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Formulation and Organoleptic Test on Cookies Made from Potato Peel Flour

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Abstract

Processing potatoes into flour is one way to reduce the risk of damage and extend the shelf life of potatoes. Potato flour has high absorption, fine texture, sweet taste, and a distinctive fragrant aroma. Cookies are dry baked goods produced by baking dough made from wheat flour, either with or without substitutes, along with oil or fat, and optionally incorporating other food ingredients and approved additives. Based on this, it is necessary to conduct research on potato flour formulations in cookies with organoleptic tests to determine the best formulation for making cookies from potato peel flour, obtaining the best formulation it can reduce the dependence of the community and industry on the use of wheat flour. The research used a Completely Randomized Design (CRD) with four formulations (0%, 25%, 50%, and 75% potato peel flour substitution) and two repetitions. Organoleptic testing, including hedonic and hedonic quality assessments, was conducted to evaluate panellists' preferences for colour, texture, taste, and aroma. The results showed that cookies with 25% potato peel flour substitution (F1) were the most preferred, achieving the highest scores in all sensory attributes. However, increasing the substitution level resulted in a darker colour, firmer texture, and a more pronounced bitter taste, affecting overall acceptability.

Introduction

Indonesia is currently the second-largest wheat importer in the world. The Indonesian Wheat Flour Producers Association (Aptindo) noted that in the third quarter of 2017, Indonesia's wheat flour imports reached 5.8 million tons. Therefore, it is necessary to reduce dependence on wheat flour by shifting the use of wheat flour to non-wheat flour ingredients (Rosida et al., 2020). Local tubers have great potential as an alternative source that can be developed to replace wheat flour (Parinduri et al., 2021). Processing potatoes into flour is one way to reduce the risk of damage and extend the shelf life of potatoes (Pratiwi, 2024; Mu et al., 2027; Saini et al., 2023).

Potato (Solanum tuberosumL) is a common processed carbohydrate in Indonesia and one of the staple foods widely loved worldwide. The main composition of potatoes consists of 78% water, 19% carbohydrates, 2% protein, vitamin C, and vitamin B1 (Putri et al., 2022). Potassium in potatoes is 396 mg and whose sodium is 7 mg per 100 grams, which is higher when compared to wheat flour, whose potassium content is only 0 mg and sodium content is 2 mg (Kispriatama & Gusnita, 2023). Sodium causes an increase in blood pressure, while potassium lowers blood pressure. Therefore, the high ratio of potassium and sodium in potatoes is very beneficial for health as it can prevent high blood pressure. Potatoes can also be made into dough. This high carbohydrate content makes potatoes a popular food ingredient that can

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replace (substitute) other carbohydrate sources such as rice, corn, and wheat (Bao et al., 2021). Potato flour has high absorption, delicate texture, sweet taste, and a distinctive fragrant aroma (Rezona & Gusnita, 2021; Noreen et al., 2024; Mundiastuti et al., 2024).

Cookies or pastries are one type of food product favoured by all levels of society ranging, from children to adults (Hidayah et al., 2023; Stoin et al., 2021). Cookies are dry baked goods produced by baking dough made from wheat flour, either with or without substitutes, along with oil or fat, and optionally incorporating other food ingredients and approved additives (Badan Standar Nasional, 2018). In processing cookies, crispness and texture must be considered. The quality or quality of cookies in addition to being determined based on chemical content (water, carbohydrates, protein, fat) and microbiological, can also be determined from texture, colour, taste and aroma, and how long cookies can be stored. In making cookies, a type of flour with low protein content is needed because using protein-rich flour will produce more complex and less crunchy cookies (Wati et al., 2020; Nurilmala et al., 2024; Suresh et al., 2025). The fine texture makes the characteristics of potato flour almost the same as wheat flour so that potato flour can be processed into various interesting and high-value products (Rezona & Gusnita, 2023; Pęksa & Miedzianka, 2021; Khongla et al., 2024; Taglieri et al., 2021).

The results of research conducted by Anova et al. (2014) show that potato cookies have good nutrition and appearance, and acceptability (organoleptic) including favourable to very favourable at 50% potato flour formulation. Based on this, it is necessary to conduct research on potato flour formulations in cookies with organoleptic tests to determine the best formulation for making cookies from potato peel flour, obtaining the best formulation can reduce the dependence of the community and industry on wheat flour.

