

Experiments of Beneng Taro Flour (*Xantoshoma undipes* K. Koch): Physical Analysis, Taste Level, and Protein Content of Nastar

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Abstract

Beneng taro flour comes from the tubers of the native Indonesian taro plant, which has the potential to be used as a food variation ingredient. However, this is not in line with the diversity of processed products made from Beneng taro flour. One way to increase the diversity of processed products from Beneng taro flour is to diversify it into nastar. This study aims to determine consumer preference, physical quality, and the protein content for nastar cookies substituted with beneng taro flour. This research was conducted by experimental method using a Completely Randomized Design (CRD) with one factor and four substitution treatments. The results of the study showed that there were differences in consumer preferences for the parameters of color, aroma, texture, taste, and overall acceptance. The highest overall acceptance scores of the nastar cookies was P1 (10%) = 7.94. The results of the physical quality tests showed that the highest hardness value (g) was found in treatment P0 (0%) at 1322.4; the highest cohesiveness value was also in P0 (0%) at 0.10; the highest elasticity value (mm) was observed in treatments P2 (20%) and P3 (30%) at 17.6; and the highest adhesiveness value (mJ) was found in P3 (30%) at 0.66. The physical color quality results showed that P0 (0%) had a pastel yellow color (brighter), P1 (10%) was golden yellow, P2 (20%) was cream, and P3 (30%) was light brown (darker). The protein content decreased with the increasing proportion of beneng taro flour, with the following results: P0 (0%) = 5.89%, P1 (10%) = 5.81%, P2 (20%) = 5.70%, and P3 (30%) = 5.55%. However, this decrease was not significant, and the nastar cookies substituted with beneng taro flour still met the Indonesian National Standard (SNI 2973:2022) for biscuits, which requires a minimum protein content of 2.7%. The results provide perspectives and references for developing food ingredients based on Beneng taro flour as a processed product that has marketability and meets the required nutritional criteria.

Keywords: *nastar, beneng taro flour, wheat flour, protein content.*

INTRODUCTION

Beneng taro is a type of local taro originating from Pandeglang, Banten, characterized by its yellowish-white color. The beneng taro plant is widely cultivated in Indonesia. Beneng taro can be processed into local flour as an alternative to imported wheat flour. The higher protein content of beneng taro flour compared to other taro varieties is one of the key indicators of its potential as a substitute for wheat flour (Kusumasari et al., 2019). The fact that Indonesia is dependent on wheat flour is evident from the data showing that in 2022, Indonesia imported 9.5 million metric tons of wheat to produce approximately 6.661 million metric tons of wheat flour (UNICEF, 2022). Current conditions also still exist in this activity.

Wheat flour contains elements that require attention, one of which is gluten. While gluten is generally safe for consumption, excessive intake may trigger sensitivity reactions to the protein in the digestive system (Finani, 2023). Controlling wheat flour imports also aims to reduce factors that can cause disorders in the immune system, stomach, and intestines, as well as to prevent allergic reactions in some individuals. Efforts to explore the consumption of local flour in Indonesia have been extensive. One example of this local flour is made from the Beneng taro (*Xanthosoma undipes* K. Koch) as an alternative food ingredient. This alternative food ingredient is used as the basis for making cakes that have characteristics typical of Beneng taro-producing areas.

One alternative application is making nastar. Nastar is a type of cookie shaped like a small round ball with a soft texture and a filling that melts in the mouth. This flavorful pastry typically contains pineapple jam as its filling. In the process of making nastar, the main ingredients are medium-protein wheat flour, margarine, eggs, and sugar. It is referred to as a cookie because it is made primarily from wheat flour and fat, processed through baking, and comes in various sizes with a texture that is not too dense—crispy on the outside and soft on the inside—and has a sweet taste (Rosida et al., 2020).

The substitution of beneng taro flour for wheat flour in nastar has the potential to affect its physical properties, particularly color and texture. Consumer preferences must also be considered to ensure that nastar made with beneng taro flour is well accepted. Additionally, the protein content in beneng taro flour may influence the nutritional composition of the experimental product. A previous study conducted by Fitriani (2021) on the quality of nastar made with taro flour substitution stated that the X1 (15%) formulation produced the best quality, characterized by a uniform and neat shape, golden-yellow color, pleasant aroma, crumbly texture, and sweet taste.

