Development and evaluation of *beneng* taro (*Xanthosoma undipes K. Koch*) flour sable cookies

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Abstract. The study investigates the substitution of wheat flour with *beneng* taro flour in the production of sable cookies. The aim is to develop a healthier alternative to sable cookies by emphasizing the nutritional benefits of *beneng* taro, a local food ingredient. Organoleptic tests were conducted to evaluate color, taste, aroma, and texture preferences among 30 semi-trained panelists. The findings indicate that sable cookies with 45% *beneng* taro flour substitution were well-received and had a shelf life of up to 8 hours when stored in PET jars at low temperatures. The study concludes that *beneng* taro flour can be a healthier alternative to wheat flour, offering lower energy and fat contents sable cookies. Further research is recommended to optimize the ingredient composition and storage conditions.

1 Introduction

Beneng taro is a type of wild tuber plant originated from Pandeglang Regency, Banten Province. The term "*beneng*" comes from the Sundanese language, where "*beuneur*" means large and "*koneng*" means yellow. The wild tuber can reach a weight of 2.4 - 15 kg with a length of 38-150 cm in one year and has a moderate yellow color on the inside due to carotenoid pigments [1]. The *beneng* taro plant is often found in hilly areas, especially at the foot of the hills, making it easy to cultivate. The Agricultural Research and Development Agency of Indonesia recorded *beneng* taro cultivation in Pandeglang, Serang, Lebak, Bogor, and Sukabumi with a total cultivation area to 176 ha. [2].

The utilization of *beneng* taro as a food ingredient is limited because it is only processed traditionally by boiling, steaming, frying, or as an ingredient in soups. However, *beneng* taro can produce other processed products of economic value. Previous research indicates that most of the abundant *beneng* taro harvest is not optimally utilized and is sold at relatively low prices [3].

Beneng taro flour is one processed product that can be used to make various new products beneficial for food product development. It has a long shelf life, is easy to mix, and has nutritional content that can meet daily energy needs. According to previous research by Suryandani *et al*., the process of making *beneng* taro flour involves several stages, from raw tuber preparation, sorting, and washing to grinding and sieving after sun drying [4].

Beneng taro flour can substitute low protein wheat flour in pastry products due to its low-calorie content, making it suitable for developing low-calorie functional foods [5]. *Beneng* taro has lower starch content compared to wheat flour, with starch content at 15.21% of total carbohydrates, whereas wheat flour has 78.36% carbohydrate content in the form of starch [6]. According to prior research by Rostianti *et al.*, the average protein content of *beneng* taro flour is 3.4±0.24%, which is lower than the 10% protein content in wheat flour used for cake products [7]. This is supported by Muthiahwari *et al.*, who stated that low-protein flour with a protein content of 8%-9.5% is ideal for products requiring crispiness rather than volume or elasticity [8]. Making pastry products with *beneng* taro flour substitution can produce products with a crunchy texture. The combination of wheat flour and *beneng* taro flour is expected to complement the nutritional content of the processed products.

Pastry products that can be made using *beneng* taro flour include sable cookies. Sable cookies are a type of French shortbread biscuit known as butter cookies. The word "*sablé*" is French for "sand," derived from the English term "breadcrumbs." Making sable cookies uses a simple method by mixing low-protein wheat flour, butter, eggs, powdered milk, and sugar, then baking. Therefore, making sable cookies can be easily modified by substituting wheat flour with *beneng* taro flour to enhance flavor and nutritional value compared to the original product [9]. Besides serving as an alternative carbohydrate source, *beneng* taro flour can reduce the use of low-protein wheat flour in making bread and pastry products and optimize the use of *beneng* taro flour from local food sources.

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2 Materials and Methods

2.1 Research Design, Time, and Location

This research is experimental research in the form of a completely randomized design with 3 formulas: based on the composition of *beneng* taro flour and wheat flour namely F1 (15%:85%), F2 (30%:70%), and F3 (45%:55%). This research was conducted at the Culinary Laboratory of College of Vocational Studies, IPB University from February to July 2024.

The study covered the process of product making, organoleptic testing, nutritional content testing, and shelf-life testing of the sable cookies. The parameters used in this study were hedonic test that evaluated color, taste, aroma, and texture on a 4 points Likert scale (1=strongly dislike, 2=dislike, 3=like, 4=strongly like), and a hedonic quality test to determine the best quality of the sable cookies. The testing involved 30 semi-trained panelists who were healthy and willing to participate as panelists. The data obtained from organoleptic tests were analyzed using the Statistical Program for Social Science (SPSS) 26.0, with the Kruskal- Wallis test for differences, and further analyzed using the Mann-Whitney test. Nutritional contents of the product were measured using proximate analysis while shelf-life testing was done using observational method by storing the cookies in polyethylene terephthalate (PET) jar at low temperature for 24 hours.