Methods

In this study, the total number of cookies tested for each formulation was done with two repetitions. Each panelist tested a total of 8 cakes. The panelists involved were 6th-semester students of the Nutrition Science study program, with an age range between 20 to 21 years. Panelists already had basic knowledge of organoleptic testing, as they had previously studied related material in lectures. The total number of panelists in this study was 30 people. Organoleptic testing was conducted simultaneously at one time, using the same panelists in each testing session. To ensure the assessment results remained accurate, panelists were required to neutralize their taste buds by drinking water before and after tasting the samples. This was done to avoid any residual flavours from the previous sample that could affect the assessment of the next sample.

This study used an experimental approach with a complete randomized design (CRD) to evaluate the effect of adding potato peel flour on the organoleptic properties of cookies. This research was conducted from April to September 2021. The research began with the material preparation stage, where potato skins were processed into flour before being used in cookie formulations. Potato skin flour was used in four formulation variations, namely 0%, 25%, 50%, and 75%. The selection of this substitution level refers to research conducted by Anova (2014), which examined the impact of potato peel flour replacement on the sensory and physical characteristics of food products (Anova et al., 2014). This variation aims to understand the extent to which the addition of potato skin flour can affect the texture, taste, color, and aroma of cookies, as well as the level of panelist acceptance of the final product. Making cookies involves mixing the main ingredients (wheat flour, margarine, sugar, and eggs) with potato peel flour and then baking according to standard methods. According to Sukrianto et al. (2024), the model is as follows.

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$Yij = \mu + \alpha i + \varepsilon ij$

Description:

Yij : Effect of potato peel flour addition

μ : Generalized mean value

αi : Effect of the addition of potato peel flour on cookies at the i-th level (i=1, 2, 3, 4)

εij : Experimental error in the i-th treatment combination at the j-th repetition (1, 2). jth repetition (1, 2)

Organoleptic tests were conducted at the Binawan University Culinary Laboratory to assess panellists' acceptance of sensory attributes (colour, aroma, taste, texture, and overall) through hedonic and hedonic quality tests. Organoleptic data were analyzed descriptively using Microsoft Excel 2010 and statistical software, followed by an Analysis of Variance (ANOVA) to evaluate the treatment effects. If ANOVA revealed a significant impact, further analysis was conducted using Duncan's Multiple Range Test (DMRT) to identify treatment differences (Hasanah et al., 2023). Meanwhile, the proximate analysis results for the control and selected formulations were evaluated using the Independent Sample T-test for comparison.

Results and Discussion

The high-potassium potato peel flour cookies were then tested for organoleptic properties including hedonic and hedonic quality tests. The organoleptic test aims to evaluate the use of formulation ingredients for potato peel flour cookies with banana skin flour substitution levels including 0% (F0); 25% (F1); 50% (F2); and 75% (F3). F0 is a biscuit formula without the addition of potato peel flour (0%), F1 is a cookie formula with the addition of 25% potato peel flour, F2 is a cookie formula with the addition of 50% potato peel flour, F3 is a cookie formula with the addition of 75% potato peel flour. The results of potato peel flour cookies obtained from the formulations that have been made can be seen in Figure 1.

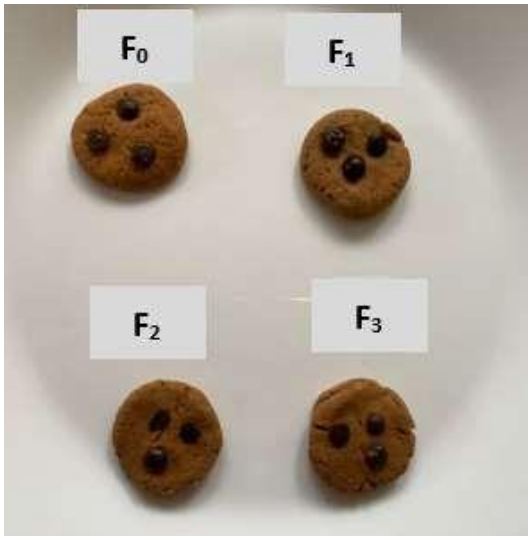

Figure 1. Organoleptic Test of Potato Peel Flour Cookies

The percentage of the selected formula is done by looking at the highest average value of the favourite level test (hedonic test). The results for each assessment attribute were analyzed descriptively and statistically using a variance test (ANOVA) to compare differences among more than two groups, followed by Duncan's further test. The outcomes of the hedonic and hedonic quality tests for potato peel flour cookies are presented in Table 1. and Table 2.