Therefore, a study was conducted to determine the effect of beneng taro flour substitution in nastar based on physical analysis, preference level, and protein content. The benefit of this research is to expand and develop scientific knowledge regarding food products made from beneng taro flour. In addition, the reason for making nastar using beneng taro flour is to utilize it as an alternative food ingredient that can promote the use of local flour in Indonesia, produce an innovative version of nastar, and increase the popularity of beneng taro-based products among other taro varieties.

METHODS

This study used an experimental method, which is classified as quantitative research. This study was conducted from August to February 2025. The study used a Completely Randomized Design (CRD) mathematical model, which consisted of one factor, namely the formulation of Beneng taro flour (0%, 10%, 20%, and 30%), with four experiments. The research stages included: (1) analyzing and determining the starting recipe to be used based on three reference nastar recipes; (2) conducting an experiment with partial substitution of the main ingredients, namely wheat flour with Beneng taro flour, following the sample code and formulation ratio presented in Table 1; (3) performing the CRD test using a line scale instrument with 80 untrained panelists, assessing parameters such as color, aroma, texture, taste, and overall impression to obtain preference scores; (4) conducting physical quality tests at the Integrated Laboratory Unit (UPT Laboratorium Terpadu) of Diponegoro University (UNDIP) to measure hardness, cohesiveness, elasticity, and adhesiveness; and (5) conducting a laboratory test for protein content at PT Saraswati Indo Genetech Laboratory. preference scores; (4) conducting physical quality tests at the Integrated Laboratory Unit (UPT Laboratorium Terpadu) of Diponegoro University (UNDIP) to measure hardness, cohesiveness, elasticity, and adhesiveness; and (5) conducting a laboratory test for protein content at PT Saraswati Indo Genetech Laboratory.

TABLE 1. Experimental Test Treatment of Nastar with Beneng Taro Flour Substitution

Treatments	Ratio Comparison (%)		
	Wheat Flour	:	Beneng Taro Flour
P0	100	:	0
P1	90	:	10
P2	80	:	20
P3	70	:	10

Before conducting the experiment, the researcher analyzed three nastar recipes to determine the starting recipe that would be used for making nastar with beneng taro flour as the base ingredient. Table 2 below presents the starting recipe.

Starting Recipe

After analyzing three nastar recipes, the starting recipe was obtained as shown in Table 2. This starting recipe was used as a reference for the further development of nastar products substituted with beneng taro flour.

TABLE 2. Starting Recipe with The Substitution of Beneng Taro Flour

Ingredients	Formula (gram)			
	P0 (0%)	P1 (10%)	P2 (20%)	P3 (30%)
Beneng taro flour	0	19	38	57
Wheat Flour	188	169	150	132
Milk Powder	55	55	55	55
Cornstarch	50	50	50	50
Margarine	63	63	63	63
Butter	63	63	63	63
Powdered sugar	55	55	55	55
Egg yolk	50	50	50	50
Salt	1	1	1	1

Trial Test

Based on the obtained starting recipe, four trial tests were then conducted. The trials were carried out by partially substituting wheat flour with beneng taro flour to develop the standard recipe for the nastar product. In the trial process, all ingredients for each formula were first weighed and placed into separate containers. Next, the wet ingredients (margarine, butter, egg yolks, and powdered sugar) were mixed in a bowl until well combined. Gradually, the dry ingredients (wheat flour, beneng taro flour, milk powder, cornstarch, and salt) were added to the wet mixture. The dough was then shaped into small balls weighing 5 grams each and filled with 2 grams of pineapple jam. The cookies were baked at 150°C for 25 minutes. After baking, they were removed from the oven, brushed with an egg wash on top, and baked again for 5 minutes. Once done, the nastar cookies were cooled and stored in jars. The physical quality test included texture analysis using a Texture Analyzer with a cylindrical probe at the Integrated Laboratory Unit (UPT Laboratorium Terpadu) of Diponegoro University (UNDIP), as well as color observation using the Digital Color Meter application. The preference test was conducted with 80 untrained panelists using an organoleptic test (scale 1–9) assessing the parameters of color, aroma, texture, taste, and overall acceptance. The chemical analysis included protein determination using the Kjeldahl method and iron content analysis using spectrophotometry. The preference test data were analyzed using the non-parametric Kruskal–Wallis and Mann–Whitney tests.

RESULTS AND DISCUSSION

Diference in Preference Level

The results of the study showed a significant difference ($p < 0.05$) in texture, taste, and panelists' preference levels among the formulation treatments.