2.2 Sable Cookies Production

The preparation of sable cookies involved using several ratios of *beneng* taro flour to wheat flour. According to Zakiyah and Handayani, the formulation for cookies substituted with tuber flour can be substituted to several formulations of 15% (F1), 30% (F2), and 45% (F3) of tuber flour to the weight of wheat flour used [10].

Fig.1. *Beneng* taro sable cookies

The first step of the production was to weigh the ingredients: 90 g of flour, 60 g of unsalted butter, 10 g of egg yolk, and 35 g of powdered sugar. Next, the powdered sugar was whipped for 10 minutes until evenly mixed, then combined with the butter. The appropriate amount of flour was then added according to the ongoing treatment, followed by mixing with a mixer for 15 minutes. The resulting dough was then colored, mixed with egg yolk, and shaped using a round cookie cutter with a diameter of 5 cm and a thickness of 1 cm. The shaped dough was then placed in an oven at 80°C for 13 minutes. After baking, the sable cookies were removed from the oven and cooled to room temperature. Finally, the room temperature sable cookies were packaged in airtight packaging.

3 Results and Discussions

3.1 Hedonic Test

Table 1. Hedonic test results

Indicators	F1	F2	F3
Color	4.40 ± 0.81^{a}	3.92 ± 0.90^{a}	3.43 ± 1.10^{b}
Taste	3.93 ± 0.90^{a}	3.60 ± 0.96^{a}	4.07 ± 0.98^{a}
Aroma	3.93 ± 0.64^{a}	3.50 ± 1.00^{a}	3.93 ± 0.90^{a}
Texture	3.40 ± 1.16^{a}	4.03 ± 0.80^{b}	3.93 ± 0.78^{a}

Notes: Different superscripts on the same row indicate significant differences based on post hoc testing ($p<0.05$) using the Mann-Whitney Test.

3.1.1 Color

Based on the hedonic test shown in Table 1, it can be concluded that the panelists' preference for the color of *beneng* taro flour sable cookies ranged from 3.43 to 4.40. This indicates that the panelists tended to like to somewhat like the color produced. The color indicator most favored by the panelists was sable cookies F1 (15% substitution concentration) with a score of 4.40 ± 0.81, although the preference was not significantly different with F2 cookies. The panelists' preference for the color of sable cookies decreased with the addition of more *beneng* taro flour. The color differences in the sable cookies are influenced by the percentage of *beneng* taro flour used in each formula tested, as *beneng* taro flour is browner compared to wheat flour. Consequently, with the higher substitution of taro *beneng* flour, the cookies' color grows darker. Additionally, the Maillard reaction during baking causes the cookies to turn brown [11].

3.1.2 Taste

The taste evaluation of sable cookies aimed to determine which percentage of *beneng* taro flour substitution is preferred by the panelists. Generally, sable cookies have a sweet and buttery taste. According to Table 1, the panelists' preference for the taste of sable cookies ranged from 3.60 to 4.07, indicating a tendency to like the produced sable cookies. The hedonic test results show that the panelists favored the taste of F3 sable cookies (45% *beneng* taro flour) at 4.07 ± 0.98 compared to other formulas. Taste is one of the most determining indicators of panelist preference compared to other indicators. The addition of *beneng* taro flour can be tricky as higher concentrations can make the cookies taste slightly bitter due to the sap content in taro [12]. In F3 cookies, the balance between *beneng* taro flour and wheat flour helps mitigate the bitterness, and the sweet filling also masks the bitter taste.

3.1.3 Aroma

The hedonic test data on aroma in Table 1 shows that the highest average score was obtained from sable cookies F3 (45% *beneng* taro flour), followed by F1 (15% *beneng* taro flour). The aroma of sable cookies F3 was preferred because *beneng* taro flour produces a stronger aroma compared to wheat flour [13], and it has a savory aroma characteristic. The percentage of *beneng* taro flour significantly influences the produced aroma. The addition of taro flour and fat in the cookie dough enhances the aroma since taro has delicious and tasty starch [14]. Additionally, the results indicate that panelists are more familiar with the market's buttery aroma- lacking cookies, making F3 more preferred. The hedonic aroma test results for F1 (15% *beneng* taro flour) were equivalent to F3. Taro flour has a slightly musty smell, which can influence the aroma when substituted with other flours. Therefore, some panelists disliked higher *beneng* taro flour substitution formulas due to its slightly musty aroma, reducing the fragrant aroma of sable cookies. Aroma is a challenging parameter to measure, often leading to varied opinions on its quality, as individual scent perception and preference vary [13].

