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Cornflour Substitute Onion Sticks: Physical and Sensory Quality

[1]Adinda Mutiara Dewi, [2]Nur Riska, [3]Rusilanti
[123]Pendidikan Tata Boga, Fakultas Teknik, Universitas Negeri Jakarta

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Abstract
This research aims to examine the effect of corn flour (Zea mays L.) substitution on the physical and sensory qualities of onion sticks as an alternative to partially replacing wheat flour. The study was carried out experimentally with three levels of corn flour substitution: 20%, 30%, and 40%. Physical tests included expansion power, thickness, and crispness; while sensory evaluation assessed color, aroma, taste, texture, and thickness. ANOVA test results showed significant effects on expansion power, thickness, and crispness. The Kruskal-Wallis test revealed that the level of corn flour substitution significantly affected thickness, while color, margarine aroma, savory taste, corn flavor, and texture were not significantly influenced. The Tukey test indicated that 20% substitution produced the best thickness quality. These findings suggest that corn flour substitution up to 20% can produce onion sticks with good physical and sensory quality, and support food diversification efforts based on local ingredients to reduce dependence on imported wheat flour.

Corresponding Author:
Adinda Mutiara Dewi
Universitas Negeri Jakarta

1. INTRODUCTION

Corn (*Zea mays*) is one of the main food commodities in Indonesia that plays a vital role in supporting national food security. As the main source of carbohydrates after rice, corn is widely cultivated in various regions of Indonesia and utilized in various sectors, including the food, beverage, and chemical industries (Suarni & Muh. Yasin, 2015; Erlangga et al., 2019). The continuing increase in demand for corn, both in the domestic and international markets, has contributed to an increase in national production, which reached 29.02 million tons in 2020, with East Java Province as the largest contributor at 23.16% (Komalasari, 2021).

Diversification of corn processing has produced various traditional food products such as lemet, tako, lepet, and dodol jagung, which generally use fresh corn as the main ingredient (Usman et al., 2022). However, the limited shelf life of fresh corn, which only lasts 2–3 days at room temperature (28–30°C), is a major obstacle to its utilization (Lapanga et al., 2020). Therefore, processing corn into flour is a suitable alternative to extend its shelf life and support food diversification. Corn flour, which is white to pale yellow in color, can be used as a base ingredient for various food products and has the potential to substitute wheat flour at a proportion of 20–70% (Rais et al., 2016).

According to Putri (2020), the use of corn flour affects the color, aroma, taste, and texture of pancakes. Furthermore, substituting corn flour in dry noodle production can increase provitamin A content and affect the physical and chemical properties of the product (Lena et al., 2022). Given Indonesia's high dependence on imported wheat flour, which reached 11.1 million tons in 2020 (Dewandari et al., 2023), the use of local corn flour, particularly the pearl corn variety (*flint corn*), which is pest-resistant and of good quality, is a potential solution in realizing national food independence (Djafar et al., 2021).

Onion sticks are a popular snack in Indonesia, featuring a long shape, crispy texture, and

savory flavor. These products are made by mixing ingredients into dough, molding, and frying until golden brown (Oktavianingsih, 2009). Over time, the main ingredient of onion sticks, wheat flour, has been modified with substitutes such as moringa leaf flour, sorghum, gayam, and tuber flour to increase nutritional value (Dewandari et al., 2023). One potential innovation is the use of corn flour as a substitute for wheat flour, which is expected to reduce dependence on imports and produce innovative local food products. Therefore, this study aims to produce the best formulation of onion sticks as a corn flour substitute through physical and organoleptic tests to obtain optimal product quality.

2. MATERIALS AND METHODS

Quality is a set of characteristics that reflect the level of consumer acceptance of a food product (Mamuaja, 2016). In the context of making onion sticks, quality is greatly influenced by the raw materials used, where high-quality materials will produce a product with better quality. Quality evaluation can be carried out through physical testing that describes the properties of food ingredients such as shape, size, color, weight, porosity, and water content (Mamuaja, 2016). Physical testing can be carried out directly through the five senses or with the help of simple laboratory equipment. Two main parameters that The parameters used in this study were crispiness and thickness. Crispiness reflects the ease with which a product crumbles when chewed and is measured using a texture analyzer to obtain accurate mechanical data (Fauzia, 2019). Meanwhile, thickness indicates the product's expansion during processing and is measured using a caliper (Hajrah et al., 2019).