Color Aspect

The results of the Kruskal–Wallis test showed a significance value of $0.000 < 0.05$, indicating that H_0 was rejected and H_a was accepted. Therefore, there was a difference in color among the beneng

taro flour nastar samples. Due to the observed differences in preference, the analysis was continued with the Mann–Whitney test, as presented in TABLE 3.

TABLE 3. Mann–Whitney Test Results for the Color Parameter

Comparison Between Samples		Comparative Value and Significance Value	Information
Color	P0-P1	0,000 < 0,05	Different
	P0-P2	0,000 < 0,05	Different
	P0-P3	0,000 < 0,05	Different
	P1-P2	0,023 < 0,05	Different
	P1-P3	0,004 < 0,05	Different
	P2-P3	0,463 > 0,05	Not Different

Aroma Aspect

From the results of the Kruskal–Wallis test, it was found that there were differences among the samples ($p < 0.05$), with a significance value of $P = 0.019$. It can be concluded that H_0 is rejected and H_a is accepted. Due to the observed differences in preference, the analysis was continued with the Mann–Whitney test, as presented in TABLE 4.

TABLE 4. Mann–Whitney Test Results for the Aroma Parameter

Comparison Between Samples		Comparative Value and Significance Value	Information
Aroma	P0-P1	0,125 > 0,05	Not Different
	P0-P2	0,916 > 0,05	Not Different
	P0-P3	0,070 > 0,05	Not Different
	P1-P2	0,139 > 0,05	Not Different
	P1-P3	0,001 < 0,05	Different
	P2-P3	0,149 > 0,05	Not Different

Texture Aspect

Based on the results of the normality test, which showed a non-normal distribution, the Kruskal–Wallis test was used. The results indicated that there was a difference in the texture parameter, with a p-value of 0.000. It can be concluded that H_0 is rejected and H_a is accepted. Due to the observed differences in preference, the analysis was continued with the Mann–Whitney test, as presented in TABLE 5.

TABLE 5. Mann–Whitney Test Results for the Aroma Parameter

Comparison Between Samples		Comparative Value and Significance Value	Information
Texture	P0-P1	0,001 < 0,05	Different
	P0-P2	0,601 > 0,05	Not Different
	P0-P3	0,012 < 0,05	Different
	P1-P2	0,000 < 0,05	Different
	P1-P3	0,000 < 0,05	Different
	P2-P3	0,041 < 0,05	Different

Taste Aspect

The results of the Kruskal–Wallis test showed a significance value of $0.000 < 0.05$, indicating that H_0 was rejected and H_a was accepted. Therefore, there was a difference in taste aspect among the beneng taro flour nastar samples. Due to the observed differences in preference, the analysis was continued with the Mann–Whitney test, as presented in TABLE 6.

TABLE 6. Mann–Whitney Test Results for the Taste Parameter

Comparison Between Samples		Comparative Value and Significance Value	Information
Taste	P0-P1	0,000 < 0,05	Different
	P0-P2	0,000 < 0,05	Different
	P0-P3	0,000 < 0,05	Different
	P1-P2	0,627 > 0,05	Not Different
	P1-P3	0,169 > 0,05	Not Different
	P2-P3	0,462 > 0,05	Not Different

Overall Aspect

The results of the Kruskal–Wallis test showed a significance value of $0.000 < 0.05$, indicating that H_0 was rejected and H_a was accepted. Therefore, there was a difference in overall aspect among the beneng taro flour nastar samples. Due to the observed differences in preference, the analysis was continued with the Mann–Whitney test, as presented in TABLE 7.

TABLE 7. Mann–Whitney Test Results for the Overall Parameter

Comparison Between Samples		Comparative Value and Significance Value	Information
Overall	P0-P1	0,001 < 0,05	Different
	P0-P2	0,306 > 0,05	Not Different
	P0-P3	0,083 > 0,05	Not Different
	P1-P2	0,000 < 0,05	Different
	P1-P3	0,000 < 0,05	Different
	P2-P3	0,446 > 0,05	Not Different

Physical Characteristics

Texture is one of the important parameters in assessing the physical quality of a product, as it influences consumer acceptance of the product. The test results can be seen in the following table.

