

Proximate Analysis and Organoleptic Evaluation of Bagea Cookies Substituted with Teo Tuber Starch (*Tacca leontopetaloides* (L.) Kuntze)

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Abstract

Teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) has potential as a substitute for sago flour in the production of bagea cookies. This study aimed to analyze the proximate composition and evaluate the organoleptic acceptance of bagea cookies substituted with teo tuber starch. The study used an experimental method with a quantitative descriptive approach involving five treatments of teo tuber starch substitution in the production of bagea cookies. The observed parameters included proximate analysis (carbohydrates, protein, fat, crude fiber, moisture, and ash contents) and organoleptic evaluation (color, taste, aroma, and texture) using 35 panelists. Proximate data were analyzed descriptively, while organoleptic data were analyzed using the Kruskal-Wallis test. The best treatment was determined using the De Garmo effectiveness index. The results showed carbohydrate content ranging from 76.83–82.53%, protein content from 1.98–3.32%, fat content from 4.78–8.92%, crude fiber content from 2.24–4.06%, moisture content from 4.41–7.62%, and ash content from 0.95–3.99%. The De Garmo effectiveness index values for the proximate analysis of F1–F5 were 0.4066, 0.8677, 0.5710, 0.2824, and 0.5739, respectively, with F2 identified as the best treatment. The organoleptic test showed that substitution did not result in significant differences ($p > 0.05$) in color, taste, aroma, or texture. Bagea cookies substituted with teo tuber starch were accepted by the panelists at a moderately preferred level. Based on these results, the De Garmo effectiveness index values for the organoleptic evaluation of F1–F5 were 1.000, 0.552, 0.320, 0.280, and 0.040, respectively, with F1 identified as the best treatment.

Keywords: Bagea cookies; Polynesian arrowroot; Tuber Starch; Proximate analysis; Organoleptic test.

INTRODUCTION

Teo tuber (*Tacca leontopetaloides* (L.) Kuntze) is one of the tuber crops that grows in tropical regions, including coastal areas of Indonesia, and has a high starch content, making it a potential alternative food source to support food diversification and self-sufficiency (Erlinawati *et al.*, 2018). In addition to its high starch content, teo tuber starch also has physicochemical characteristics and functional properties that have the potential to be utilized as a raw material for various food products (Yonata *et al.*, 2023).

According to Yonata *et al.* (2024), *Tacca leontopetaloides* (L.) Kuntze is one of the underutilized plants, despite having a relatively high starch content and potential as a food and energy source, particularly for coastal communities. One form of utilizing teo tuber is through processing the tuber into starch, thereby increasing its added value and making it easier to apply in various food products. A study by on *Tacca leontopetaloides* (L.) Kuntze in Nigeria showed that this tuber has a high starch content and can be processed into

flour with functional characteristics similar to sago flour, making it suitable for use in various traditional food products. According to Kogoya *et al.* (2017), *Tacca leontopetaloides* (L.) Kuntze starch contains 85.74% carbohydrates, 0.18% protein, 0.05% fat, 12.1% moisture, 0.49% ash, and 0.56% crude fiber. The high carbohydrate content indicates that teo tuber starch has the potential to be utilized as an alternative raw material in the development of food products based on local resources.

The utilization of teo tuber starch as a raw material for various food products is one effort to promote food diversification based on local resources. Food diversification aims to optimize the utilization of local food resources to reduce dependence on a single type of food while supporting community food security (Hardono, 2014). One traditional food product that has the potential to be developed through the substitution of teo tuber starch is bagea cookies.

Bagea is a traditional cake originating from Ternate, Maluku, Indonesia, which is commonly purchased as a souvenir and traditionally produced by household-scale

industries. It is primarily made from sago flour (Banudi *et al.*, 2017). The cake has a dry and slightly hard texture, with a sweet and savory taste (Masud *et al.*, 2023).

Sago flour is a major source of carbohydrates; however, its protein, fat, mineral, and other nutrient contents remain relatively low (Rahman & Naiu, 2021). Therefore, bagea cookies made from sago flour tend to be predominantly carbohydrate-based, with relatively low levels of other nutrients (Dewi *et al.*, 2022). Sago flour has been reported to contain 88.79% carbohydrates, 1.84% protein, 6.75% moisture, 0.07% ash, 0.42% fat, and 2.14% fiber (Tarigan *et al.*, 2015). In addition, native sago flour contains specific minerals, including calcium at 32.4 mg/100 g dry weight (DW), phosphorus at 98.6 mg/100 g DW, iron at 2.1 mg/100 g DW, and potassium at 128.3 mg/100 g DW (Mawardi *et al.*, 2026). Therefore, Teo tuber starch has the potential to be utilized as a substitute for sago flour in the production of bagea cookies as an effort to diversify food products based on local resources.