3.1.4 Texture

Texture assessment in food products can broadly refer to the physical state, especially in dry cookies like sable cookies. Generally, *beneng* taro sable cookies have a crispy and slightly fragile texture. The crispiness of sable cookies is influenced by the ingredients used, baking temperature, and duration [2]. Based on the hedonic test results summarized in Table 1, the texture hedonic test scores for sable cookies with *beneng* taro flour substitution ranged from 3.40 to 4.03, indicating that the panelists tended to somewhat like to like the produced texture. The panelists preferred the texture of F2 sable cookies (30% *beneng* taro flour). Texture is one of the parameters determining consumer acceptance of sable cookies. The texture is influenced by the high dietary fiber content, which enhances the crispy and slightly fragile texture [15].

3.2 Quality Hedonic Test

Table 2. Quality hedonic test results

Indicators	F1	F2	F3
Color	4.63 ± 0.80^{a}	3.23 ± 0.56^{b}	3.27 ± 1.48^{b}
Taste	3.63 ± 066^{a}	3.47 ± 0.90^{a}	3.83 ± 0.69^{a}
Aroma	3.80 ± 0.61^{a}	3.53 ± 0.93^{a}	3.87 ± 0.73^{b}
Texture	2.67 ± 0.99^{a}	3.63 ± 0.89^{b}	3.57 ± 1.04^{a}

Notes: Different superscripts on the same row indicate significant differences based on post hoc testing ($p<0.05$) using the Mann-Whitney Test.

3.2.1 Color

Color is one of the key indicators in evaluating the quality of a product. The results of the hedonic quality test shown in Table 2 indicate that the color indicator scored between 3.23 and 4.63. This demonstrates that the sable cookies produced ranged in color from red to dark red with increase of *beneng* taro flour substitution. The highest color indicator score was obtained by F1 (15% substance concentration) with a score of 4.63 ± 0.80 (red). The red color of F1 sable cookies is influenced by the addition of red food coloring, the percentage of *beneng* taro flour, and the baking process. *Beneng* taro flour is darker in color compared to wheat flour due to hydrolysis and enzyme reactions during the drying and heating of *beneng* taro flour [16]. Various processes used to produce *beneng* taro flour can cause changes in color, flavor, and texture.

3.2.2 Taste

Taste is a determining factor for panelists' preference for a product. Based on the average hedonic quality results with taste indicators listed in Table 2, the scores ranged from 3.47 to 3.83, indicating a range from slightly bitter to sweet. This shows that panelists generally preferred a sweet taste. The desired taste for sable cookies in this observation is sweet and buttery. The buttery taste from unsalted butter is due to its fat and protein content, which imparts a savory flavor to the cookies. According to Winarno in Medho *et al*., the increase in the delicious taste of a food product is determined by its protein and fat content [17]. The use of butter produces a sweet taste in sable cookies, resulting in F3 (45% *beneng* taro flour) scoring 3.83 (sweet). The sweet taste of F3 is influenced by the balanced composition of *beneng* taro flour and wheat flour, masking the flavor of *beneng* taro flour and enhancing the sweet taste from the butter.

3.2.3 Aroma

Aroma is one of the parameters that affect the perception of a food's taste. The average hedonic quality results for the aroma of sable cookies listed in Table 2 ranged from 3.53 to 3.87, indicating a range from less strong to sufficiently strong. The desired aroma in this observation is a sufficiently strong aroma for sable cookies, with the highest score obtained by F3, scoring 3.87 ± 0.69. The characteristic aroma of F3 sable cookies is typical of baked goods, influenced by ingredients such as fat (unsalted butter), milk, egg yolks, and *beneng* taro flour. The aroma in cookies is likely due to the reaction of fats during baking, where sugar and fat melt and undergo changes. During baking, starch gelatinizes, CO_2 gas and aroma components are released. Since the sable cookies were served cold during the organoleptic test, the aroma differences were not significantly distinct. This is influenced by volatile compounds that easily evaporate, making the aroma differences less noticeable [18].

3.2.4 Texture

Texture plays an important role in the quality of a product. *Beneng* taro sable cookies have a crispy and slightly fragile texture. The average hedonic quality results for the texture of cookies listed in Table 2 ranged from 2.67 to 3.63, indicating a range from fragile to slightly fragile. The desired texture in this observation is a crispy and slightly fragile texture, with the highest texture score chosen by the panelists being slightly fragile, obtained by F2 (30% *beneng* taro flour) with a score of 3.63 ± 0.89 (slightly fragile). The texture of the sable cookies made is influenced by the high dietary fibre content, which enhances the crispy and slightly fragile texture. The crispiness of sable cookies is also affected by the ingredients used, temperature, and baking time.