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Table 1. Hedonic Test Results of Potato Peel Flour Cookies

Formula	Attributes				
	Colour	Texture	Taste	Aroma	Overall
F0 (0%)	4.10d	3.87b	3.83d	4.07c	3.97d
F1 (25%)	4.00c	4.10b	3.47c	4.00bc	3.89c
F2 (50%)	3.63b	3.20a	2.43b	3.63b	3.22b
F3 (75%)	3.37a	2.77a	1.70a	3.13a	2.74a

Description: 1 = very dislike; 2 = dislike; 3 = normal; 4 = like; 5 = very like.
: Different letters on the same line indicate significant differences ($p<0.05$)

The results of the hedonic test organoleptic assessment on colour attributes (Table 1) show that cookies at the F0 level obtained the highest favorability score of 4.10 (like), followed by F1 which received a score of 4.00 (normal), F2 of 3.63 (like), and F3 with the lowest level of favorability of 3.37 (normal). The ANOVA test results showed that different potato peel flour substitution levels had a significant effect ($p<0.05$) on the panellists' level of liking for the colour attribute. Duncan's further test results showed that the difference in concentration in the control formula (F0) to the three cookie test formulations of potato peelflour substitution for each formulation showed a significant difference ($p<0.05$). As the amount of potato peel flour in the cookies increased, the panellists' preference for the colour attribute decreased.

The results of the hedonic test organoleptic assessment on flavour attributes (Table 1) show that cookies at the F0 level obtained the highest favorability value for the flavour attribute of 3.83 (like), F1 at 3.47 obtained, F2 at 2.30 (dislike), and F3 at 1.70 obtained the lowest value (dislike). The ANOVA test results indicated that varying levels of banana peel flour substitution significantly influenced ($p<0.05$) the panellists' preference for the flavour assessment attribute. Duncan's further test results showed that the difference in concentration in the control formula (F0) to the three cookie test formulations of potato peel flour substitution for each formulation showed a significant difference ($p<0.05$).

The results of the hedonic test organoleptic assessment (Table 1) show that cookies at the F0 level obtained the highest favorability score of 4.10 (like), followed by F1 at 4.00 (like), F2 at 3.63 (normal) towards like and F3 obtained the lowest favorability score of 3.13 (normal). ANOVA test results showed that different levels of potato peel flour substitution had a significant effect ($p<0.05$) on the level of panellists' liking of the aroma attribute. Duncan's further test results showed that the difference in concentration in the control formula (F0) to F1 was not significantly different, but significantly different from F2 and F3 ($p<0.05$) on the hedonic test on the aroma assessment attribute.

Table 2. Hedonic Quality Test Results of Potato Peel Flour Cookies

Formula	Attributes				
	Colour	Texture	Taste	Aroma	Overall
F0 (0%)	4.37d	3.20b	3.80d	4.20c	3,90d
F1 (25%)	3.33c	3.57b	3.47c	3.90bc	3,57c
F2 (50%)	2.60b	2.63a	2.30b	3.50b	2,80b
F3 (75%)	2.07a	2.23a	1.37a	3.07a	2,20a

Description:

Colour 1= dark brown; 2 = slightly dark brown; 3 = brown; 4 = light brown; 5 = golden brown
Texture 1 = very soft; 2 = soft; 3 = normal; 4 = crunchy; 5 = very crunchy
Taste 1 = very bitter; 2 = slightly bitter; 3 = slightly sweet; 4 = sweet; 5 = very sweet

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Aroma 1 = very faint; 2 = faint; 3 = ordinary; 4 = fragrant; 5 = very fragrant
: Different letters on the same line indicate significant differences ($p<0.05$)

The results of the hedonic quality test on colour attributes (Table 2) show that cookies at the F0 level tend to be light brown, F1 tends to be brown, F2 tends to be dark brown, and F3 is slightly dark brown. The ANOVA test results indicated that the varying levels of potato peel flour substitution had a significant impact ($p<0.05$) on the colour assessment attribute of hedonic quality. The results of Duncan's further test showed the same status, namely the difference in concentration in the control formula (F0) to the three cookie test formulations of potato peel flour substitution, each formulation showed a significant difference ($p <0.05$).