The potential utilization of teo tuber is also supported by its natural availability in Torosiaje Village, Pohuwato Regency. The local community has utilized teo tuber as a raw material for various traditional food preparations, such as porridge, kolak, cookies, and baby food. The utilization of teo tuber by the community indicates that this plant has been used as a food source and has become part of the traditional food wisdom of coastal communities. Based on this potential, teo tuber starch can be developed as a substitute for sago flour in the production of bagea cookies as a form of food diversification based on local resources.

The development of food products based on local raw materials requires scientific studies to ensure that local food innovations meet quality and food safety standards and to determine the level of consumer acceptance of the resulting products. Studies on the proximate characteristics and organoleptic acceptance of bagea cookies substituted with teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) are still needed. Proximate analysis is an important step in determining the main nutrient contents of a product, including moisture, ash, protein, fat, carbohydrate, and crude fiber contents (Kurnijasanti, 2016). The results of this analysis provide a basis for evaluating the nutritional characteristics of the product. In addition, organoleptic testing is necessary to determine the level of panelist acceptance of the product based on the attributes of color, aroma, taste, and texture (Suryaningsih, 2024).

Based on the description above, the author is interested in conducting a study focused on proximate analysis and organoleptic testing of bagea cookies substituted with teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) as a potential alternative local raw material that supports food diversification based on local wisdom.

MATERIALS AND METHODS

Materials

The equipment used in this study included a digital balance, containers, a mixer, a spatula, an oven, and measuring cups. The materials used for bagea cookie production consisted of *Tacca leontopetaloides* flour, sago flour, eggs, coconut milk, vanilla, baking soda, and cinnamon powder

Procedures

Preparation of *Tacca leontopetaloides* Flour

Fresh *Tacca leontopetaloides* (L) Kuntze starch were washed and peeled, followed by slicing and grating. The grated tubers were soaked in water at a ratio of 1:1 (w/v) for 3 × 24 h. The soaked material was then sedimented, and the precipitate obtained was dried in an oven at 80°C for 12 hours. The dried material was milled and sieved through an 80-mesh sieve to obtain flour, which was subsequently stored for further analysis.

Preparation of Bagea Cookie

Bagea cookies were prepared by mixing eggs, sugar, coconut milk, vanilla, and baking soda until homogeneous using a mixer. Sago flour and *Tacca leontopetaloides* (L) Kuntze starch were added according to the formulation and mixed until a uniform dough was obtained. Cinnamon powder was then incorporated into the dough. The dough was shaped and baked in an oven until fully cooked. After cooling, the bagea cookies were packaged and stored for further analyses.

Five formulations were prepared with different substitution levels of sago flour and *Tacca leontopetaloides* flour: F1 (100:0), F2 (75:25), F3 (50:50), F4 (25:75), and F5 (0:100)

Data Analysis

Data analysis in this study used a quantitative descriptive approach. Proximate analysis data, including carbohydrate, protein, fat, moisture, ash, and crude fiber contents of bagea cookies substituted with teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze), were processed to obtain mean values and then analyzed descriptively by comparing the results among treatments. The proximate data were used to determine the best treatment using the De Garmo effectiveness index method with equal weighting for each parameter. Organoleptic test data, including color, aroma, taste, and texture, were analyzed descriptively based on the mean panelist scores and presented in graphs. Furthermore, the organoleptic data were analyzed using the Kruskal-Wallis test with the assistance of Statistical Package for the Social Sciences (SPSS) software to determine differences in panelist acceptance among treatments, and were subsequently used to determine the best treatment using the De Garmo effectiveness index method.

RESULTS AND DISCUSSION

Proximate Analysis of Teo Tuber Flour

The proximate analysis of teo tuber flour (*Tacca leontopetaloides* (L.) Kuntze),) showed variations in the values of each parameter measured. The flour contained 84.76% carbohydrates, 0.58% protein, 0.24% fat, 0.72% crude fiber, 13.37% moisture content, and 0.33% ash content. The results of the proximate analysis of teo tuber flour are presented in Table 1.

Table 1. Proximate analysis results of *Tacca leontopetaloides* (L.) Kuntze) Starch.

