lower score of (M=8.04), described as "liked very much." While cassava has a subtle aroma, it complements the black rice's nuttiness, making the overall scent pleasant, though not as aromatic as sweet potato.

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In terms of taste, the sweet potato variant (M=8.90) surpassed the other two variants. This supports the findings of Pradhanang & Yu (2022) and Sun (2022), who noted that sweet potato flour enhances the flavor of steamed food products. Taro came in second with a score of (M=8.39), and cassava followed with (M=8.31), both still considered "liked extremely." Taro's slight earthiness might have added depth to the flavor, while cassava, although typically mild in taste, benefited from the blend with black rice. These findings are consistent with Aidoo (2022), who emphasized cassava's need for flavor enhancement when used in food products.

Concerning texture, the sweet potato variant emerged with the highest rating in (M=9.00), described as "liked extremely," indicating that its formulation produced a notably soft and pleasing consistency. This result is reinforced by the findings of Manoi and Santhosh (2017) and Sun (2022), who both reported that sweet potato flour enhances the softness and moistness of baked and steamed products due to its excellent water-holding and gelatinization properties. Additionally, the high fiber and beta-carotene content in sweet potato may contribute to a balanced density that improves overall mouthfeel without being overly gummy or sticky.

Interestingly, cassava-based puto pao also was also "liked extremely" (M=8.31). Cassava's high starch and water absorption capacity were noted by Apea-Bah et al. (2016) and Sunmonu et al. (2021) to improve elasticity and volume in composite flour products. However, unlike sweet potato, cassava's contribution to texture is more neutral, it does not add much flavor or color, which can sometimes limit its sensory impact. Still, cassava has been considered a reliable base ingredient in gluten-free baking due to its ability to mimic the structure of wheat-based products (Oladunmoye et al., 2019).

The taro variant, although it gained the lowest score in texture (M=8.19), still fell within the "liked extremely" range. This suggests that while acceptable, there were textural nuances that made it slightly less preferred compared to the other two. Notably, taro has been identified by Kaushal, Kumar, & Sharma (2015) and Nagar (2021) as having strong water-binding capacity and a high starch content, which are advantageous for moisture retention.

Contrasting findings from Arici (2020) showed that taro flour could replace wheat flour in both gluten-free and traditional baked goods without negatively affecting texture provided that substitution levels are optimized. This suggests that while taro is a promising ingredient for steamed and gluten-free applications, its usage must be carefully balanced with other ingredients to achieve a desirable texture.

Moreover, the incorporation of black rice, common across all treatments, may have also influenced texture outcomes. As noted by Kumari and Gupta (2024), black rice increases fiber content and antioxidant activity but can also contribute to slight grittiness or coarser texture, depending on the grind size and processing. Therefore, the interaction between root crop starches and black rice composition is an important factor to consider in future product development.

In general, while the results of the current study validate sweet potato as the most texturally acceptable variant for puto pao, previous research also indicates that cassava and taro hold significant potential when carefully formulated. The findings emphasize that achieving optimal texture in steamed root crop-based products requires not just selecting the right main ingredient, but also balancing moisture, starch structure, and fiber interactions, especially when nutrient-rich components like black rice are included.

Table 3. General acceptability of puto pao in terms of appearance, aroma, taste and texture.

Sensory Qualities	TREATMENTS					
	A (Cassava)		B (Sweet Potato)		C (Taro)	
	Mean	AD	Mean	AD	Mean	AD
Appearance	8.02	LVM	9.00	LE	8.11	LVM
Aroma	8.04	LVM	9.00	LE	8.49	LE
Taste	8.31	LE	8.90	LE	8.39	LE
Texture	8.31	LE	9.00	LE	8.19	LE
Acceptability	8.17		8.98		8.30	

Legend: AD -Adjectival Description LE-Liked Extremely LVM- Liked Very Much

Difference in Sensory Qualities of Root Crops Puto Pao in terms of Appearance, Aroma, Taste and Texture

Table 4 presents the difference in sensory qualities of root crops puto pao variants in terms of appearance, aroma, taste and texture.

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The analysis of variance (ANOVA) revealed no statistically significant difference in the appearance scores of the three treatments (*f= 1.783, p=0.187 > 0.01*). indicating that all variants were visually acceptable to the panelists regardless of the root crop used. Thus, the null hypothesis "there is no significant difference in the appearance of root crop puto pao" is accepted.

This implies that the inclusion of black rice and the formulation method produced a consistent and generally appealing visual result. The result conforms the findings of Apea-Bah et al. (2016) and Oladunmoye et al. (2019), who emphasized cassava's compatibility in composite flour formulations for maintaining attractive product appearance. Furthermore, Tan et al. (2019) reported that both sweet potato and taro contribute natural pigments that enhance visual appeal, particularly when used in steamed products. Therefore, the uniformity in appearance scores across all three treatments suggests that each root crop variant can contribute acceptably to product aesthetics when combined with black rice.