The results of the hedonic test organoleptic assessment on texture attributes (Table 1) show that cookies at the F1 level obtained the highest favorability score of 4.10 (like), followed by F0 at 3.87 (like), F2 at 3.20 (normal), and F3 obtained the lowest favorability score of 2.77 (normal). The ANOVA test results showed that different levels of potato peel flour substitution had a significant effect ($p<0.05$) on the level of panellists' liking for the texture assessment attribute. The results of Duncan's further test revealed that the different concentrations in cookies from the F0 and F1 treatments significantly differed from the F2 and F3 levels in the texture assessment attribute of the hedonic test. The results of the hedonic quality test on texture attributes (Table 2) show that cookies at the F1 level have a crunchy texture and are preferred compared to other levels. The ANOVA test results show that different levels of potato peel flour substitution have a significant effect ($p<0.05$) on hedonic quality at the texture attribute. The results of Duncan's post hoc test show that the concentration difference in cookies between F0 and F4 is significantly different from F0 and F1, but not significantly different from F2 and F3.

The results of the hedonic quality test on flavour attributes (Table 2) show that F0 cookies have a sweet taste, F1 has a slightly sweet taste, F2 has a slightly bitter taste and F3 has a very bitter taste. The results of the ANOVA test showed that the difference in cookies substituted with potato peel flour had a significant effect ($p<0.05$) on the hedonic quality of the taste attributes. The results of Duncan's further test showed the same status, namely the difference in concentration in the control formula (F0) against the four test formulations of potato peel flour substitution cookies, each formulation showed a significant difference ($p <0.05$).

The results of the hedonic quality test on aroma attributes (Table 2) show that cookies at the F0 and F1 levels are fragrant, while at the F2 and F43 levels, they have a normal aroma. The ANOVA test results showed that different levels of potato peel flour substitution had a significant effect ($p<0.05$) on the level of panellists' liking of the aroma attribute. Duncan's further test results showed that the difference in concentration in the control formula (F0) to F1 was not significantly different, but significantly different from F2 and F3 ($p<0.05$) on the hedonic test on the aroma assessment attribute. Panellists' assessment of the aroma attribute tended to decrease in line with the higher addition of potato peel flour.

Table 3. Proximate Analysis of Control (F0) and Selected Formula (F1) Cookies

Component	F0 (0%)	F1 (25%)
Moisture (%)	5.12	5.35
Protein (%)	7.85	8.42
Fat (%)	21.34	20.87
Carbohydrate (%)	64.28	63.10
Ash (%)	1.41	2.26
Crude Fiber (%)	0.33	1.88

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Analyses of the proximate composition demonstrated significant differences when testing the control formula as F0 versus the alternative formula F1 that contained a 25% substitution with potato peel flour. The moistness in F1 (5.35%) exceeded F0's (5.12%) because dietary fiber in potato peels has hydrophilic properties that help it keep moisture throughout baking. The slight moisture elevation from potato peel flour addition to cookies affects their shelf life and texture by producing softer baked goods.

The protein content in F1 exceeded F0 by 8.42 percent while remaining at 7.85 percent. The extra protein content in F1 flour compared to F0 flour can be explained by residual protein substances in potato peels and suggests marginal nutritional value in the substitution of traditional flour with this alternative source. The fat content in F1 at 20.87% remained lower than F0 at 21.34% because the fiber may block fat absorption and prevent efficient integration of fat throughout the dough network.

The potato peel flour contained higher fiber content and lower starch digestibility when compared to wheat flour which led to a minor carbohydrate reduction from F0 (64.28%) to F1 (63.10%). The total mineral content as indicated by ash increased from 1.41% in F0 to 2.26% in F1 because potato peels contain higher mineral density. The addition of potato peel flour caused a considerable increase in crude fiber content from 0.33% in F0 to 1.88% in F1 thus improving dietary fiber levels in the cookies. Research data demonstrates the health benefits of potato peel utilization in baked products because it adds dietary fiber to food.

Table 4. Cookie Spread Ratio and Hardness

Formula	Spread Ratio	Texture Hardness (N)
F0	7.8	3.2
F1	7.4	3.8
F2	6.6	4.5
F3	5.9	5.1

Measurement of cookie spread ratio and texture hardness produced outcomes that directly matched fiber content levels. The cookies' spread ratio decreased between F0 and F1 because the baking dough in F1 expanded to 7.4 after F0 reached 7.8. The incorporation of potato peel flour results in the absorption of a higher amount of water which causes the dough to become less watery thereby reducing its desert-like expansion during baking. The dough produces thick cookies which develop less spread when fiber is included.