No	Parameters	Unit	Value
1.	Carbohydrates	%	84,76
2.	Protein	%	0,58
3.	Fat	%	0,24
4.	Crude Fiber	%	0,72
5.	Moisture Content	%	13,37
6.	Ash Content	%	0,33

Based on the results of the proximate analysis of teo tuber starch, the following composition was obtained: carbohydrates 84.76%, protein 0.58%, fat 0.24%, fiber 0.72%, moisture content 13.37%, and ash content 0.33%.

2 Proximate Analysis of Bagea Cookies.



F1 (SF 100g)



F2 (TS 75g:TTS 25g)

F3 (TS 50g:TTS 50g)



F4 (TS 25g:TTS 75g)

F5 (TTS 100g)

The results of the proximate analysis of bagea cookies substituted with teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) showed variations in the values of each test parameter. The carbohydrate content ranged from 76.83–82.53%, protein content from 1.98–3.32%, fat content from 4.78–8.92%, crude fiber content from 2.24–4.06%, moisture content from 4.41–7.62%, and ash content from 0.95–3.99%. The highest carbohydrate content was found in treatment F2 (82.53%), while the highest protein content (3.32%) and crude fiber content (4.06%) were found in treatment F5. The highest moisture content (7.62%) and ash content (3.99%) were found in treatment F4. The results of the proximate analysis are presented in Table 2.

Table 2. Proximate Analysis Results of Bagea Cookies Substituted with *Tacca leontopetaloides* (L.) Kuntze Starch.

No	Parameters	Units	Treatment				
			F1 (SF100 g)	F2 (SF75g+TTS25g)	F3 (SF50g+TTS50g)	F4 (SF25g+TTS75g)	F5 (TTS100g)
1.	Carbohydrates	%	80,56	82,53	80,67	78,96	76,83
2.	Protein	%	1,98	3,28	2,59	2,41	3,32
3.	Fat	%	8,92	5,74	5,94	4,78	8,09
4.	Crude Fiber	%	2,34	3,09	2,91	2,24	4,06
5.	Moisture Content	%	5,15	4,41	6,77	7,62	5,12
6.	Ash Content	%	1,07	0,95	1,12	3,99	2,58

Notes. SF: Sago Flour, TTF: Teo Tuber Starch

Based on the results of the proximate analysis for each treatment, the best treatment was subsequently determined using the Effectiveness Index Method (De Garmo). This method was used to determine the best treatment based on several proximate parameters that had

been analyzed. In this study, each parameter was assigned an equal weight of 0.1667. The results of the calculation of the effectiveness values and effectiveness index for each treatment are presented in Table 3.

Table 3. Results of the Effectiveness Index Calculation Using the De Garmo Method for the Proximate Analysis of Bagea Cookies.

Parameters	Weight	F1	F2	F3	F4	F5
Carbohydrates	0,1667	0,1090	0,1667	0,1123	0,0622	0
Protein	0,1667	0	0,1617	0,0758	0,0534	0,1667
Fat	0,1667	0	0,1280	0,1199	0,1667	0,0334
Crude Fiber	0,1667	0,0091	0,0778	0,0613	0	0,1667
Moisture Content	0,1667	0,1282	0,1667	0,0441	0	0,1298
Ash Content	0,1667	0,0161	0,1667	0,1573	0	0,773
Effectiveness Index	1	0,4066	0,8677	0,5710	0,2824	0,5739

The The results of the effectiveness index calculation for the proximate analysis of bagea cookies substituted with teo tuber starch using the De Garmo method showed differences in values among the treatments. The effectiveness index values for treatments F1, F2, F3, F4, and F5 were 0.4066, 0.8677, 0.5710, 0.2824, and 0.5739, respectively.

Sensory Evaluation

The organoleptic test results of bagea cookies substituted with teo tuber starch (*T. Leontopetaloides* (L.) Kuntze) in terms of color, taste, aroma, and texture are presented in Table 4. The mean panelist scores ranged from 3.20 to

3.74, which were categorized as moderately liked. Formulation F1 obtained the highest mean scores for all parameters. The lowest mean scores were observed in different formulations for each parameter, namely F5 for color and texture, F4 for taste, and F3 for aroma. The organoleptic evaluation involving 35 panelists was analyzed using the Kruskal–Wallis test. The results showed that the substitution of teo tuber flour (*T. leontopetaloides* (L.) Kuntze) in bagea cookies did not result in significant differences ($p>0.05$) compared with bagea cookies made from 100% sago flour, with the same level of panelist acceptance across all treatments.