In addition to physical testing, sensory quality testing is conducted to assess the level of consumer acceptance of a product through the five human senses. Sensory quality encompasses aspects of color, aroma, taste, texture, and thickness (Mamuaja, 2016). This method is important in product development to detect quality changes, ensure product conformity to consumer preferences, and support quality improvement strategies (Ismanto, 2023). The assessment is carried out by panelists who play a role in providing systematic sensory evaluations (Fadila et al., 2021; Alsuhendra & Ridawati, 2008). In this study, the panel used was a somewhat trained panel consisting of 45 students from the Culinary Arts Education Study Program, Jakarta State University, because they have basic knowledge in organoleptic assessment.

2.1 Method

This study used an experimental method aimed at determining the effect of corn flour substitution on the sensory and physical quality of onion sticks. The study was conducted in the Pastry and Bakery Laboratory and the Food Engineering and Organoleptic Laboratory, Culinary Arts Education Study Program, Jakarta State University, from April 2024 to October 2025. Three corn flour substitution treatments were used in this study: 20%, 30%, and 40%. Samples were taken randomly and coded. Sensory quality assessment was carried out through a hedonic quality test on the aspects of color, taste, aroma, crispness, and thickness, which were assessed by 5 expert panelists and 45 semi-trained panelists. Meanwhile, the physical quality test (level of crispness) was carried out using a texture profile analyzer, and the swelling power was measured using a caliper and was carried out three times for each treatment.

This study began with a trial of a control formulation without cornstarch and continued with a substitution formulation, until the best formula was found. Sensory quality data were analyzed using the Kruskal-Walli's test and continued with the Tuckey test, while physical quality data were analyzed using ANOVA with a Completely Randomized Design and continued with the Duncan test. The hypotheses tested included the effect of cornstarch substitution on the sensory quality and physical quality of onion sticks. This study is expected to determine the optimal cornstarch-substituted onion stick formulation based on sensory preferences and physical characteristics.

3. RESULTS

3.1 Physical Quality Test of Corn Flour Substituted Onion Sticks

1. Crispness Level

The hypothesis test for the analysis of the level of crispiness was carried out using the ANOVA test, which obtained the following results.

Table 1. ANOVA Test Results for Crispiness Level

SK	Db	JK	KT	Fcount	Ftable
Error	2	1,56	0,78	9,33	5,14
Handling	6	0,50	0,08		
Total	**8**	**2,06**	**0,86**		

Based on the analysis using the ANOVA test on the physical test of the crispiness of the onion sticks substituted with corn flour, the calculated F value was 9.33, while the F table value was recorded at 5.14. It is known that the calculated F value > F table, so that Ho is rejected. Showing that there is a significant influence on the results of the physical test of the crispiness level of the onion sticks substituted with corn flour at the percentage levels of 20%, 30%, and 40%. In the next stage, a Duncan test was carried out to determine which groups had significant differences. The following are the results of the Duncan test on the onion sticks substituted with corn flour.

Table 2. Results of Duncan's Test Calculation on Crispiness Level

Treatment	Rate-rate	Average+DMRT	Symbol	Conclusion
3 (40%)	8,17	8,74	a	Real difference
2 (30%)	8,83	9,42	b	Not significantly different
1 (20%)	9,17		b	Not significantly different

Based on the Duncan test results in Table 2, the 20% and 30% corn flour substitutions showed the same notation (b), so there was no significant difference in the level of crispiness of the onion sticks. However, the treatment with a 40% corn flour substitution was at a different notation (a), which indicated a significant difference compared to the other treatments. The increase in the level of crispiness was due to the higher proportion of corn flour used, because corn flour has characteristics that can produce a drier and crispier texture in the final product. Thus, the 40% corn flour substitution produced onion sticks with the highest crispiness compared to the other treatments.