The cookies became harder as the amount of potato peel flour increased in the product formulations. A hardness value of 3.2 Newtons was recorded in the control (F0) compared to the value of 3.8 Newtons detected in F1. As the replacement ratios of potato peel flour rose beyond F1 (F2 and F3), the cookies developed increased firmness and lost their tender необходимость. The firmer structure develops because gluten dilution combined with fiber-induced structural damage in the dough. The development of gluten becomes disrupted by fibers which leads to denser and brittle final textures. Both panellists and sensory feedback revealed that high substitution levels led to unfavorable rating outcomes because the cookies became harder and lost their crispiness.

Overview of Organoleptic Findings

The organoleptic test is a method of evaluating the quality of products by using the sensitivity of human sensory organs, such as the eyes, nose, mouth, and fingertips. These tests are considered subjective measurements since they rely on individual human responses as the basis for assessment (Handayani & Rosidah, 2017). The organoleptic tests carried out were the

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hedonic test (liking) and the hedonic quality test. The criteria used in formulating the formulation are colour, texture, taste and aroma of biscuits with the treatment of adding potato peel flour to the control formula. Organoleptic testing conducted on cookies with the composition of F0 (0%) as the control formula, F1 (25%) as the selected formula, F2 (50%), and F3 (75%) gave results that were overall significantly different in terms of taste, colour, aroma, and texture (Table 1). Based on the hedonic test results, the F1 formulation with 25% potato peel flour composition obtained the highest overall mean value compared to the other two formulations with an overall percentage of 3.89 for the hedonic test and 3.57 for the hedonic quality test.

Flavour is a food attribute encompassing appearance, aroma, taste, texture, and temperature. Taste results from the collaboration of the five human senses: taste, smell, touch, sight, and hearing (Manzalina et al., 2019). The cookies taste will taste bitter as the addition and increase in the concentration of potato peel flour is used. The results of the organoleptic test in terms of taste are significantly different at varying levels of liking, which means there are changes in taste when potato peel flour is added (Table 1). The level of preference for the flavour attribute of the selected cookie formula was considered sweet. This result is quite good because the flavour is an essential factor in determining the quality of food (Sarbini et al., 2009; Barrett et al., 2010; Stroebele & De Castro, 2004). In addition, potato peel flour imparts a unique flavour, which most panellists still recognized. Flavour, closely linked to the sense of taste, is also affected by the proper level of maturity.

Sensory Attribute Analysis

The physical testing (texture) conducted on cookies showed no significant differences in hardness, softness, consistency, and crispness about the level of liking. The panellists level liking of the physical appearance of the cookies was on a scale of 4.10 out of a scale of 5 (Table 1) and indicated a significant difference. This indicates that the formulation of cookies affects the consumption level of cookies because the level of acceptance is significantly different. The texture is crucial to food quality, often considered even more important than taste, aroma, and colour. The softness and crispness of food depend on the texture or physical appearance of the cookies. The most commonly considered texture criteria are hardness, density and moisture content.

Colour is an essential criterion for determining food quality. The colour used in making cookies is the colour of the use of the material itself because it can affect the colour of the cookies, such as sugar, eggs, and flour (Al Ghifari & Gusnita, 2022). The colour character of cookies in all research results shows that the colour is brown and the more potato flour concentration is added, the more it will go towards dark brown. The results of the colour assessment attributes in this study show a brown colour with a panellist's level of preference of 4.00 on a scale of 5 which is categorized as like (Table 1). The brown colour produced from potato peel flour is the effect of the browning reaction, which is an oxidation reaction with air so a browning reaction is formed by the influence of enzymes contained in potato skins (enzymatic browning) (Ratnayani et al., 2021). The development of brown colour in biscuits is caused by enzymes that facilitate a reaction between oxygen and phenolic compounds, which is catalyzed by polyphenol oxidase. This enzyme helps oxidize phenolic compounds into quinones, which then polymerize to form brown melanin pigments (Damayanti & Ansharullah Asyik, 2019).

Aroma is a component most closely related to a person's assessment of drinks and food (Fatima, 2021). Aroma testing in the food industry is crucial as it provides rapid assessments of a product, helping to determine whether consumers will likely accept it. This quick feedback is vital for evaluating the product's appeal and overall quality (Afidah & Mardiana, 2021). The

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assessment attribute of the smell of cookies is fragrant with a favorability score of 3.89 (Table 1). The fragrance obtained in making cookies is not like the smell of wheat flour or other similar flour because potato peel flour has its flour aroma characteristics. Using potato starch composite will strengthen the savory fragrant aroma of the cookies. This is because potato tubers after drying produce a fragrant savory aroma typical of potato tubers. The savory aroma is because potato flour having a fat content of 0.1 grams (Fajiarningsih, 2013).

