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Peanut Crackers Substituted with Arrowroot Flour: Physical Properties and Sensory Quality

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Abstract

This study aims to analyze the effect of arrowroot flour (Maranta arundinacea L.) substitution on the physical properties and sensory quality of peanut rempeyek. The research was conducted at the Food Processing Laboratory, Culinary Education Study Program, Universitas Negeri Jakarta, from April 2025 to October 2025. The method used in this study was an experimental method. The research samples were peanut rempeyek with arrowroot flour substitution at levels of 20%, 35%, and 50%. The physical test included oil absorption measurement using oil paper, carried out in three replications for each sample. The hypothesis testing for physical properties was analyzed using ANOVA followed by Duncan's test. The results showed that arrowroot flour substitution at 20%, 35%, and 50% significantly affected oil absorption, with the lowest oil absorption found in the 50% substitution treatment. The sensory evaluation was conducted with 45 semi-trained panelists. Based on the Kruskal-Wallis test, the results indicated that arrowroot flour substitution at 20%, 35%, and 50% did not significantly affect the sensory attributes of peanut rempeyek across all evaluated aspects. Sensory quality assessment revealed that all three products had comparable quality. The conclusion of this study is that the 50% substitution sample was the best treatment in terms of oil absorption. Therefore, peanut rempeyek with 50% arrowroot flour substitution is recommended to optimize the utilization of arrowroot flour as an alternative to rice flour.

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1. INTRODUCTION

Indonesia is a tropical country with abundant natural resources, particularly in the agricultural sector. Food crops such as rice, corn, cassava, sweet potatoes, and various local tubers such as suweg, taro, ganyong, and arrowroot have great potential as alternative carbohydrate sources (Widowati, 2023). However, this potential has not been matched by diverse consumption patterns, as Indonesians remain heavily dependent on rice as their primary carbohydrate source (Sholikhah & Anjani, 2023). This dependence accounts for approximately 78% of total national carbohydrate consumption, while tubers and grains contribute less than 10% (Ramadanus et al., 2013). This situation poses risks to national food stability, particularly when production disruptions, price fluctuations, or climate crises occur.

In the food industry, rice is often processed into rice flour, which plays a crucial role in the production of various traditional foods such as rempeyek (crackers), kue mankok (cupcakes), and onde-onde ketawa (laughing onde). Rice flour is known for its soft and crunchy texture, but it has the disadvantage of high oil absorption when fried, which can increase fat content and accelerate

rancidity (Gardjito et al., 2023). One potential alternative to partially replace rice flour is arrowroot flour, produced from a locally available tuber with attractive functional properties.

Arrowroot tubers (Maranta arundinacea L..) are a tropical plant that can grow in low-fertility land with minimal maintenance, and is resistant to pests and diseases (Sukarsa, 2011). Despite its great potential, its utilization is still limited in rural areas such as West Java, Maluku, and Sumatra (Septianingrum, 2014). The main content of arrowroot tubers consists of 69–72% water and around 19–22% carbohydrates (Khalimi et al., 2023). The processing process into flour not only extends the shelf life but also increases the glycemic index (GI) value from 14–27 to 29–41 (Ramadhani & Rahmawati, 2022), which is still relatively low compared to rice flour with a GI of 72–98 (Atkinson et al., 2008). Thus, arrowroot flour has the potential to be a healthier low-GI food ingredient for diabetics and consumers on a low-glycemic diet.

Physically, arrowroot flour is white to cream in color with a smooth texture and a high starch content of 80–85% (Estiasih et al., 2017). Its starch composition, consisting of 73.46% amylopectin and 26.54% amylose (Maylanti et al., 2021), makes this flour superior in forming a dense layer during frying, thereby reducing oil absorption. The low glucose content also helps reduce browning reactions, resulting in brighter product colors (Miksusanti et al., 2020). Previous research has shown the success of substituting arrowroot flour at a rate of up to 60% in making semprong cakes, resulting in a crispier texture and a color preferred by panelists (Priantini & Rahmawati, 2018). This indicates that arrowroot flour has the potential to be applied in traditional fried products such as peanut rempeyek.