2. Thickness Expansion Force

The hypothesis test for thickness expansion analysis was carried out using the ANOVA test, which obtained the following results.

Table 3. ANOVA Test Results for Thickness Swelling Power

SK	Db	JK	KT	Fcount	Ftable
Treatment	2	7,01	3,50	14,69	5,14
Error	6	1,43	0,23		
Total	**8**	**8,45**	**3,74**		

Referring to the results of the table calculations above, in the physical test of the thickness of the onion sticks substituted with corn flour, the calculated F value was 14.69, while the F table value was 5.14. Because the calculated F > F table, then H_0 is rejected. Thus, it can be concluded that there is an effect of the use of corn flour on the physical test of the thickness swelling power of onion stick products with substitution levels of 20%, 30%, and 40%. In the next stage, a further Duncan test was carried out to compare significant differences in each treatment. The results of the Duncan test on the physical test of the thickness swelling power of onion sticks substituted with corn flour are as

follows.

Table 4. Duncan Test Calculation Results for Thickness Swelling Power Test

Treatment	Rate-rate	Average+DMRT	Symbol	Conclusion
3 (40%)	63,53	64,50	a	Real difference
2 (30%)	65,07	66,08	b	Not significantly different
1 (20%)	65,62		b	Not significantly different

The Duncan test results in Table 4 show that the 20% and 30% corn flour substitutions are in the same notation group (b), so there is no significant difference in the swelling power of the onion sticks. In contrast, the 40% corn flour substitution is in a different notation group (a), which indicates a significant difference compared to other treatments. This indicates that increasing the proportion of corn flour to 40% affects the dough structure and reduces the dough's ability to expand optimally. Thus, the use of corn flour up to 30% can still be maintained without having a significant effect on the swelling power of the onion sticks.

3.2 Sensory Quality Test of Onion Sticks Substituted with Corn Flour

Organoleptic Test

1) Color Aspect

Table 5. Results of Sensory Quality Test for Color Aspect

Rating Scale	Score	Corn Flour Substitute Onion Sticks					
		20%		30%		40%	
		n	%	n	%	n	%
Golden yellow	5	6	40	9	60	6	40
Bright yellow	4	8	53,3	5	33,3	7	46,67
Light yellow	3	1	6,7	1	6,7	2	13,33
Brownish yellow	2	0	0	0	0	0	0
Chocolate	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,33**		**4,53**		**4,27**	

The average calculation results show that the 30% substitution has an average value of 4.53. The color of the sample is close to golden yellow. Substituted onion sticks 20% and 40% have average values of 4.33 and 4.27, which are closer to the bright yellow category.

2) Corn Aroma Aspect

Table 6. Results of Sensory Quality Test of Corn Aroma Aspect

Rating Scale	Score	Corn Flour Substitute Onion Sticks					
		20%		30%		40%	
		n	%	n	%	n	%
The aroma of corn is very not strong	5	8	53,33	6	40	5	33,33
The aroma of corn is not strong	4	7	46,7	9	60	8	53,33
The aroma of corn is quite strong	3	0	0,0	0	0	2	13,33
Strong corn aroma	2	0	0	0	0	0	0

The aroma of corn is very strong	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,53**		**4,33**		**3,93**	

The average calculation results show that onion sticks with substitution of 20%, 30%, and 40% have average values of 4.53, 4.40, and 4.20, respectively, indicating that the three onion sticks substituted with corn flour have a mild corn aroma.

3) Savory Taste Aspect

Table 7. Sensory Quality Test Results for Savory Taste Aspect

Rating Scale	**Score**	**Corn Flour Substitute Onion Sticks**					
		20%		**30%**		**40%**	
		n	**%**	**n**	**%**	**n**	**%**
It tastes very tasty	5	8	53,3	7	46,7	3	20
Tastes delicious	4	7	46,7	6	40	8	53,33
It tastes a bit savory	3	0	0	2	13,3	4	26,67
It doesn't taste savory	2	0	0	0	0	0	0
It's not really noticeable tasty	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,53**		**4,33**		**3,93**	

The average calculation results show that the onion sticks with a substitution of 20% and 30% have an average value of 4.53 and 4.33, respectively, indicating that both onion sticks with corn flour substitutes have a savory aroma category. Meanwhile, at a percentage of 40%, the average value is 3.93, which is included in the savory taste category.

