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Pengaruh Substitusi Tepung Jagung (*Zea Mays* Indurate) terhadap Sifat Fisik dan Kualitas Sensorik Kulit Pastel Kering Mini

[The Effect of Corn Flour (Zea Mays Indurate) Substitution on the Physical Properties and Sensory Quality of Mini Dry Pastel Skin]

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ABSTRACT

This study aimed to analyse the effect of corn flour substitution on physical properties, including brittleness and oil absorption, as well as sensory quality tests covering colour, aroma, taste, and texture in mini dry pastel skins. The research was conducted from December 2024 to June 2025 at the Pastry Bakery Laboratory for sensory quality testing, while physical properties were tested at the Food Engineering Laboratory, Jakarta State University. This type of research is classified as quantitative research using the experimental method, with corn flour substitution treatments of 20%, 30%, and 40%. Sampling was conducted randomly, with each panellist receiving one randomly selected sample, coded only by the researcher. Sensory quality testing was conducted on 15 moderately trained panellists for each sample. Physical properties were tested using a Texture Profile Analyser for brittleness and oil absorption, by calculating the difference between the amount of oil absorbed before and after the baking paper was exposed to it. The physical property analysis technique used the Anova test, followed by the Duncan test, while the sensory quality analysis used the Kruskal-Wallis test, followed by the Tukey test. The brittleness test results showed a significant effect, with the best results obtained at 30% treatment, while there was no significant effect on oil absorption. Sensory quality test results for colour, corn aroma, savoury taste, corn taste, and texture (crispness) showed no significant effect. The results of this study recommend a percentage of 30% as a reference for further research, as it is considered to be in line with the characteristics of a crispy but not too brittle pastel crust and for the optimal use of corn flour.

Keywords: pastel crust, corn flour, physical properties, sensory quality test

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh substitusi tepung jagung terhadap sifat fisik mencakup aspek kerapuhan dan daya serap minyak serta uji mutu sensoris mencakup aspek warna, aroma, rasa dan tekstur pada kulit pastel kering mini. Penelitian dilaksanakan dari bulan Desember 2024 hingga Juni 2025 di Laboratorium Pastry Bakery untuk uji mutu sensoris sedangkan sifat fisik bertempat di Laboratorium Rekayasa Pangan, Universitas Negeri Jakarta. Jenis penelitian ini termasuk kedalam penelitian kuantitatif dengan metode eksperimen, dengan perlakuan substitusi tepung jagung sebanyak 20%, 30% dan 40%. Teknik pengambilan sampel dilakukan secara acak, dimana setiap panelis mendapatkan satu sampel acak dengan diberi kode yang hanya diketahui oleh peneliti. Pengujian uji mutu sensoris dilakukan kepada 15 panelis agak terlatih untuk setiap sampelnya. Uji sifat fisik menggunakan alat Texture Profile Analyzer untuk aspek kerapuhan dan untuk aspek daya serap minyak menggunakan perhitungan perbandingan selisih antara sebelum dan sesudah kertas baking paper terserap minyak. Teknik analisis sifat fisik menggunakan uji Anova dan dilanjutkan dengan uji Duncan, sedangkan untuk analisis uji mutu sensoris menggunakan uji Kruskal Wallis dan dilanjutkan dangan uji Tuckey. Hasil uji kerapuhan menunjukan adanya pengaruh nyata dengan hasil terbaik yaitu pada perlakuan 30%, sementara pada aspek daya serap minyak tidak terdapat pengaruh nyata. Hasil pengujian mutu sensoris pada aspek warna, aroma jagung, rasa gurih, rasa jagung, dan tekstur (kerenyahan) menunjukan tidak adanya pengaruh nyata. Adapun hasil dari penelitian ini persentase yang direkomendasikan terdapat pada persentase 30% untuk dijadikan acuan penelitian

selanjutnya, karena dinilai sesuai dengan karakteristik kulit pastel yang renyah namun tidak terlalu rapuh serta untuk oengoptimalan penggunaan tepung jagung.