Peanut rempeyek is a traditional Indonesian food favored for its savory flavor and crunchy texture (Fadiati et al., 2022). This product is generally made from rice flour, water, and spices, fried until crispy (Pratama et al., 2025). Several studies substituting alternative flours such as MOCAF, black rice flour, and jackfruit seed flour have shown significant effects on the physical and sensory quality of rempeyek (Kelana, 2018). Therefore, this study aims to produce the best formulation of peanut crackers substituted with arrowroot flour through physical and organoleptic tests to obtain optimal product quality.

2. METHOD

This study used an experimental method aimed at determining the effect of arrowroot flour substitution on the sensory and physical quality of peanut crackers. The research on making arrowroot flour substituted rempeyek products was conducted at the Food Processing Laboratory of the Culinary Arts Education Study Program, Faculty of Engineering, Jakarta State University. Organoleptic tests were conducted on Culinary Arts Education students, Faculty of Engineering, Jakarta State University. This study began from June 2024 to October 2025. Three arrowroot flour substitution treatments in this study were 20%, 35%, and 50%. The physical quality test assessment of the oil absorption capacity of peanut crackers was carried out three times for each treatment.

The sampling technique was carried out randomly by assigning a code to each sample, known only to the researcher. The sensory quality test was conducted in two stages: a product validation test by five expert panelists from the Culinary Arts Education Study Program, Jakarta State University, and an organoleptic test by 45 semi-trained panelists who were students from the same study program and had met academic qualifications related to organoleptic assessment and traditional food processing.

Data Analysis Techniques

Data analysis techniques are used to process and interpret data into easily understandable information. Data analysis techniques in this study are divided into two: physical property analysis and sensory quality analysis. Physical property analysis is used to process data measuring the physical properties of oil absorption in peanut crackers, namely the ANOVA test, with the following formula.

Table 1. Test Calculation Formula of *One-way* ANOVA

Source Variations	(JK)	(dk)	MK	Fh
Between Group	JK_{On}	m – 1	MK_{On}	$\frac{MK_{On}}{MK_{From\ ti}}$
In Group	$JK_{From\ the}$	N – m	$MK_{From\ the}$	
Total	JK_{To}	N – 1		

Where:

$$JK_{On} = \sum \frac{\left(\sum X_{who}\right)^2}{n_{who}} - \frac{\left(\sum X_{To}\right)^2}{N}$$

$$JK_{To} = \sum {X_{To}}^2 - \frac{\left(\sum X_{To}\right)^2}{N}$$

$$JK_{From\ the} = JK_{To} - JK_{On}$$

$$MK_{On} = \frac{JK_{On}}{dk_{On}}$$

$$MK_{From\ the} = \frac{JK_{From\ the}}{dk_{From\ the}}$$

Information:
JKtot : Total Sum of Squares
JKdal : Sum of Squares in Sample
JKant : Sum of Squares Between Samples
MKdal : Mean Squared In Sample
MKant : Mean Square Between Samples
dk : Degrees of Freedom
m : Number of Sample Groups
N : Total Number of Sample Members
n : Number of Individuals in Each Sample

Next, the calculated F result (Fh) is compared with the F table (F table) using the appropriate numerator and denominator dk. If Fcount> *Ftable*, it can be concluded that H_0 is rejected and H_a is accepted, namely that there is an effect of arrowroot flour substitution on the physical properties of peanut crackers.

Meanwhile, sensory quality analysis uses the Kruskal-Wallis test to determine whether there is a statistically significant difference between two or more groups of independent variables on an ordinal scale dependent variable.

The Kruskal-Wallis formula used is as follows:

$$H = \frac{12}{N\ (N+1)} \sum_{\{t=1\}}^{k} \frac{Rj^2}{nj} - 3\ (N+1)$$

Information:

H = Kruskal-Wallis value from the calculation results

Rj = Number of rankings in the jth group

nj = Amount of data in the jth group

k = Number of treatment groups

N = Total number of observations ($N = n_1 + n_2 + ... + n_k$)

If $H_{count} > H_{table}$, it can be concluded that H0 is rejected and Ha is accepted, namely that there is an effect of arrowroot flour substitution on the sensory quality of peanut crackers.
If there are significant differences in the results of the physical properties or sensory quality tests, a multiple comparison test is performed. Further testing for physical properties uses the Duncan test, and further testing for sensory quality uses the Tukey test.