4) Aspects of Corn Flavor

Table 8. Results of Sensory Quality Tests for Corn Flavor Aspects

Rating Scale	**Score**	**Corn Flour Substitute Onion Sticks**					
		20%		**30%**		**40%**	
		n	**%**	**n**	**%**	**n**	**%**
It doesn't really taste like corn.	5	8	53,3	6	40	2	13,33
No corn taste	4	5	33,3	6	40	8	53,33
It tastes a bit like corn.	3	2	13,3	3	20,0	5	33,33
Tastes like corn	2	0	0	0	0	0	0
Really tastes like corn	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,40**		**4,20**		**3,80**	

The average calculation results show that onion sticks with a substitution of 20% and 30% have an average value of 4.40 and 4.20, respectively, indicating that both onion sticks with corn flour substitutes are in the category of not tasting corn. Meanwhile, at a percentage of 40%, the average value is 3.80, which is included in the category of slightly tasting corn.

5) Texture Aspect

Table 9. Results of the Texture Aspect Sensory Quality Test

Rating Scale	Score	Corn Flour Substitute Onion Sticks					
		20%		30%		40%	
		n	%	n	%	n	%
Very crispy	5	4	26,7	6	40	9	60
Crispy	4	8	53,3	7	46,7	6	40
A bit crunchy	3	3	20,0	2	13,3	0	0
Not crispy enough	2	0	0	0	0	0	0
Not crispy	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,07**		**4,27**		**4,60**	

The average calculation results show that onion sticks with a substitution of 20% and 30% have an average value of 4.07 and 4.27, respectively, indicating that both onion sticks with corn flour substitutes have a crunchy texture category. Meanwhile, at a percentage of 40%, the average value is 4.60, which is closer to the very crunchy texture category.

6) Thickness Aspect

Table 10. Results of Sensory Quality Test for Thickness Aspect

Rating Scale	Score	Corn Flour Substitute Onion Sticks					
		20%		30%		40%	
		n	%	n	%	n	%
Very thick	5	8	53,3	4	26,7	0	0
Thick	4	7	46,7	11	73,3	10	66,67
Quite thick	3	0	0	0	0	5	33,33
Thin	2	0	0	0	0	0	0
Very thin	1	0	0	0	0	0	0
Amount		**15**	**100**	**15**	**100**	**15**	**100**
Mean		**4,53**		**4,27**		**3,67**	

The average calculation results show that onion sticks with a substitution of 20% and 30% have average values of 4.53 and 4.27, respectively, indicating that both onion sticks with corn flour substitutes are categorized as thick. Meanwhile, at a percentage of 40%, the average value is 3.67, which is included in the category of being somewhat thick.

Hypothesis Testing

A. Test of *Kruskal Wallis*

Table 11. Hypothesis Test Results of *Kruskal Wallis*

Testing Aspects	x count	x table	Conclusion
Color	1,48	5,99	x^2count < x^2table, then **Accept H0, reject H1**
Corn Aroma	2,04	5,99	x^2count < x^2table, then **Accept H0, reject H1**
Savory Taste	5,59	5,99	x^2count < x^2table, then **Accept H0, reject H1**

Corn Flavor	3,97	5,99	x^2count < x^2table, then **Accept H0, reject H1**
Texture	4,62	5,99	x^2count < x^2table, then **Accept H0, reject H1**
Thickness	22,01	5,99	x^2count > x^2table, then **reject H0, accept H1**

Based on the results of the hypothesis test in Table 11, it shows that variations in the percentage of corn flour of 20%, 30%, and 40% did not affect the color, corn aroma, savory taste, corn flavor, and texture of the onion sticks. Meanwhile, in terms of thickness, variations in the percentage of corn flour of 20%, 30%, and 40% did affect the onion sticks, so further testing is needed of *Tuckey*.