Kata kunci: kulit pastel, tepung jagung, sifat fisik, uji mutu sensoris

Introduction

Wheat flour is a processed product derived from wheat, the supply of which in Indonesia is still dependent on imports. This dependence on wheat imports is due to Indonesia's limited production capacity. Wheat can only grow optimally in subtropical climates (Cipta et al., 2023). Based on data from APTINDO, wheat flour consumption in Indonesia increased by 1.8% per year in the January-September 2023 period, reaching 5.01 million tons or equivalent to 6.43 million tons of wheat (Sayekti, 2024). This shows that wheat flour has become a raw material that is closely related to the food processing industry. Along with changes in people's consumption patterns, the demand for wheat flour has increased, especially for processed products such as bread and noodles. This increase is influenced by practicality and modern lifestyle trends, as stated by the President Director of Cerestar Indonesia, Indra Irawan (Sayekti, 2024). Franciscus Welirang, Chairman of the Indonesian Wheat Flour Association (APTINDO), stated that the new policy could threaten the domestic wheat flour supply, even potentially reducing the wheat flour supply by up to 50% (Rizky, 2024). This condition highlights the importance of finding alternative raw materials that can replace or complement wheat flour to maintain supply sustainability and support food product diversification.

Wheat flour contains starch consisting of two main components, namely amylose and amylopectin. High amylose and low amylopectin levels will affect the crispness of a product; the higher the amylose and the lower the amylopectin, the greater the crispness (Putri et al., 2019). The starch content in wheat flour is 25% amylose and 75% amylopectin (Rochliana et al., 2018). Therefore, alternative local ingredients with similar starch characteristics can be a solution to create food products with the desired texture while supporting raw material diversification. The use of local ingredients needs to be increased as a substitute or mixture in wheat flour-based products (Pramono et al., 2021). One raw material that has the potential to replace some wheat flour is corn flour.

Corn flour is made from ground corn kernels. Corn is a crop that can be cultivated in Indonesia. Paeru et al. (2017) stated that corn production continues to increase every year due to its great potential in cultivation. Corn is divided into seven types based on the shape of the kernels, one of which is pearl corn. In Indonesia, pearl corn is the most widely cultivated, especially on the island of Java, which accounts for more than 70% of corn plantations (Syahrial, 2019). Pearl corn that is made into corn flour has an amylose and amylopectin content that is almost similar to wheat flour. Horse tooth endosperm and pearl- s contain 27-29% amylose and 71-73% amylopectin of the total starch (Ambarsari et al., 2015).

Corn flour is a semi-finished product that can be further processed into various foods such as bread, cookies, noodles, chips, and others, with a certain percentage of use as needed. Corn flour can replace wheat flour by 20-70% in food processing, depending on the type of product (Ambarsari et al., 2015). Corn-based processed products, such as corn flour, are known to have nutritional advantages, one of which is a relatively low glycemic index, making them more beneficial for controlling blood glucose

levels. Corn has a glycemic index of around 59, which is lower than wheat flour, making it safe for diabetics and helpful in maintaining stable blood sugar levels. Considering the advantages of corn flour, such as its high nutritional content and low glycemic index, its use as a substitute raw material in processed food products, including mini dry pastries, has great potential.

Mini dry pastries are a popular snack among Indonesians. As a processed food product, mini dry pastries are characterised by their crispy and savoury crust and various fillings, such as meat, vegetables, or eggs. The use of wheat flour, which still depends on wheat imports, poses a challenge to national food security. Corn, which is abundant in Indonesia, can be used as an alternative flour because it is gluten-free, has a low glycemic index, and can produce a crispy texture. The use of corn flour in mini dry pastries has the potential to provide a healthier solution, support the sustainability of local resources, and meet the needs of a broad market (Ambarsari et al., 2015).

Based on research conducted by Nursa'adah (2019), it was stated that the use of corn flour can produce a crispier texture in fried stick food products. This study shows that substituting corn flour can increase the crispiness of the product, making it crisper when consumed. However, the use of corn flour also needs to be balanced with the right proportions so as not to reduce the softness and crispiness of the product.