3. RESULTS AND DISCUSSION

Physical Properties Test

Oil Absorption Test

The oil absorption capacity was measured by calculating the difference in weight of the oil paper before and after the cooked peanut crackers were placed on it. Each test was repeated three times on each sample, both the control sample in the form of peanut crackers with 100% rice flour and the treatment sample with arrowroot flour substitution of 20%, 35%, and 50%. The following are the results of the hypothesis test of the oil absorption capacity of peanut crackers with arrowroot flour substitution.

Table 2. Results of the Oil Absorption Hypothesis

Testing Criteria	F count	F table	Conclusion
Oil Absorption Capacity	4,110	4,066	Fcount > Ftable, then **H_0rejected, $H_a$accepted**

Based on the analysis using the ANOVA test on the oil absorption test of peanut rempeyek substituted with arrowroot flour, the calculated F value was 4.110, while the F table value was recorded at 4.066. It is known that the calculated F value > F table, so that Ho is rejected. This shows that there is an effect of arrowroot flour substitution on the physical properties of peanut rempeyek in the aspect of oil absorption, so that the calculation is continued with Duncan's advanced test to find out which groups have significant differences. The following are the results of the Duncan test on peanut rempeyek substituted with arrowroot flour.

Table 3. Test Results of *Duncan* Oil Absorption Capacity

Treatment	Rate-rate	Notation
Control	3,8	a
20%	3,0	ab
35%	2,8	ab
50%	1,7	b

The Duncan test results showed that the control peanut rempeyek was significantly different from the 50% arrowroot flour substitution treatment, while the 20% and 35% treatments were not significantly different from either. The 50% substitution treatment produced the lowest oil absorption capacity of 1.7, compared to the control with 3.8. Thus, the higher the proportion of arrowroot flour used, the lower the oil absorption capacity of the rempeyek, and the best formulation was obtained at 50% substitution.

Sensory Quality Test

Color Aspect

The average value of the color aspect of peanut rempeyek substituted with 20% arrowroot flour has a score of 3.87, which is included in the pale-yellow category. Peanut rempeyek substituted with 35% arrowroot flour has a score of 4.0,7, which is included in the pale-yellow category. Peanut rempeyek substituted with 50% arrowroot flour has a score of 4.3, which is included in the pale-yellow category.

The results of the analysis and hypothesis testing on the color aspect of peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 4. Results of the Sensory Quality Hypothesis for the Color Aspect

Testing Criteria	x^2 count	x^2 table	Conclusion
Color	1,96	5,99	x^2count < x^2table, then**H_0accepted**

Aroma Aspects of Arrowroot Flour

The average value of the aroma aspect of arrowroot flour peanut rempeyek substituted with 20% arrowroot flour has a score of 4.4, which is included in the category of slightly aromatic arrowroot flour. Peanut rempeyek substituted with 35% arrowroot flour has a score of 4.3, which is included in the category of slightly aromatic arrowroot flour. Peanut rempeyek substituted with 50% arrowroot flour has a score of 4.5,3 which is included in the category of slightly aromatic arrowroot flour.

The results of the analysis and hypothesis testing on the aroma aspect of arrowroot flour in peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 5. Results of the Sensory Quality Hypothesis of the Aroma Aspect of Arrowroot Flour

Testing Criteria	x^2 count	x^2 table	Conclusion
Aroma of Arrowroot Flour	0,73	5,99	x^2count < x^2table, then**H_0accepted**

Aroma Aspects of Lime Leaves

The average value for the aroma aspect of lime leaves for peanut rempeyek substituted with 20% arrowroot flour has a score of 4.47, which is included in the category of having a moderately citrus leaf aroma. Peanut rempeyek substituted with 35% arrowroot flour has a score of 4.53, which is included in the category of having a moderately citrus leaf aroma. Peanut rempeyek substituted with 50% arrowroot flour has a score of 4.6, which is included in the category of having a mildly citrus leaf aroma.