3.3 Nutritional Contents of Sable Cookies

Based on the hedonic and hedonic quality tests, F3 with 45% *beneng* taro flour was determined as the most preferred sable cookies formula by the panelists. Subsequently, the nutrient contents of the selected formula were analyzed using proximate test.

Table 3. Nutritional contents of sable cookies

Nutrition Facts	Amount Per Serving %Dv
Serving Size 40 g (1 pc) Total Energy 196 kcal Energy from Fat 91 kcal	Total Fat 10 g 15% Protein 2 g 3% Total Carbohydrate 24 g 7%
*Percent Daily Values are based on a 2,150 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs.	

Overall, one serving size of sable cookies weighted 20 g has 46 kcal energy content consisted of 1.1 g protein, 2.9 g fat, and 4.3 g carbohydrate. The comparison with commercial sable cookies presented in Table 4 shows that sable cookies substituted with *beneng* taro flour has several benefits [19].

Table 4. Comparison to commercial sable cookies

Nutritional contents per cookie	Beneng Taro Sable Cookies	Commercial Sable Cookies
Energy (kcal)	196	210
Protein (g)	2	2
Fat (g)	10	11
Carbohydrate (g)	24	26

Beneng taro sable cookies have significantly lower energy content, providing only 46 kcal per cookie compared to 105 kcal in commercial sable cookies. Additionally, they contain less fat, with 2.9 g per cookie compared to 5.5 g in their commercial counterparts. The protein content is slightly higher in *beneng* taro sable cookies, at 1.1 g per cookie, compared to 1 g in commercial versions. Moreover, the carbohydrate content is substantially lower in *beneng* taro sable cookies, with 4.3 g per cookie compared to 13 g in commercial ones. Overall, substituting *beneng* taro flour in sable cookies offers a healthier alternative with lower energy and fat contents while maintaining similar protein levels.

3.4 *Beneng* Flour Sable Cookies Shelf Life

The results of shelf-life tests of sable cookies packaged in PET jar showed that the texture of the cookies becomes less crispy. The longer the sable cookies are stored in the refrigerator, the softer their texture becomes. Biscuit damage can occur during storage due to the absorption of water vapor from the air through food packaging [20]. The shelf life of biscuits can be extended if they are packaged in suitable packaging. A very important factor in preventing the deterioration of food products is the choice of product packaging [21].

Table 5. Sable cookies shelf life

Time	Characteristics			
	Color	Texture	Aroma	Flavor
8 hours	Red	Soft, melts inside	Milk and butter aroma	Sweet and sour
10 hours	Red	Slightly soft, melts inside	Milk and butter aroma	Sweet and sour
24 hours	Red	Very soft, melts inside	Milk and butter aroma	Sweet and sour

From the shelf-life observation, it can be inferred that the appearance and color of the product remain consistently attractive and red throughout the 24-hour period. The aroma remains consistent, with a noticeable scent of milk and butter throughout the observation period. The taste is also stable, characterized by a sweet and sour flavor from the strawberry jam, which does not change significantly over the 24 hours. The texture, however, changes over time. Initially, at 8 hours, it is soft and melts inside. By 10 hours, it becomes slightly softer but still maintains its melting quality. After 24 hours, it becomes very soft, indicating a progressive increase in softness over time, which could impact the product's perceived freshness and mouthfeel.

In a study by Astuti *et al.*, the water content of biscuits stored in polypropylene (PP) plastic was higher than that of biscuits stored in glass jars [22]. The water content in plastic packaging is higher than that in glass packaging because plastic packaging is prone to water degradation. Biscuits with a high-water content tend to be non-crispy and therefore have an undesirable texture. Therefore, sable cookies in PET packaging can only last for up to 8 hours in the refrigerator, as the longer the storage time, the water content inside affects the shelf life of the sable cookies. For better quality, the sable cookies should be stored at glass jar so it would still have better texture quality in the span of 24 hours.

4 Conclusion

The study formulated the effect of substituting wheat flour with *beneng* taro flour on the quality of sable cookies. The results showed that a 45% substitution of *beneng* taro flour for wheat flour produced sable cookies that were liked by panelists and had a relatively good shelf life at 8 hours in PET jar at low temperature. The use of *beneng* taro flour on sable cookies can also be an alternative to wheat flour to reduce its use. The sable cookies made from *beneng flour* also have lower energy and fat contents compared to commercial sable cookies, making it healthier choice of product. Further research is needed to optimize the composition of ingredients and storage conditions for sable cookies.

Acknowledgements

This study was supported by the College of Vocational Studies, IPB University, research grant number 5879/IT3.S3/PT.01.03/P/T/2024.

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