Table 4. Mean Values, Standard Deviations, and Kruskal–Wallis Test Results for the Sensory Attributes of Bagea Cookies.

Treatment	F ₁	F ₂	F ₃	F ₄	F ₅	p
Color	3.60±0,913	3.54±0,780	3.34±0,968	3.57±0,739	3.20±1,023	0,285
Teste	3.51±0,919	3.37±1,031	3.45±0,918	3.25±1,086	3.36±0,980	0,477
Scant	3.74±0,816	3.60±0,976	3.40±0,976	3.42±0,916	3.42±0,884	0,507
Texture	3.74±0,918	3.42±0,884	3.37±1,002	3.37±1,086	3.31±1,050	0,333

Comparing kruskal Wallis' test results with significant value ($p> 0.05$) on all the parameters observed, thus showing no significant difference in treatment of the characteristic organoleptic bagea cake. This indicates that the variety of teo tuber meal substitutions on each

treatment has not made an apparent impact on its panelic preference. Nevertheless, based on their average value, there is a tendency for some treats to have a higher preference than others.

Table 5. Results of the Effectiveness Index Calculation Using the De Garmo Method for the Organoleptic Analysis of Bagea Cookies.

Parameter	Bobot	F1	F2	F3	F4	F5
Color	0,25	0,25	0,212	0,087	0,231	0
Teste	0,25	0,25	0,129	0,198	0	0,025
Scant	0,25	0,25	0,147	0	0,014	0,014
Texture	0,25	0,25	0,063	0,034	0,034	0
Effectiveness Index	1	1	0,552	0,320	0,280	0,040

The results of the organoleptic effectiveness index calculation for bagea cookies substituted with teo tuber starch using the De Garmo method showed differences in values among the treatments. The effectiveness index values for treatments F1, F2, F3, F4, and F5 were 1, 0.552, 0.320, 0.280, and 0.040, respectively.

Discussion

Proximate Analysis of Teo Tuber Flour

Based on the proximate analysis, the carbohydrate content of *Tacca leontopetaloides* (L.) Kuntze starch was 84.76%, indicating that carbohydrates are the major component of the starch. The high carbohydrate content suggests that *Tacca leontopetaloides* (L.) Kuntze starch

has considerable potential as an energy source in various food products. This value is higher than the range reported by Susiarti (2015), which was 77.09–82.56%. The differences in carbohydrate content may be attributed to variations in growing location, environmental conditions, harvest maturity, and processing methods prior to flour production. Furthermore, since carbohydrate content was determined by difference, the calculated value was influenced by the moisture, protein, fat, and ash contents of the sample.

The protein content of *Tacca leontopetaloides* (L.) Kuntze starch was 0.58%. This value was lower than the minimum protein requirement of 7% specified in SNI 3751:2009. However, SNI 3751:2009 is a quality standard applicable to wheat flour; therefore, the comparison was used only as a general reference. The result obtained in this study is comparable to the protein content of *Tacca leontopetaloides* (L.) Kuntze starch reported by Yonata *et al.* (2023), which ranged from 0.42% to 0.83%. Variations in protein content may be influenced by cultivation location and processing methods. The low protein content in *Tacca leontopetaloides* (L.) Kuntze starch is likely attributable to the grating, filtration, and sedimentation processes, which may have caused part of the non-starch components, including proteins, to be separated during processing. In addition, high drying temperatures may lead to protein denaturation, thereby affecting the measured protein content (Erni *et al.*, 2018).

The moisture content of *Tacca leontopetaloides* (L.) Kuntze starch was 13.37%. This value was lower than the maximum moisture content limit of 14.5% specified in SNI 3751:2009, indicating that the resulting starch met the moisture quality standard and has the potential for good shelf life. The moisture content obtained in this study was higher than that reported by Kogoya *et al.* (2017), who found a moisture content of 12.1% in Tacca starch. These differences may be attributed to variations in drying methods, drying duration, raw material conditions, tuber maturity, and postharvest handling practices employed in each study. According to Syamaladevi *et al.* (2016), low moisture content can inhibit microbial growth and delay food deterioration, making it an important factor in maintaining the quality and shelf life of food products.