In terms of aroma, the inferential analysis found no significant difference among treatments, *(p-0.187 > 0.01). Similarly, the null hypothesis ""*there is no significant difference in the appearance of root crop puto pao" was accepted. This indicates that the three puto pao variants have almost the same aroma. This finding is consistent with the observations of Focbit et al. (2025), who noted that sweet potato imparts a naturally pleasant aroma, enhancing the sensory appeal of steamed goods. Similarly, cassava and taro are relatively neutral in scent, which allows them to blend well with other ingredients like black rice.

On the other hand, a significant difference was found in the taste scores of the three variants *(f= 12.814, p=0.000< 0.01)*. It indicates that the tastes of the three variants vary. Therefore, the null hypothesis "There is no significant difference in the taste of the puto pao variant was rejected. This supports findings from Sun (2022) and Pradhanang & Yu (2022), who noted that sweet potato enhances both the flavor and nutritional quality of steamed delicacies. Treatment C (taro) followed, offering a mild earthy taste, while Treatment A (cassava) had the lowest taste rating.

Texture also revealed a highly significant difference among the three treatments *(F=17.224, p=0.000< 0.01)*. This implies that the three puto pao variants differ in taste in favor of the sweet potato variants. It has a soft and smooth texture, the null hypothesis "There is no significant difference in the texture of the product was rejected". This is in line with the findings of Santiago et al. (2020) and Manoi & Santhosh (2017), who found that sweet potato's starch structure contributes to excellent gelatinization and moisture retention, ideal for steamed products.

The significant differences found in taste and texture among the three treatments underscore the importance of ingredient selection in food product development. The superiority of sweet potato in both taste and texture suggests that it is the most suitable root crop base for puto pao with black rice, offering both enhanced flavor and a pleasing mouthfeel. These findings support earlier studies that champion sweet potato's use in functional, steamed, and gluten-free products for its sensory and nutritional benefits.

The Post Hoc Test using the Least Square Difference (LSD) at a 0.01 level of significance further revealed that sweet potato puto pao variant (TB) and Cassava puto pao variant (TA) p=0.000 < 0.01 showed significant difference in both taste and texture. Same is true with sweet potato puto pao (TA) and taro puto pao variant (p = 000 < 0.01) . This suggests that while the root crop composition influences sensory attributes, certain formulations yield comparable results in terms of consumer acceptability.

On the other hand, the acceptability of cassava and taro particularly in appearance and aroma demonstrates that these root crops still hold promise, especially when paired with flavor enhancers or adjusted formulations.

Table 4. Difference in the sensory qualities of root crop puto pao with black rice

Sensory Qualities	F	P value	Remarks
Appearance	1.783	0.187	ns
Aroma	3.717	0.037	ns
Taste	12.814	0.00	s
Texture	17.224	0.00	s

p-value>.01, not significant, p-value<.01, significant

Difference in the General Acceptability of Root Crops Puto Pao in terms of Appearance, Aroma, Taste and Texture

Table 5 presents the statistical analyses of the differences in general acceptability of root crops *puto pao* variants. The results indicate a significant difference in the appearance, aroma, taste, and texture of the product at 0.01 level of significance. Specifically, the analysis of variance (ANOVA) yielded p-values of 0.00 <0.01 in all sensory attributes, leading to the rejection of the null hypothesis, which stated that there is no significant difference in the sensory qualities among the different treatments. This suggests that the type of root crop used whether cassava, sweet potato, or taro has a significant impact on the sensory characteristics of *puto pao* such as appearance, aroma tasted and texture.

The findings imply that each root crop possesses distinct physicochemical properties that influence the product's overall acceptability. For example, sweet potato flour is known for its natural sweetness and vibrant color, which may enhance the visual appeal and flavor profile of *puto pao* (Sun et al., 2022). In contrast, cassava flour is widely used in food formulations due to its neutral flavor and high starch content, which may contribute to texture but could require additional flavoring agents to improve overall taste (Aidoo et al., 2022). Taro flour, on the other hand, has a distinct earthy flavor and high moisture-retaining properties, which may influence the softness and cohesiveness of steamed products (Nagar et al., 2021).

The Post Hoc Test using the Least Square Difference (LSD) at a 0.01 level of significance further reveals that certain *puto pao* variants exhibit significant variations in sensory attributes. Specifically, the cassava *puto pao* variant (TA – 95g C + 5g BR) and the sweet potato variant (TC - 90g T + 5g BR) showed significant difference in appearance ($p = 0.00 < 0.01$), taste ($p = 0.00 < 0.01$), and texture ($p = 0.00 > 0.01$). This suggests that while the root crop composition influences sensory attributes, certain formulations yield comparable results in terms of consumer acceptability.