Additionally, the effect of corn flour substitution on the sensory quality of the product must also be considered. Research conducted by Adimarta (2023) shows that the use of corn flour in onde-onde products, the higher the concentration of corn flour added, the more delicious the taste of the onde-onde, but it does not reduce the overall taste of the product. Therefore, the effect of corn flour substitution on the taste and aroma of mini dry pastries needs to be tested sensorily to ensure that the resulting product still meets consumer expectations.

This study aims to investigate the effect of corn flour substitution at different levels (20%, 30%, and 40%) on the physical properties of mini dry pastel skin, specifically brittleness and oil absorption capacity. In addition, this research evaluates the impact of corn flour substitution on sensory quality attributes, including color, aroma, taste, and texture. The study seeks to identify the optimal substitution level of corn flour that can produce mini dry pastel skins with desirable physical characteristics while maintaining acceptable sensory quality. The results are expected to provide scientific evidence for the utilization of corn flour as a partial substitute for wheat flour in the development of healthier and more sustainable snack products.

Materials and Methods

Research on the production of mini dry pastel skins with corn flour substitution was conducted at the Pastry Bakery Laboratory of the Food Service Management Study Program and the Food Engineering Laboratory of Jakarta State University from December 2024 to June 2025, to analyze the effect of corn flour substitution at 20%, 30%, and 40% on physical properties (brittleness and oil absorption capacity) and sensory quality (color, corn aroma, savory taste, corn taste, and texture/crispness).

Materials and Equipments

The materials used in this study included wheat flour, margarine (15%), cold water (20%), and salt (1%), with wheat flour partially substituted by corn flour at levels of 20%, 30%, and 40%. The equipment used for sample preparation consisted of a mixing bowl, pasta maker, rolling pin, dough cutter, wok, spatula, scale, silpat mat, timer, thermometer, and spider strainer. Physical property

analysis was conducted using a Texture Profile Analyzer (TPA) to measure brittleness, while oil absorption capacity was determined using the baking paper gravimetric method by measuring weight differences before and after oil absorption. Sensory quality evaluation was carried out using sensory evaluation sheets with a five-point hedonic scale administered to trained panelists.

Research Stages

The procedure included literature review, preliminary research, making control pastel dough, making corn flour through sorting, grinding, sifting 100–200 mesh, and storage, as well as making corn flour substitute pastels with wheat flour and corn flour formulations according to the substitution percentage, mixing ingredients using the all-in-rub method, resting for 30 minutes, shaping using a pasta maker with a thickness of number 9 and a 5 cm diameter ring cutter, filling with 1 gram of shredded meat, frying at 150°C for 4 minutes, draining, and packaging. All data obtained were then analysed according to their respective statistical techniques to test the hypothesis that corn flour substitution affects the physical properties and sensory quality of mini dry pastel skins.

Evaluation Parameters

This study used an experimental method with the independent variable being the percentage of corn flour substitution (20%, 30%, 40%) and the dependent variables being the physical properties and sensory quality of mini dry pastel skins. Fragility was determined through the peak load value on the TPA, while oil absorption was calculated from the difference in the weight of the baking paper before and after absorbing oil. Sensory quality evaluation was conducted using a five-point hedonic test, assessing panelists' level of preference for color, corn aroma, savoury taste, corn taste, and texture (crispness) of the mini dry pastel skins.

Physical analysis was performed using ANOVA RAL followed by Duncan, while sensory analysis used the Kruskal–Wallis test followed by Tukey. The research stages included determining the control formula through three experiments, validation tests, physical tests, and sensory tests, then determining the acceptable substitution limits (20–40%) based on their proximity to the control. The research subject was mini dry pastel shells substituted with corn flour, with samples consisting of substitution variations that were physically tested using TPA and sensorially tested by 15 moderately trained panellists, after being validated by five expert panellists. Corn flour-substituted pastry dough is defined as a product made from medium-protein wheat flour, partially replaced with corn flour of 100–200 mesh size.