The ash content of *Tacca leontopetaloides* (L.) Kuntze starch was 0.33%, which was lower than the maximum ash content limit of 0.70% specified in SNI 3751:2009. The low ash content indicates a relatively low level of inorganic minerals in the starch and reflects its good quality for use as a substitute ingredient in cookie production (Kristiandi *et al.*, 2021). The ash content obtained in this study was lower than that reported by Kogoya *et al.* (2017), who found an ash content of 0.49% in Tacca starch. These differences may be attributed to variations in raw materials, environmental conditions where the plants were grown, and the processing methods employed. In addition, the

washing, filtration, and sedimentation processes during flour production may have caused some soluble minerals to be removed from the material, resulting in a lower ash content.

The fat content of *Tacca leontopetaloides* (L.) Kuntze starch was 0.24%, which was lower than the value reported by Susiarti (2015), who found a fat content of 1.90% in Tacca flour. This difference may be attributed to variations in raw materials and starch processing methods. Low fat content can be advantageous because it enhances starch stability during storage. Moreover, the reduction in fat content may result from the loss of lipid molecules during the starch production process (Ariani *et al.*, 2024).

The crude fiber content of *Tacca leontopetaloides* (L.) Kuntze starch was 0.72%, which was slightly higher than the value reported by Susiarti (2015), namely 0.60%. This difference may be influenced by the characteristics of the raw materials and the processing methods used. The starch production process involved grating, filtration, and sedimentation steps. During tuber starch extraction, filtration is carried out to separate starch from undesirable solids or residues (Dorantes *et al.*, 2024). Therefore, some non-starch components may have been retained in the residue, thereby affecting the crude fiber content of the final product.

Proximate Analysis of Bagea Cookies

Proximate analysis of bagea cookies was conducted to determine changes in the chemical characteristics of the product based on the use of teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze). The parameters analyzed included carbohydrate, protein, fat, crude fiber, moisture, and ash contents.

Based on the results of the proximate analysis, the carbohydrate content of bagea cookies across all treatments ranged from 76.83–82.53% (Table 2). The highest carbohydrate content was obtained in treatment F2, which consisted of a formulation of 75% sago flour and 25% teo tuber starch, with a value of 82.53%, whereas the lowest carbohydrate content was observed in F5, which used 100% teo tuber starch, with a value of 76.83%. These results indicate that changes in the proportion of sago flour and teo tuber starch did not produce a linear pattern in carbohydrate content. In other words, increasing the proportion of teo tuber starch in the formulation did not directly result in either an increase or decrease in carbohydrate content.

The determination of carbohydrate content in this study was conducted using the by difference method, which involves calculating the difference between 100% and the total contents of moisture, ash, protein, fat, and crude fiber. This method was also used by Muhammad *et al.* (2025), who determined carbohydrate content by calculating the difference between 100% and the contents of moisture, ash, protein, fat, and fiber. Therefore, the carbohydrate content obtained in this study does not solely represent the direct carbohydrate content, but is

also influenced by the levels of other proximate components included in the calculation. In addition, fluctuations in the measured carbohydrate content of the final product may also be related to the occurrence of the Maillard reaction during oven baking, in which thermal interactions among these components also contribute to determining the final color characteristics of the bagea cookies produced (Martins *et al.*, 2017).

Based on the results of the proximate analysis, the protein content of the bagea cookies across the five formulations ranged from 1.98–3.32%. The highest protein content was obtained in treatment F5 (100% teo tuber starch), at 3.32%, whereas the lowest protein content was observed in treatment F1 (100% sago starch), at 1.98%. These results indicate a tendency for the protein content to increase as the proportion of teo tuber starch in the formulation increased, although the changes in protein content among treatments did not exhibit a completely linear pattern.

The increase in protein content in the bagea cookies cannot be directly attributed to a high protein content of teo tuber starch, as the raw material analysis showed that teo tuber starch contained only 0.58% protein. The protein content of the final product results from the contribution of all ingredients used in the formulation, as well as changes in the composition of components during processing. Therefore, differences in the proportions of ingredients among treatments may result in differences in the protein content of the final product. Changes in the proportion and type of substitution ingredients can affect the protein content of the final product. Hadero (2019) showed that differences in the proportion of substitution ingredients in cookies were associated with changes in the protein content of the product. Similarly, Rahman and Naiu (2021) reported a protein content of 9.44% in bagea cookies for the best treatment with anchovy flour substitution. These differences in results indicate that the characteristics of the substitution ingredients are related to the protein content of the resulting product.