TABLE 8. Texture Test Results

No.	Test Sample Code	Hardness (g)	Bond	Elasticity (mm)	Adhesive Power (mJ)
1	P0	1322,4	0,10	15,3	0,46
2	P1	932,7	0,02	10,5	0,41
3	P2	778,4	0,01	17,6	0,58
4	P3	641,7	0,02	17,6	0,66

Based on the table above, it can be seen that the hardness value in treatment P0 was 1322.4, in treatment P1 was 932.7, in treatment P2 was 778.4, and in treatment P3 was 641.7. The cohesiveness values were 0.10% for P0, 0.02% for P1, 0.01% for P2, and 0.02% for P3. Meanwhile, the elasticity values of the nastar substituted with beneng taro flour were 15.3% for P0, 10.5% for P1, and 17.6% for both P2 and P3. The adhesiveness test results showed values of 0.46% for P0, 0.41% for P1, 0.58% for P2, and 0.66% for P3.

Color Characteristics

Color is one of the important parameters in assessing the quality of food products, as consumer perception greatly influences the product's quality and attractiveness. In this study, color testing was conducted using the Digital Color Meter application, which can identify the dominant color of nastar substituted with beneng taro flour based on the visual appearance of the product. The test results can be seen in the following picture.

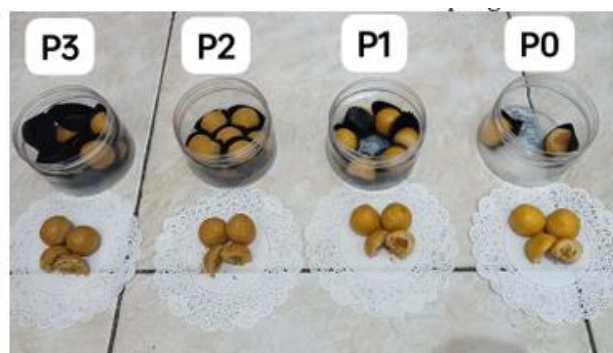


FIGURE 1. Results of Nastar Substituted with Beneng Taro Flour

Protein Content Test

The results of the protein content test for nastar substituted with beneng taro flour with treatments P0 (100%:0%), P1 (90%:10%), P2 (80%:20%), and P3 (70%:30%) can be seen in the table below.

TABLE 9. Protein Content Test Results

Sample Code	Protein (%)	Information
P0	5,89	Meets SNI (Minimum 2.7%)
P1	5,81	Meets SNI (Minimum 2.7%)
P2	5,70	Meets SNI (Minimum 2.7%)
P3	5,55	Meets SNI (Minimum 2.7%)

Based on the table above, the results of the laboratory analysis of protein content with two replications showed that sample P0 had a protein content of 5.89%, sample P1 had 5.81%, sample P2 had 5.70%, and sample P3 had 5.55%.

This section discusses the results of the preference test, the physical characteristics test (texture and color), and the laboratory test for protein content of nastar substituted with beneng taro flour under treatments P0 (100%:0%), P1 (90%:10%), P2 (80%:20%), and P3 (70%:30%). The discussion includes details on the effect of beneng taro flour substitution on nastar, the physical quality of nastar substituted with beneng taro flour, and the protein content of the substituted nastar. A detailed explanation is presented below.

Based on the research results, the P0 treatment had the highest color preference score (8.30), while P3 had the lowest (7.01). The higher the substitution of beneng taro flour, the lower the color preference, as the flour's yellowish-brown color is influenced by its β -carotene content. Moreover, the baking process triggers the Maillard reaction between reducing sugars and proteins, forming melanoidin compounds responsible for the dark brown color. Factors such as temperature, time, humidity, and pH also affect the final color, with the P3 treatment producing a darker appearance. Based on the color test results using the Digital Color Meter application, treatment P0 produced a pastel yellow color (brighter result), while treatment P3 produced a light brown color (darker result). The protein content in food ingredients affects color changes during the heating process. This occurs due to a reaction between amino groups from proteins and reducing sugars, forming brown melanoidin compounds that darken the surface of the food — a process known as the Maillard reaction (Kusnandar, 2019).

Based on the research results, treatment P1 had the highest aroma score (7.55), while P3 had the lowest (7.00). The increase in beneng taro flour substitution did not reduce the aroma preference due to the influence of margarine, which masked the distinctive aroma of beneng taro flour. The fat content in margarine plays an important role in providing the characteristic aroma of cookies; therefore, the aroma of the nastar was mainly influenced by the use of margarine and other ingredients.