B. *Tuckey's* Test

Based on the results of the hypothesis test above, it shows that in terms of thickness, there is an influence of corn flour substitution on onion sticks, so it is necessary to continue with a multiple comparison test using the test of *Tuckey* as follows:

Table 12. Multiple Comparison Test of *Tuckey* Regarding Thickness Aspect

Difference Between Each Treatment	Comparison of Results	Conclusion
|A- B| = |4,53 – 4,27| = 0,27	0,27 > 0,036	There is a real difference
|A - C| = |4,53 – 3,67| = 0,87	0,87 > 0,036	There is a real difference
|B - C| = |4,27 – 3,67| = 0,60	0,60 > 0,036	There are different real

Based on the research results, cornstarch substitution affected the final quality of the onion sticks, particularly in terms of thickness. Referring to the highest average values in Table 12, the treatment with 20% cornstarch substitution produced the best thickness, ranging from thick to very thick, and was most preferred by panelists compared to the 30% and 40% treatments.

3.3 Discussion

Discussion of Physical Quality Testing

The physical quality testing of corn flour substituted onion sticks in this study covered two aspects, namely crispiness and thickness expansion power. Based on the results of the ANOVA analysis, corn flour substitution showed an effect on the crispiness of onion sticks. Duncan's further test showed that the treatment with 40% corn flour substitution was significantly different compared to 20% and 30% substitution, indicating that the addition of corn flour was directly proportional to the increase in the level of crispiness of the product. Thus, the 40% corn flour substitution treatment produced the crispiest onion stick texture among the other treatments.

According to Prasetyo et al. (2021), at a 40% substitution level, the starch and protein structure in the dough changes, resulting in a more brittle and crispy texture. This occurs because substituting some wheat flour with corn flour lowers the gluten content, resulting in a drier dough and a crispier final texture. Similarly, Meidayanti et al. (2023) stated that the lower gluten content and higher starch content at 40% substitution resulted in a more brittle product structure after processing.

Crispness is the degree to which a product is easily crushed when pressure is applied. The lower the crispness value detected by the device, the lower the crispness value detected by the device.*texture analyzer*, the easier the product breaks (Indrawati et al., 2024). The starch content in corn flour, particularly amylopectin, plays a role in creating a crispy texture. During the baking process, starch granules absorb water and expand, forming a porous structure that

makes it easier for the product to break when bitten (Aini et al., 2016).

Additionally, the lower protein content of corn flour compared to wheat flour reduces gluten formation, making the dough less elastic and more brittle. This factor contributes to increased crispiness because the structure becomes lighter and more easily broken (Horstmann et al., 2017). Water content also plays a significant role, as corn flour produces a lower final moisture content after processing, helping to maintain crispness for longer (Stephen et al., 2023). These results align with research by Rochliana et al. (2018), which showed that the combination of high starch, low gluten, and low moisture in corn flour can create an optimal crispy texture.

However, increasing the proportion of corn flour too high can cause the product to become too brittle and break easily. Therefore, a balanced formulation is needed to maintain a stable structure without sacrificing the crispy texture (Aziza et al., 2024). The results of physical tests on the aspect of thickness expansion showed that the onion sticks before frying had a thickness of around 2.2 mm, while after frying showed variations depending on the level of substitution. Based on the ANOVA analysis, the F count value (14.69) > F table (5.14), indicating a significant effect of corn flour substitution on thickness expansion at the 20%, 30%, and 40% levels.

Duncan's further test showed that 20% and 30% corn flour substitution treatments did not significantly differ in terms of thickness expansion, while 40% substitution did significantly differ. According to Musita (2016), this is because structural changes at 20–30% substitution levels are still considered reasonable and do not significantly affect product quality. These results are supported by Andriyani et al. (2021), who stated that other formulation ingredients are able to balance the changes caused by corn flour substitution, so that the product remains stable. The still dominant proportion of wheat flour maintains dough elasticity and stability (Sihombing, 2021). In line with research by Fauziah et al. (2025), corn flour substitution of up to 30% generally does not significantly affect the physical or organoleptic properties of food products.