The moisture content values presented in Table 2 show that the moisture content of bagea cookies substituted with teo tuber starch differed among treatments. The highest moisture content was observed in treatment F4 (25% sago flour substituted with 75% teo tuber starch), at 7.62%, whereas the lowest moisture content was found in treatment F2 (75% sago flour substituted with 25% teo tuber starch), at 4.41%. According to SNI 2973:2022 for Biscuits, the maximum moisture content requirement is 5%. Based on the results of this study, treatment F2, with a moisture content of 4.41%, met this requirement, whereas treatments F1, F3, F4, and F5 did not meet the requirement because their moisture contents exceeded 5%. Hasriani *et al.* (2018), in a study of bagea cookies substituted with purple sweet potato flour, reported moisture contents ranging from 10–13%. The difference in moisture content between that study and the present study may be influenced by

differences in ingredient formulations and processing conditions.

The moisture content of cookies is influenced by the baking process and the composition of the ingredients used. During baking, an increase in temperature causes water in the dough to evaporate, thereby reducing the moisture content of the product. In addition, differences in flour and starch composition may affect the ability of the ingredients to bind and retain water during processing. This is consistent with the findings of Ariyantoro *et al.* (2024), which showed that differences in starch substitution in biscuits resulted in differences in moisture content. These differences are related to the characteristics of the constituent ingredients and the ability of the components to retain water during processing.

Differences in moisture content among the treatments were presumably influenced by variations in the ingredient formulations used. This is related to the ability of the ingredients to absorb and bind water during processing, such that differences in ingredient composition can affect the moisture content of the final product (Rakhmawati *et al.*, 2014).

Ash content is the inorganic residue remaining after the combustion of a material. Ash content is related to the mineral content of a material (Winata *et al.*, 2015). The ash content values in Table 4.2 show that the highest ash content in bagea cookies substituted with teo tuber starch was found in treatment F4 (25% sago flour substituted with 75% teo tuber starch), which was 3.99%. Meanwhile, the lowest ash content was found in treatment F1 (100% sago flour), which was 1.07%.

Differences in ash content in bagea cookies are related to the mineral content originating from the ingredients used to make the bagea cookies. Research conducted by Ogbonna *et al.* (2017) showed that *Tacca leontopetaloides* (L.) Kuntze starch contains several minerals, including potassium, calcium, magnesium, phosphorus, iron, zinc, sodium, manganese, and copper. The mineral content of *Tacca leontopetaloides* (L.) Kuntze may also vary depending on the growing conditions and location of the material (Yonata *et al.*, 2024). Based on the results of raw material characterization, teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) had an ash content of 0.33%. The results showed that the ash content of bagea cookies did not increase linearly with increasing proportions of teo tuber starch. The differences in ash content values indicate that the mineral content in the final product is a contribution from all ingredients used in each formulation.

The fat content of bagea cookies can be seen in Table 2. The fat content values ranged from 4.78%–8.92%, indicating that the highest fat content in bagea cookies substituted with teo tuber starch was found in treatment F1 (100% sago flour), which was 8.92%. Meanwhile, the lowest fat content was found in treatment F4 (25% sago flour substituted with 75% teo tuber starch), which was

4.78%. Based on these results, a decrease in fat content was observed in several treatments due to changes in the substitution formulation used. Based on SNI 2973:2022 regarding the quality requirements for cookies, the minimum fat content of cookies is 9.5%. Based on the results of this study, the fat content of bagea cookies ranged from 4.78%–8.92%. These values are still below the minimum fat content limit according to SNI 2973:2022; therefore, all treatments did not meet the established standard.

The crude fiber content of bagea cookies in Table 2 ranged from 2.24–4.06%, indicating that the highest crude fiber content in bagea cookies substituted with teo tuber flour was found in treatment F5 (100% teo tuber starch), which was 4.06%. Meanwhile, the lowest crude fiber content was found in treatment F4 (25% sago flour substituted with 75% teo tuber starch), which was 2.24%.

The high crude fiber content in F5 indicates that the formulation containing 100% teo tuber starch resulted in a higher crude fiber content compared to the other treatments. The presence of fiber in *T. leontopetaloides* (L.) Kuntze has been reported in previous studies. Ogbonna *et al.* (2017) reported a crude fiber content of 5.44% in the *T. leontopetaloides* (L.) Kuntze tuber starch that they analyzed. Other studies have also shown that the proximate characteristics of Tacca can change due to processing and washing processes.

Increasing the substitution of teo tuber starch did not result in a linear increase in crude fiber content. F4, which used 75% teo tuber starch, had the lowest crude fiber content of 2.24%, whereas F5, with 100% teo tuber starch, had the highest content of 4.06%. These differences indicate that the crude fiber content of bagea cookies is influenced by the composition of the ingredients used and the processing process, and therefore is not determined solely by the percentage of teo tuber starch substitution. This is consistent with the study by China *et al.* (2022), which showed that changes in the proportion of ingredients in cookie formulations can result in changes in the crude fiber content of the product.