Consumers can accept a product with the desired flavour Faridah et al. (2023). Therefore, the taste is a sensory attribute that determines the acceptance of panellists. The results of F1 (25%) cookies as the selected formula are in accordance with several studies related to the substitution of potato peel powder or flour that previous studies have carried out. Mithul Aravind et al (2014) formulated black potato peel cookies with the selected potato peel flour substitution range of 30% because it was preferred by panellists. The concentration was 5% higher than in this study, but not significantly different (Cicilia et al., 2018). Research by Anova et al. (2014) on the substitution of wheat flour with potato peel flour (*Solanum* sp) in the manufacture of potato cookies showed the results of the selected formula, namely with the concentration of adding potato peel flour by 50%, cookies with colour texture, taste and aroma were obtained (Anova et al., 2014).

Nutritional and Chemical Composition

The use of potato peel flour in cookie formulations has an impact on various sensory aspects, including color, texture, taste, and aroma. According to research conducted by Pareyt & Delcour (2008), increasing fiber substitution in high amounts tends to decrease sensory acceptance due to significant changes in the texture, taste, and color of the product (Pareyt et al., 2010; Puljić et al., 2025; Krajewska & Dziki, 2023). One of the main factors affecting color change is the presence of phenolic compounds in potato skins. These compounds can undergo oxidation reactions when exposed to air and heat during the baking process, which then produces golden brown to dark brownish pigments in the cookies. This phenomenon is known as enzymatic browning reaction, which is catalyzed by enzymolyphenol oxidase (PPO). This process contributes to the visual appeal of the product as well as affecting the level of sensory acceptance by consumers. Studies conducted by Damayanti & Ansharullah (2019) also confirmed that the content of phenolic compounds in food ingredients can increase the intensity of color in products that undergo thermal treatment during processing (Damayanti & Ansharullah, 2019; Ribas-Agustí et al., 2018; Jiménez-Sánchez et al., 2017).

Physical Properties and Structural Integrity

In addition to color, potato peel flour substitution also has the potential to change the texture of cookies, especially in terms of hardness and crispness. The higher the substitution level, the harder the cookies tend to be due to the increased fiber content. High amounts of fiber can disrupt the gluten structure in the dough, which in turn affects the cohesion and elasticity of the cookie dough. The main factors that determine the texture of cookies are the protein and starch content in flour. Protein plays a role in forming the structure of the cookie, while starch, especially amylose and amylopectin, affects the softness and brittleness of the final product. Rezona & Gusnita (2023) explains that the fat content in cookies also plays an important role in determining texture. Fat helps break down protein structures and coat starch and gluten molecules, which ultimately results in a crispier cookie texture (Rezona & Gusnita, 2023; Johnson, 2001). Therefore, the balance between fiber, protein, starch, and fat is a crucial factor in determining the final texture of cookies with potato skin flour substitution. Thus, potato peel flour also has a significant impact on the colour, taste, and texture of cookies. Therefore, the selection of the optimal level of substitution needs to be carefully calculated to ensure that the

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final product still has a texture that suits consumer preferences without sacrificing its sensory aspects.

Conclusion

The substitution of wheat flour with potato peel flour causes substantial modifications in the organoleptic characteristics alongside nutritional value and physical attributes of cookies. The sensory profile assessment rated cookies made with 25% potato peel flour replacement (F1) as the most acceptable because participants preferred its color, texture, taste and aroma combination. Laboratory tests showed F1 cookies enhanced nutritional properties because they contained greater fiber concentrations and minerals apart from maintaining consistent moisture and protein measurements. Physical measurements showed that using potato peel flour above 25% levels decreased cookie spread but made them harder to eat while 25% substitution matched preferred cookie texture characteristics.

Research findings indicate potato peel flour serves as a sustainable functional ingredient for cookie production allowing manufacturers to decrease their wheat flour consumption. Beyond 25% substitution triggered consumer dissatisaction because the cookies became excessively bitter while developing a firmer texture. Further research should develop taste masking techniques and processing approaches to minimize bitterness while improving sensory properties when using higher amounts of potato peel flour. The functional capabilities along with sustainable advantages indicate that potato peel flour will drive innovation within the bakery market.

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