Results and Discussion

Physical Property Test

In this study, the null hypothesis (H_0) states that different levels of corn flour substitution have no significant effect on the physical properties of mini dry pastel skins, while the alternative hypothesis (H_1) states that corn flour substitution has a significant effect. Hypothesis testing was conducted at a significance level of $\alpha = 0.05$. The decision criteria applied were that H_0 is rejected and H_1 is accepted when Fcount > Ftable, whereas H_0 is accepted and H_1 is rejected when Fcount ≤ Ftable.

Based on the data presented in **Table 1**, the analysis of variance for brittleness showed an Fcount value of 4.92 with 3 degrees of freedom for treatment and 8 degrees of freedom for error, resulting in an Ftable value of 4.07. Since Fcount was greater than Ftable, the null hypothesis (H_0) was rejected

and the alternative hypothesis (H1) was accepted, indicating that corn flour substitution significantly affected the brittleness of mini dry pastel skins. Duncan's multiple range test revealed that the 40% substitution level showed a significantly lower mean value, indicating higher brittleness, while the 30% substitution level produced optimal brittleness characteristics. This result indicates that increasing corn flour substitution reduces gluten content, which plays an important role in forming elastic structures in wheat flour–based dough. The decrease in gluten content leads to a more porous and brittle structure, consistent with the findings reported by Lena et al. (2022).

Table 1. Physical Properties of Mini Dry Pastel Skins with Corn Flour Substitution (Brittleness and Oil Absorption Capacity)

EvaluationAspect	Treatment (Duncan Test Results)				ANOVA Hypothesis Results	
	Control	20%	30%	40%	Fcount	Ftable
Brittleness (N)	1946.73^{a}	1735.42^{abc}	1744.90^{ab}	1090.25^{d}	4.92	4.07
Oil Absorption (%)	50.00	50.00	42.86	28.57	1.57	4.07

Different superscript letters within the same row indicate significant differences at $\alpha = 0.05$ based on Duncan's multiple range test.

Figure 1. Mini Dry Pastel Skin with Corn Flour Substitution

In contrast, the analysis of variance for oil absorption capacity showed an Fcount value of 1.57, which was lower than the Ftable value of 4.07 at $\alpha = 0.05$. Therefore, the null hypothesis (H_0) was accepted and the alternative hypothesis (H_1) was rejected, indicating that variations in corn flour substitution levels (20%, 30%, and 40%) did not have a significant effect on oil absorption capacity. Although statistically insignificant, the 30% substitution level showed a lower mean oil absorption value compared to the control and 20% treatment. This phenomenon is influenced by pore formation during the gelatinization process of starch granules, where water evaporation during frying creates pores that allow oil penetration (Estiasih, 2022). Corn flour granules tend to form pores during heating; however, at moderate substitution levels, this does not significantly increase oil absorption in fried products.

Sensory Quality Test

In the sensory quality analysis, the null hypothesis (H_0) states that different levels of corn flour substitution do not cause a significant difference in sensory attributes of mini dry pastel skins, including color, aroma, taste, and texture. The alternative hypothesis (H_1) states that corn flour substitution causes a significant difference in at least one sensory attribute. The Kruskal–Wallis test was applied at a significance level of $\alpha = 0.05$, with the decision criteria that H_0 is rejected if χ^2 calculated > χ^2 table (5.991) and H_0 is accepted if χ^2 calculated $\leq$ χ^2 table.

Based on the results presented in **Table 2**, all sensory attributes showed χ^2 calculated values lower than the χ^2 table value (5.991), indicating that the null hypothesis (H_0) was accepted. This result demonstrates that corn flour substitution at levels of 20%, 30%, and 40% did not significantly affect the sensory quality of mini dry pastel skins.

For the skin color attribute, all treatments were classified within the brownish-yellow to light-brown category. The color change is associated with the Maillard reaction between reducing sugars and amino acids during frying, producing melanoidin pigments that contribute to browning (Estiasih et al., 2022). Although statistically insignificant, the 30% substitution level produced a visually balanced color that was considered most acceptable by panelists, aligning with the findings of Saputra et al. (2021).