Moreover, the findings align with previous studies indicating that black rice flour can enhance the nutritional profile of bakery and steamed products while influencing color and texture (Kumari & Gupta, 2024). The observed sensory variations suggest that further research on the physicochemical interactions between black rice and root crop flours may lead to improved formulations.

On the other hand, some studies suggest that the use of root crops in food formulations may present challenges, such as variations in water absorption capacity and starch composition, which can affect product consistency (Zubair et al., 2023. From a commercial standpoint, the findings support the growing trend of incorporating indigenous and functional ingredients into traditional food products.

Table 5. Difference in the general acceptability of root crop puto pao with black rice

Sensory Qualities	F	P value	Remarks
Appearance	128.634	0.00	s
Aroma	23.070	0.00	s
Taste	10.243	0.00	s
Texture	19.110	0.00	s

p-value>.01, not significant, p-value<.01, significant

Shelf-life of Root Crops Puto Pao with Black Rice

The shelf life of the root crop puto pao is shown in Table 6. The shelf life was determined in terms of room and chilling temperature.

Room Temperature. The root crops puto variants were stored at room temperature for 7 days. These were monitored daily. No changes took place within 2 - 7 days. On the 14th day, the smell started to change.
Chilling Temperature. When root crops puto pao were stored at chilling temperature, it stayed in good condition for 15 days and beyond.

These results are consistent with findings from similar food shelf-life studies. For instance, Dizon et al. (2017) observed that refrigerated conditions extended the shelf life of steamed rice-based kakanin products by inhibiting microbial activity, particularly mold growth. Likewise, the work of De Leon and Beltran (2020) on root crop-based delicacies emphasized that low temperature storage significantly delayed spoilage processes due to slower enzymatic and microbial activity.

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Similarly, Amoah et al., 2020 emphasized that incorporating black rice, which contains anthocyanins with mild antimicrobial properties, may offer some protective benefit; however, this is insufficient to overcome the microbial proliferation observed by the 7th day at room temperature.

Table 6. Shelf life of root crops puto pao with black rice when stored in room and chilling temperature.

Puto Pao	Molds formation)	Molds formation, slimy	Molds formation, slimy, production of spot
Room Temperature	7 days	14 days	30 days
Sweet Potato Puto Pao	-	+	+
Chilling Temperature		15 days	30 days
Sweet Potato Puto Pao	-	-	+

Legend: *Negative (-) no mold formation* *Positive (+) mold formation is observed*

Microbial Report Analysis of Black Rice Puto Pao
Table 7 shows the microbial report analysis of Black Rice puto pao samples conducted by the DOST Regional and Testing Laboratory, Iloilo City. Test Service Request No. R6-032025-MIC-0156-0224 submitted dated March 11, 2025 and was analyzed from March 11-March 19,2025. The sample submitted was meat Rice-based Dessert.

The 250 grams black rice Puto Pao with different root crops flour substitute (Cassava) manufactured on March 11, 2025 was subjected to Aerobic Plate Count, Total Coliform Count, Escherichia coli Count and Molds and Yeast Count. Results show that CFU/g sample Aerobic Plate Count was 320 000. The total Coliform count was 2 4000CFU/g sampled*.

While the Escherichia coli Count was < 10 cfu/g sample* (estimated). Finally, the Molds and Yeast Count was 150 CFU/g sample* The result meets the microbial limits for solid food products based on the microbial standards of the food and pharmaceutical industries in the Philippines. The environmental conditions during testing were 21.2-23.0 degrees Celsius room temperature and 43-47 % relative humidity, %. The methodology used were the following: for Aerobic Plate Count the methodology was Pour Plate Method, 35 degrees celcius ,48 hours, PCA, USFDA BAM Online (2001). Then, 3M PETRIFILMTM Rapid E.coli/Coliform Count Plate. AOAC Official Method of Analysis (2021). AOAC Official Methods of Analysis 2018.13. Also, enumeration of Escherichia coli and Coliform in Broad Range of Foods and Select Environmental Surfaces, Final Action 2021. Finally, for Mold and Yeast Count, the methodology was Spread Plate Method, 25degrees Celsius, 5-7 days DRBCA, USFDA BAM Online (2001).

The Aerobic Count (APC) measures the total number of aerobic bacteria. A count of 320,000 CFU/g is relatively high but still within acceptable limits for ready-to-eat foods based on some international standards (e.g., < 10^6 CFU/g). However, it suggests that good manufacturing practices (GMP) and hygiene should be strictly followed.

Coliforms are indicators of sanitation and possible contamination. A count of 2,400 CFU/g is above ideal limits for cooked foods, which are typically expected to have <100 CFU/g. This suggests post-processing contamination or inadequate hygiene during handling or storage.