The results of the effectiveness index calculation in Table 4.3 show values of 0.4066 for F1, 0.8675 for F2, 0.5710 for F3, 0.2824 for F4, and 0.5739 for F5. Treatment F2 showed the highest value, namely 0.8675, and was therefore determined as the best formulation based on the proximate parameters. The high effectiveness index value of F2 indicates that this treatment had the best balance of characteristics and was the closest to the optimization parameters of the study. As reported by Puspitojati. (2024), the effectiveness index method is effective for determining the best food product formulation based on various quality parameters tested.

Sensory Evaluation

Bagea is a traditional cookie generally made from sago, with distinctive sensory characteristics. The substitution

of teo tuber starch in its preparation may affect the color, taste, aroma, and texture. Therefore, to determine the level of consumer acceptance, organoleptic testing was conducted on bagea cookie products with different substitution formulations for each treatment.

The organoleptic test was conducted to determine the level of panelist acceptance of bagea cookies with various levels of teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) substitution. Based on the test results, the panelists' preference scores for the attributes of color, taste, aroma, and texture ranged from 3.20–3.74 and did not show statistically significant differences among formulations. Although there were numerical differences in the mean values, these differences did not indicate a significant effect of the level of teo tuber starch substitution on panelist acceptance. This indicates that the use of teo tuber starch at various substitution levels still produced bagea cookies that were acceptable to the panelists, with a level of acceptance relatively similar to that of the control treatment F1. The results of this study are consistent with those of Putra *et al.* (2025), which showed that the use of tuber flour as a substitution ingredient in cookie production can result in variations in sensory characteristics, but at certain substitution levels, the resulting products can still be accepted by panelists. This indicates that the use of tuber-based substitution ingredients in cookies does not necessarily reduce sensory acceptance, but is influenced by the proportion of ingredients used.

Based on the panelists' preference for the color of bagea cookies ranged from 3.20–3.60%. The highest mean value was obtained for treatment F1 (100% sago flour), which was 3.60, while the lowest value was found in treatment F5 (100% teo tuber starch), which was 3.20. The results of the statistical analysis showed that differences in the level of teo tuber starch substitution did not have a significantly different effect on the panelists' preference for the color attribute of bagea cookies. The relatively lower preference score in treatment F5 was presumably related to the natural color characteristics of teo tuber starch, which has a relatively high brightness level. Yonata *et al.* (2023) reported that teo tuber starch had a brightness value of 92.01–93.62 with a whiteness index of 91.68–92.74. These characteristics indicate that teo tuber starch has a relatively white or light base color. As the proportion of teo tuber starch in the formulation increased, the color characteristics of the raw material became more dominant and potentially affected the color appearance of the resulting bagea

In addition to being influenced by the natural color of the raw materials, the color of bagea cookies is also formed during the baking process due to the occurrence of the Maillard reaction. According to Lohinova and Petrusha (2023), the Maillard reaction is a non-enzymatic browning reaction that occurs between reducing sugars and amino groups, particularly those originating from proteins, during heating. This reaction produces various intermediate compounds that subsequently form

melanoidin pigments, thereby providing the characteristic brownish color of food products. Differences in the composition of the starch matrix in the dough may also affect the occurrence of the Maillard reaction and the formation of brown color during heating (She *et al.*, 2024).

Based on the panelists' preference for the taste of bagea cookies ranged from 3.22–3.51%. The highest mean value was obtained for treatment F1 (100% sago flour), which was 3.51, while the lowest value was found in treatment F4 (25% flour and 75% teo tuber starch), which was 3.22. The tendency toward a lower mean taste preference in treatment F4 was related to the variation in formulation between sago flour and teo tuber starch, which affected the chemical composition of the dough. In the production of bakery products, changes in the proportion of raw materials have the potential to alter the taste profile and organoleptic acceptance of panelists due to differences in the inherent chemical characteristics of each ingredient. This is consistent with the findings of Gbenga-Fabusiwa *et al.* (2018), which stated that substitution of flour formulations in biscuit products can result in differences in taste preference, without necessarily significantly changing panelists' responses to the parameters of color, aroma, or texture. Therefore, the lower taste score in F4 is presumed to be only a numerical variation resulting from changes in the ratio of ingredients and does not yet indicate a significant decrease in consumer acceptance.