Based on the research results, treatment P1 had the highest texture score (8.11), while P3 had the lowest (7.00). Increasing the substitution of beneng taro flour led to a decrease in texture preference

because the nastar became softer. This is due to the starch content in beneng taro flour, which has granules with high water absorption. When heated, the starch undergoes gelatinization, causing the dough to become softer and resulting in a more tender texture as the level of beneng taro flour substitution increases. The texture test results showed that the highest hardness value was found in P0 (1322.4) and the lowest in P3 (641.7). Increasing the substitution of beneng taro flour reduced the product's hardness due to its lower amylose content. Amylose plays a role in forming dense and rigid gels, so a higher concentration increases hardness, while fat-amylose interactions can weaken the gel structure. The highest cohesiveness value was found in P0 (0.10) and the lowest in P2 (0.01), influenced by the lower gluten content in beneng taro flour compared to medium-protein wheat flour. The springiness test showed the highest results in P2 and P3 (17.6%) and the lowest in P1 (10.5%). The highest adhesion value was observed in P3 (0.66%) and the lowest in P1 (0.41%).

Based on the results of the preference test for the taste parameter, treatment P1 obtained the highest average score of 8.48, while treatment P3 had the lowest score of 7.24. These results indicate that as the substitution level of beneng taro flour increases, the taste preference tends to decrease. The beneng taro flour-substituted nastar showed no significant difference in taste. Beneng taro flour has an earthy flavor — reminiscent of soil or fresh tubers — giving a natural, slightly beany, and sometimes mildly astringent taste. However, in this study, the overall taste was dominated by ingredients such as margarine, sugar, milk powder, and pineapple jam, although a slight earthy note from the beneng taro flour was still present (Fitriani, 2022).

Based on the results of the preference test for the overall parameter, treatment P1 obtained the highest average score of 7.93, while treatment P3 had the lowest score of 7.11. The overall parameter aimed to determine the panelists' overall preference for the nastar product. Panelists were asked to evaluate and summarize all aspects of liking — including appearance, color, aroma, texture, and taste. The highest preference in treatment P1, with 10% beneng taro flour substitution, was due to its appealing appearance, golden-yellow color, pleasant aroma, crumbly texture, and sweet taste. This finding aligns with the previous study by Fitriani and Holinesti (2022), which reported that nastar with 15% substitution produced the best quality, characterized by a round, neat, and uniform shape, golden color, fragrant aroma, crumbly texture, and sweet flavor.

Based on the protein content test results of nastar with beneng taro flour substitution, the highest protein level was found in treatment P1 at 5.89%, while the lowest was in treatment P3 at 5.55%. Although increasing the substitution level tended to reduce protein content, the decrease observed in this study was not significant. In general, beneng taro flour has a relatively low protein content compared to wheat flour but is higher than that of several other taro varieties (Department of Agriculture of Pandeglang Regency, 2019). Based on these results, nastar substituted with beneng taro flour meets the protein content requirement specified in the Indonesian National Standard for Biscuits (SNI 2973:2022), which is a minimum of 2.7%.

CONCLUSION

Based on the research titled “Experiment on the Substitution of Beneng Taro Flour (*Xanthosoma undipes* K. Koch) and Analysis of Physical Properties, Preference Level, and Protein Content in Nastar,” the following conclusions were obtained:

1. The results showed that increasing the substitution level of beneng taro flour had a negative effect on the physical quality, particularly on the texture and color parameters of the nastar. Higher substitution levels produced a softer texture, reducing the desirable characteristics of nastar due to the amylose content in starch that forms a gel structure in the dough. This was evidenced by treatment P3 (30%), which had the highest adhesion value of 0.66. The color parameter was influenced by the presence of β -carotene in beneng taro tubers, which enhances the color tone of the flour. During the baking process, the Maillard reaction between reducing sugars and amino acids caused the color to darken, as shown in treatment P3 (30%), which resulted in a light brown color.

2. Based on the physical quality test, it can be concluded that the use of beneng taro flour caused differences in texture and color, where higher substitution levels resulted in more noticeable changes in the nastar's appearance.
3. Based on the laboratory analysis of protein content, the protein levels of nastar with beneng taro flour substitution were as follows: P0 = 5.89%, P1 = 5.81%, P2 = 5.55%, and P3 = 5.7%. Although the addition of beneng taro flour slightly reduced the protein content, the decrease was not significant, and the results still met the protein content standard for biscuits (SNI 2973:2022), which requires a minimum of 2.7%.

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