Discussion of Sensory Quality

The results of sensory quality tests on 45 semi-trained panelists showed that corn flour substitution had an effect on the sensory quality characteristics of onion sticks, although not all aspects showed significant differences. Based on the analysis results of *Kruskal-Wallis*, there were no significant differences between the treatments in terms of color, corn aroma, savory taste, corn flavor, and texture. However, in terms of thickness, significantly different results were obtained, so further testing was carried out using Tukey. The variation in the assessment results indicates that the level of corn flour substitution has the potential to influence panelists' perceptions of the product's visual and textural characteristics. The color aspect did not show significant differences between treatments, with the Kruskal-Wallis (χ^2 calculated 1.48 <χ^2 table 5.99) indicates that cornstarch substitution did not significantly affect the color of the onion sticks. The resulting golden yellow color is influenced by the combination of raw materials and the frying process, not by the cornstarch itself (Malik et al., 2024). The natural pigments in corn are not strong enough to significantly change the color of the product, especially at low substitution levels (Dasniati et al., 2020). This is in line with research by Istinganah et al. (2017), which reported that the use of cornstarch as a substitute did not significantly affect the color of food products.

In terms of aroma, the test results of *Kruskal-Wallis* (χ^2 calculated 2.44 < χ^2 table 5.99) indicates that corn flour substitution did not significantly affect the aroma of onion sticks. Although corn flour has a distinctive aroma, its intensity is not strong enough to dominate the overall product when used in low amounts (Aleman et al., 2023). This finding is in line with the research of Silva-Paz et al. (2024) which stated that the aroma of corn flour does not contribute significantly to the aroma of food products based on flour mixtures at low concentrations.

The taste aspects, both savory and corn flavors, also did not show a significant effect between treatments (χ^2 calculated 5.59 < χ^2 table 5.99 for savory flavor; χ^2 calculated 3.97 < χ^2

table 5.99 for corn flavor). The savory flavor is more influenced by additional ingredients such as margarine, eggs, garlic, and coconut milk (Bolini et al., 2024; Barida et al., 2021). Meanwhile, corn flour has a neutral taste characteristic due to the processing process that removes its distinctive flavor components (Adimarta, 2022), so it does not cause significant differences in the taste aspect of the product.

Different results were found in the thickness aspect, where the value of Kruskal-Wallis (χ^2 calculated 22.01 > χ^2 table 5.99) indicates a significant effect of corn flour substitution on the thickness of onion sticks. Further analysis of the Tukey test showed that each substitution level (20%, 30%, and 40%) was significantly different from each other. According to Destiana (2023), increasing the use of corn flour results in thinner products because the absence of gluten makes the dough structure less elastic and easy to spread when fried. The high amylose content and low water absorption also accelerate water evaporation during frying, resulting in products that tend to be flat. This is supported by Hussain et al. (2025) who stated that the higher the percentage of corn flour substitution, the thickness of the final product tends to decrease.

4. CONCLUSION

The results of the study showed that the substitution of corn flour in the manufacture of onion sticks with a percentage of 20%, 30%, and 40% had different effects on the sensory and physical characteristics of the product. Based on the results of sensory quality tests involving 45 semi-trained panelists, it was found that corn flour substitution had no significant effect on the aspects of color, corn aroma, savory taste, corn flavor, or texture, but had a significant effect on the thickness aspect. Treatment with corn flour substitution of 30% produced the best color, while 20% substitution gave the best results on aroma, savory taste, corn flavor, and thickness, and 40% substitution produced the best texture in onion stick products. These results indicate that the use of corn flour in certain levels can improve sensory characteristics without reducing the overall quality of the product.

Based on the results of physical properties testing, corn flour substitution affected the crispiness and thickness of onion sticks. However, Duncan's further test results showed that the three treatments (20%, 30%, and 40%) did not have statistically significant differences, as indicated by the similarity of notations between treatments. This indicates that the variation in the percentage of corn flour substitution within this range is not large enough to cause significant differences in the physical characteristics of the product. Overall, corn flour can be used as a substitute in making onion sticks up to 40% without reducing the sensory or physical quality of the product, thus having the potential to be an alternative raw material in the diversification of flour-based food processing.

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