Table 2. Results of the Kruskal-Wallis Hypothesis Sensory Quality Test

Aspect Evaluation	Treatment	Mean	Category	Kruskal-Wallis Test Hypothesis	
				X^2 calculated	X^2 table
Skin Color	20	4.33	Yellowish brown	0.90	5.991
	30	4.00	Light Brown		
	40	4.07	Light brown		
Corn aroma	20	2.87	Slightly Corn-like Aroma	0.07	5.991
	30	2.73	Slightly Corn-Flavored		
	40	2.80	Slightly corn-flavored		
Savoury Taste	20	4.27	Fairly Savory	2.22	5.991
	30	4.73	Quite Savory		
	40	4.60	Savory		
Corn flavor	20	3.07	Slightly Corn-Flavored	0.59	5.991
	30	3.27	Slightly Corn-Flavored		
	40%	3.20	Slightly Corn-Like		
Texture (Crispness)	20	4.73	Crisp	0.39	5.991
	30	4.80	Crispy		
	40%	4.67	Crispy		

Regarding corn aroma and corn flavor, all treatments were categorized as slightly corn-like, with no significant differences observed. This result suggests that volatile compounds responsible for corn aroma and flavor were partially masked by the presence of fat from margarine and frying oil. According to Azzahra (2024), lipid components play an important role in binding volatile compounds, which can reduce the perception of specific aromas and flavors.

For savoury taste and texture (crispness), all samples were rated as savory and crispy, with the 30% substitution level showing the highest mean values, although the differences were not statistically significant. This indicates that corn flour substitution within the tested range was able to maintain acceptable sensory characteristics without negatively affecting consumer preference.

The results of the savoury taste analysis showed that χ^2 calculated was lower than χ^2 table, indicating that corn flour substitution at levels of 20%, 30%, and 40% did not have a significant effect on the savoury taste of mini dry pastel skins. All treatments were categorized as savoury, with the highest mean score observed at the 30% substitution level (4.73). This finding is consistent with Andriyani et al. (2022), who reported that higher corn flour substitution could enhance savoury perception in pie crust products. The savoury taste is associated with the presence of volatile compounds derived from corn flour, such as aldehydes, ketones, alcohols, and pyrazine derivatives,

which are formed or intensified during thermal processing through Maillard reactions. These compounds interact with wheat flour, margarine, and salt, contributing to the overall flavour profile of the product. Additionally, the use of margarine enhances savoury perception by acting as a flavour carrier and facilitating the uniform distribution of taste components within the dough (Sudirman et al., 2020).

This value shows that x2 calculated < x2 table, so H0 is accepted and H1 is rejected, thus concluding that there is no significant effect on the substitution of corn flour on the crispness of mini dry pastel crusts with percentages of 20%, 30%, and 40%. All treatments are considered the same, which are included in the crispy category. The sensory quality test results show that the 30% substitution has the highest average in terms of crispiness, but statistically it is not different from the other treatments because all of them are still classified as crispy. In accordance with the opinion of Adimarta, et al 2023, a high amylose content in the material can increase crispiness because the amylose in the material will form hydrogen bonds with water in large quantities. The amylose content in corn flour is 27-29% (Ambarsari, 2015). Meanwhile, wheat flour has an amylose content of around 25% and amylopectin of 75% (Rochliana, 2018). The slightly higher amylose and amylopectin content in corn flour plays a role in increasing crispness because amylose and amylopectin tend to form a harder and crispier structure after baking or frying (Sudirman, 2020). This makes a 30% substitution of corn flour potentially the best percentage, with a balanced amylopectin and amylose content that maintains crispness without being hard or brittle.

Conclusion

This study shows that mini dry pastry shells with corn flour substitution at levels of 20%, 30%, and 40% did not have a significant effect on sensory quality or physical testing in terms of oil absorption. However, in physical testing for brittleness, there was an increase in brittleness as the use of corn flour substitution increased. Based on the results of this study, mini dry pastel skins with 30% corn flour substitution are recommended for further development because they produce the best mini dry pastel products compared to other percentages in terms of physical properties and sensory quality, and can be used to optimize the use of corn flour in the manufacture of other dry products.

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