The results of the analysis and hypothesis testing on the aroma aspect of lime leaves in peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 6. Results of the Sensory Quality Hypothesis of the Aroma Aspect of Lime Leaves

Testing Criteria	x^2 count	x^2 table	Conclusion
Aroma of Lime Leaves	0,45	5,99	x^2count < x^2table, then**H_0accepted**

Taste Aspects of Arrowroot Flour

The average value of the aspect of arrowroot flour in peanut rempeyek substituted with 20% arrowroot flour has a score of 4.73, which is included in the category of not tasting arrowroot flour. Peanut rempeyek substituted with 35% arrowroot flour has a score of 4.53, which is included in the category of slightly tasting arrowroot flour. Peanut rempeyek

substituted with 50% arrowroot flour has a score of 4.87, which is included in the category of not tasting arrowroot flour.

The results of the analysis and hypothesis testing on the taste aspect of arrowroot flour in peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 7. Results of the Sensory Quality Hypothesis of the Taste Aspect of Arrowroot Flour

Testing Criteria	x^2 count	x^2 table	Conclusion
Taste of Arrowroot Flour	2,23	5,99	x^2count < x^2table, then**H_0accepted**

Taste Aspect

The average texture score for peanut rempeyek with 20% and 35% arrowroot flour substitutes was 4.67, which is considered savory. Peanut rempeyek with 50% arrowroot flour substitutes scored 4.6, which is considered savory.

The results of the analysis and hypothesis testing on the taste aspect of peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 8. Results of the Sensory Quality Hypothesis for Tthe aste Aspect

Testing Criteria	x^2 count	x^2 table	Conclusion
Rempeyek Flavor	0,14	5,99	x^2count < x^2table, then**H_0accepted**

Texture Aspect

The average texture score for peanut crackers substituted with 20% and 50% arrowroot flour was 5, which is considered crispy. Peanut crackers substituted with 35% arrowroot flour scored 4.8, which is considered crispy.

The results of the analysis and hypothesis testing on the texture aspect of peanut crackers with arrowroot flour substitution can be seen in the following table.

Table 9. Results of the Hypothesis of Sensory Quality of Texture Aspect

Testing Criteria	x^2 count	x^2 table	Conclusion
Texture	4,09	5,99	x^2count < x^2table, then**H_0accepted**

4. Discussion

Physical Properties of Peanut Rempeyek Substituted with Arrowroot Flour

Substitution of arrowroot flour with percentages of 20%, 35%, and 50% was proven to have a significant effect on the oil absorption capacity of peanut crackers. Based on the results of the ANOVA analysis, there was a significant difference between treatments, with the lowest oil absorption value at 50% substitution (1.7%) compared to the control (3.8%). This finding indicates that the higher the proportion of arrowroot flour used, the lower the oil absorption during frying. These results indicate that the physical and chemical characteristics of arrowroot flour play an important role in suppressing oil absorption, although other factors, such as the final water

content, product thickness, and distribution of peanuts in the dough, also contribute to the final result.

Theoretically, the oil absorption capacity of a food product is influenced by its composition, particularly its water, starch, protein, and fiber content. During the frying process, water evaporates, leaving pores that can fill with oil (Ratnaningsih et al., 2007). Flour with a high amylose content tends to form a denser gel structure, thus limiting oil penetration. Arrowroot flour has an amylose content of around 26.54% and an amylopectin of 73.46% (Maylanti et al., 2021), slightly higher than rice flour with 22% amylose and 78% amylopectin (Djafar et al., 2021). This difference in composition indicates that arrowroot flour is able to form a denser dough structure and suppress the formation of large pores, which ultimately reduces the oil absorption capacity of fried foods.

In addition to starch properties, frying conditions and dough composition also influence the final oil content of the product. Ahmad et al. (2022) explained that temperature, frying time, and raw material type are the main determinants of oil absorption. In this study, constant control of temperature and frying time strengthens the hypothesis that differences in results are caused by the type of flour used. This finding aligns with Ratnaningsih et al. (2007) and Zeb (2019), who emphasized that dense starch granules and small particle size contribute to low oil absorption. Furthermore, the lecithin content in egg yolks also acts as a natural emulsifier, reducing the dough's ability to absorb oil (Rahmadianita, 2020). Therefore, the combination of arrowroot flour and eggs has the potential to produce rempeyek with lower oil content and good sensory characteristics.