E. coli was not detected in significant amounts. This is a positive result, indicating no fecal contamination and acceptable food safety at the time of testing. Molds and Yeast Count is within acceptable limits for bakery or steamed products. A count of <10^2 to <10^3 CFU/g is generally considered safe. This result implies that the root crop puto pao is safe for human consumption.

The results imply that the microbial load present in the product during testing was generally within acceptable limits, especially for E. coli and molds/yeasts. The product is safe at the time of analysis but requires improved sanitary controls, particularly during cooling, handling, and packaging to enhance shelf life and safety.

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Table 7 . Microbial report analysis of root crops puto pao.

Sample Description	Parameter	NPPC	FDA Result	
			m	M
250g Black Rice Puto Pao w/ Different Root Crop Flour Substitute (Casava)	*Aerobic Plate Cout*	320 000 CFU/g sample0cfu/g sample)	5	10^6
	Total Coliform Count	2 400 CFU /g sample	10^2	10^3
	Escherichia coli Count	< 10 CFU/g sample* (estimated)	Not detected/Absence	Not detected/Absence
(2 containers @-250g/container; MFD: 03/11/2025)	*Molds and Yeast Count*	150 CFU/g sample	10^2	10^3

Legend: m –acceptable level of microorganism determined by a specified method: values are generally based on levels that are achievable under GMP

M – level which when exceeded in one or more samples would cause the lot to be rejected as this indicates potential health hazard or imminent spoilage

Proximate Analysis of Root Crops Puto Pao with Black Rice

Table 8 presents the proximate analysis of root crops puto to pao with black rice conducted by Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory, Bacolod City. The sample was submitted on April, 21, 2025 and the report was out on April 30,2025 with reference No. 25-85791.

Results showed that for the percentage of Fat (Soxhlet Method) was 7.9. This indicates a moderate fat content, likely contributed by added ingredients like eggs, butter, or margarine. It contributes to flavor, tenderness, and satiety. This is followed by the percentage of Carbohydrates (Phenol Sulfuric Acid Method) which is 47.6. This is the main macronutrient, which is expected for a steamed bun made from sweet potato and black rice. It provides the primary source of energy.

Meanwhile, percentage of moisture was 38.6. This indicates high moisture content, typical for steamed or moist bakery products. While it enhances softness and palatability, it also makes the product more perishable, requiring proper storage. The percentage of Protein was 3.2 %. This is relatively low, which is typical for root crop-based products. Lastly, the calory (130g serving) was 356 kcal. This is a moderate energy value for a snack or light meal. Most of the calories are from carbohydrates and fats, making it a good source of quick energy.

Generally, the results indicate that root crop puto pao is energy-dense, suitable as a snack or supplementary meal, especially for active individuals or schoolchildren. It is low in protein, so pairing it with a protein-rich food (e.g., meat filling, beans, or milk) would enhance its nutritional value. The high moisture content supports good texture but may reduce shelf life, reinforcing the need for cool storage or refrigeration. The product provides a healthier alternative to refined flour buns due to the presence of sweet potato and black rice.

Table 8. Proximate Analysis of puto pao with black rice

Sample Description	Parameter	Result g/100ml
Black Rice with Sweet Potato Puto Pao	**% Fat –** *Soxhit Extraction Method*	7.9
	% Carbohydrates *Phenol Sulfuric Acid Method*	47.6
	% Moisture *Gravimetric Oven Drying a 105 degrees Celsius*	38.6
	% Protein *Kjeldahl Method*	3.2
	Calories SS:130g	**356**

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IV. CONCLUSION

The sensory evaluation demonstrated that root crop *puto pao* variants, when combined with black rice, maintained favorable sensory qualities. The product showed promising potential for consumers due to its appealing appearance, desirable texture, and unique taste.

Sweet potato variant outshined the casava and taro variant in the sensory qualities making it the generally acceptable variant. This can be attributed to the unique characteristics of potato in terms of its color, water content and meat texture. The ANOVA results reveal a statistically significant difference in all sensory attributes—appearance, aroma, taste, and texture—among the root crop *puto pao* variants. This indicates that the type of root crop filling (cassava, sweet potato, or taro) significantly influences the product's sensory qualities.

Storing root crop *puto pao* under chilling conditions significantly delayed spoilage and maintained product quality compared to room temperature storage, indicating improved shelf life.

The microbial profile of the black rice *puto pao* with cassava flour is generally within safe and acceptable limits for ready-to-eat products. The absence of *E. coli* confirms the product's safety regarding fecal contamination.

Root crop *puto pao* with black rice is a nutrient-rich snack characterized by high energy and moisture content, making it suitable for diverse consumers. While it offers a healthier alternative to refined flour products due to the use of sweet potato and black rice, its low protein content and high perishability highlight areas for improvement.

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