Based on the panelists' preference for the aroma of bagea cookies, the mean scores ranged from 3.40–3.74. The highest aroma preference score was obtained for treatment F1 (100% sago flour), with a mean score of 3.74, while the lowest score was found in treatment F3 (50% sago flour and 50% teo tuber starch), with a mean score of 3.40. The relatively lower aroma preference score in treatment F3 was presumably related to differences in the composition of sago flour and teo tuber starch used. Differences in the type and proportion of ingredients can affect the characteristics of volatile compounds that contribute to the aroma of the product. This is consistent with Pico *et al.* (2017), which showed that the use of different types of flour and starch can affect the composition of volatile compounds and the aroma characteristics of products. The study by Putri *et al.* (2023) also showed that substitution of flour-based ingredients can affect sensory characteristics, including aroma.

Based on the panelists' preference for the texture of bagea cookies, the mean scores ranged from 3.31%–3.74%. The highest texture preference score was obtained for treatment F1 (100% sago flour), with a mean score of 3.74%, while the lowest score was found in treatment F5 (100% teo tuber starch), with a mean score of 3.31%. The relatively lower texture preference score in treatment F5 was presumably related to the characteristics of the starch present in sago flour and teo

tuber starch. Based on the composition analysis, teo tuber starch had a higher amylopectin content (43.88%) than amylose content (22.77%). Differences in starch composition, particularly the ratio of amylose to amylopectin, strongly influence water absorption capacity and the gelatinization process during heating. Mujahanah *et al.* (2024) stated that the amylose component contributes to increasing product hardness, whereas a high amylopectin content tends to make products softer and more prone to breakage. Therefore, the difference in the proportion of sago flour and teo tuber starch in F5 was presumed to contribute to a relatively harder texture of the bagea cookies, thereby reducing the panelists' level of preference.

Differences in preference scores for each organoleptic attribute indicate variations in panelists' responses to the bagea cookies substituted with teo tuber starch produced from each treatment. To determine the significance of these differences, an analysis was conducted using the Kruskal-Wallis test. Based on the analysis results in Table 4, significance values of 0.285 for color, 0.477 for taste, 0.507 for aroma, and 0.333 for texture were obtained. All of these significance values were greater than 0.05, indicating that the substitution of teo tuber starch did not have a significantly different effect on the panelists' level of preference for the organoleptic characteristics of bagea cookies, including color, taste, aroma, and texture. Thus, the use of teo tuber starch at the proportions used in this study still produced bagea cookies with organoleptic characteristics that were acceptable to the panelists.

Based on the results of the Kruskal-Wallis test, which showed no significant differences among treatments for all organoleptic attributes, an effectiveness analysis was subsequently conducted using the De Garmo method. This analysis was used to determine the most optimal treatment based on the overall organoleptic attributes observed. The determination of the best treatment using the De Garmo method has also been applied in food research to obtain the most optimal formulation based on several observed parameters (Kenenbudi *et al.*, 2026). The results of the effectiveness analysis using the De Garmo method showed effectiveness values for F1, F2, F3, F4, and F5 of 1, 0.552, 0.320, 0.280, and 0.040, respectively. Treatment F1 had the highest effectiveness value, whereas F5 had the lowest. A higher effectiveness value indicates a more optimal treatment based on the established criteria and weights. Therefore, F1 was determined as the best treatment because it obtained the highest effectiveness value, namely 1.

CONCLUSIONS

Based on the results of the study, the substitution of teo tuber starch (*Tacca leontopetaloides* (L.) Kuntze) in bagea cookies resulted in variations in proximate composition, with protein content ranging from 1.98%–

3.32%, carbohydrates from 76.83%–82.53%, moisture content from 4.41%–7.62%, ash content from 0.95%–3.99%, fat content from 4.78%–8.92%, and crude fiber content from 2.24%–4.06%. Based on the De Garmo effectiveness index analysis, F2 had the highest effectiveness index for the proximate characteristics, with a value of 0.8675. Meanwhile, the organoleptic evaluation showed that panelist preference scores ranged from 3.20–3.74, with no significant differences among treatments ($p>0.05$) compared with the control treatment (100% sago flour), indicating that the substitution of teo tuber starch still produced bagea cookies with an acceptable level of sensory preference. Based on the De Garmo effectiveness analysis of the organoleptic attributes, F1 obtained the highest effectiveness value of 1 and was therefore identified as the best treatment for the organoleptic characteristics.

Competing Interests: The authors declare no conflicts of interest.

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