Sensory Quality of Peanut Rempeyek Substituted with Arrowroot Flour

The results of the hypothesis test showed that substitution of arrowroot flour up to 50% did not significantly affect the sensory quality of peanut rempeyek color. All treatments produced a pale-yellow color similar to the control, indicating that the natural pigments in arrowroot flour were not strong enough to affect the final color of the product. The color of rempeyek is more influenced by the frying process through the Maillard reaction between amino acids and reducing sugars (Safitri et al., 2023), as well as by the oil content of the peanuts, which contributes to the natural yellowish color of the product. Thus, the dominant factor in the formation of rempeyek color does not come from the variation in flour type, but from the thermal process and the composition of the fatty ingredients used.

The aroma of peanut crackers at various levels of arrowroot flour substitution showed relatively similar consistency. The use of arrowroot flours up to 50% did not cause significant changes in aroma characteristics, because this ingredient has a neutral aroma due to its low volatile compound content (Firdausy et al., 2025). This indicates that arrowroot flour does not interfere with the distinctive aroma of crackers, which generally comes from kaffir lime leaves. Volatile compounds such as limonene and linalool still provide a distinctive fresh aroma in all treatments (Suardhika et al., 2018). This finding is in line with the results of Priantini and Rahmawati (2018) and Masturah and Suryanto (2023), which showed that the use of arrowroot flour or kaffir lime leaves in various processed products did not significantly reduce aroma acceptance.

Taste is the primary determinant of panelist acceptance of food products. Substitution of up to 50% arrowroot flour did not significantly alter the taste of rempeyek. Panelists still rated savory as the dominant and most preferred attribute, derived from a combination of traditional spices such as garlic, candlenut, coriander, salt, and the addition of broth and peanuts (Widyoretno, 2018). According to Pawestri et al. (2025), savory flavor is more influenced by amino acid compounds and volatile components resulting from heating reactions, rather than by the type of starch used. In addition, processing arrowroot flour, such as drying and milling, also reduces the intensity of the tuber's distinctive flavor (Alfikry et al., 2024), thus not changing the primary taste of rempeyek. These results align with the findings of Nia et al. (2024), who reported that the substitution of up to 50% arrowroot starch in onde-onde products did not reduce consumer acceptance.

The texture of rempeyek is an important attribute that determines the crispiness characteristics of the product. Based on the results of sensory tests, all treatments showed textures acceptable to the panelists, with a substitution level of 20% producing the best crispiness. Increasing the proportion of arrowroot flour to 50% slightly increased the hardness of the product due to its higher amylose content compared to rice flour (**Pratiwi** et al., 2025). Supriyadi (2012) explained that the ratio of amylose, amylopectin, and water content affects the crispness and hardness of fried products. Overall, the test results showed that substitution of arrowroot flour up to 50% did not significantly reduce the sensory quality of rempeyek. The color, aroma, taste, and texture remained in the good acceptance category, so arrowroot flour has the potential as a local substitute in diversifying traditional foods without changing the main sensory characteristics of the product.

5. CONCLUSION

Arrowroot flour substitution (*Maranta arundinacea L.*.) in peanut rempeyek with percentages of 20%, 35%, and 50% did not show significant differences in all aspects of sensory quality based on the Kruskal–Wallis test. Evaluation by 45 semi-trained panelists showed that the characteristics of color, aroma, taste, and texture of rempeyek remained in the good acceptance category in all treatments. This indicates that arrowroot flour has fairly neutral sensory properties, so that it does not significantly affect the main organoleptic quality of rempeyek.

Although there were no statistically significant differences in sensory testing, descriptive results showed that a 50% substitution tended to produce the highest scores for color, arrowroot flour aroma, lime leaf aroma, and flavor. Meanwhile, savory flavor attributes were preferred at 20% and 35% substitutions, and the best texture was achieved at 20% and 50% substitutions. This indicates that using arrowroot flour up to 50% can still maintain the product characteristics favored by panelists, including the crispy texture that is characteristic of rempeyek.

In the physical properties test, arrowroot flour substitution had a significant effect on oil absorption based on ANOVA and Duncan tests. The 50% treatment showed the lowest oil absorption compared to the control and other treatments, which is thought to be influenced by the higher amylose content, which forms a denser dough structure and inhibits oil penetration during frying. Thus, the use of 50% arrowroot flour can be stated as the best treatment because it is able to reduce oil absorption without reducing the sensory quality of rempeyek, and supports food diversification based on local ingredients.

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