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Potato Flour Substitution: Sensory, Physical, and Chemical of Fried Dumpling Skin

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ABSTRACT - This study aims to analyze the sensory characteristic and chemical content of fried dumpling skin as an effort to develop local based product. Four levels of potato flour substitution (0%, 10%, 20%, and 30%) were included in the Completely Randomized Design (CRD) to be analyzed through ANOVA at 5% level of significance then continued by Duncan's Multiple Range Test. 3 expert panelists participated in organoleptic test and 80 untrained panelists participated in hedonic test. The result indicated that expert panelists found there was no significant on each treatment, whereas the untrained panelists found different significancy to each treatment. In terms of nutrition, the product that substituted 30% potato flour had the highest water and kalium value. Color analysis using CIE L*a*b* revealed that potato flour substitution can decrease L* (lightness), and increase a* (redness), and b* (yellowness). The best treatment according to hedonic test was 10% potato flour substitution which enhanced nutritional values without decreasing consumer acceptance. It is applicable to the local food diversification for improving the quality of local-based product.

Keywords: Potato flour, sensory characteristic, physical characteristic, chemical content, fried dumpling skin.

INTRODUCTION

Dumpling skin is a pasta-based product that made form wheat flour, water, salt, and oil, used as wrappers that can be fried or steamed (Widyaningrum et al., 2024). As pasta product, dumpling skin quality is very effected by kinds and characteristic of wheat flour, especially from protein content which acts in texturing (Anugrahati et al., 2017). In Indonesia, the dependence of wheat flour is an issue considering that wheat is uncultivated optimally in tropical region, so that national necessities still rely on imports.

Diversification efforts of food based on local resources are an important strategy to reduce subordination on imported raw materials with the use of potato flour as a substitution. Potato is one of carbohydrate sources which contents quite high nutrition values and also potentially to be developed as alternative food (Setiadi, 2007 on Saputrayadi et al., 2018). In worldwide, potato stands on important position as primary food supplies. However, the usage in Indonesia is still dominated for simple processed products. Estimation of water content in fresh potato is about 78%, that causes this commodity can easily spoiled, so that making potato to be flour is one of the alternative to keep the shelf life and also increase the product value (Ain Rahmada et al., 2024).

Potatoes are also strategic horticultural commodity with a demand trend that continuously increase along with population growth and the development of processed food industry based on potato. It is predicted that potato market will play a large role with projected growth reaching 3.5% in 2027 (Aria Erlangga, 2023). National potato production is concentrated in a few provinces with high productivity, especially in Java Island, like Central Java, East Java, and West Java (BPS, 2025). One of the main centers of potato production in Central Java is Dieng, Banjarnegara Regency which known for high quality of yellow potato, such as granola and agria variety (Kipfer, 2021).

Yellow potato has characteristic that supports in flour producing, including high solid content, color and good texture, also low reducing sugar, so it is appropriate for starch-based dry products (Aini, 2012; Pantastico, 1993 on Yustina Wuri Wulandari, 2019). Additionally, potato also contains major mineral like kalium that has role to keep balance body electrolyte. Kalium content in potato flour is higher than wheat flour, while the sodium content is relative lower, thus providing additional nutrition value to the product (Bastian, 2022; Kemenkes RI, 2019b).

Various studies show that the substitution of non-wheat flour in dumpling skin products significantly impacts toward sensory characteristic and chemical content of the product. High level of potato flour proportion can increase water absorption capacity of the dough yet lower the stretchability, so it is necessary to control the substitute level to keep quality product stays optimal (Effendi et al., 2020). Furthermore, Yang (2020) shows that substitution of potato flour up to 30% on pasta product can increase nutrition value.

Types of starch and amylopectin content also important to determine physical quality of fried dumpling skin. The substitute of tapioca flour around 30% produces the best quality and highest score on hedonic test. This study shows that flour with high level of amylopectin content potentially increases firmness and stability of dumpling skin texture (Anugrahati et al., 2017). This was confirmed by Vieri (2022) that MOCAF can produce good texture of dumpling skin cracker, even though the products studied were different.

Based on dough-based product, the use of MOCAF as a substitute of wheat flour impacts crispness of fried dumpling skin, where the increase of non-wheat flour proportion tends reducing crispness (Prianggorowati & Bahar, 2015). Similar result stated by Christiningrum et al. (2021) that substitution of taro flour on dumpling skin has optimal limit around 25%, for it will affect to color and texture of the product it is used above the limit. The interaction between wheat flour and potato flour on the noodles product increases water absorption and disrupts gluten matrix, thereby reducing dough elasticity (Buzera et al., 2024).

Although many studies on the substitution of root vegetables flour have been carried out, this study is likely to cover the gap of previous researches that are still limited to integrate sensory characteristic, physical characteristic to analyze the color, and chemical content like water and kalium levels of fried dumpling skin with potato flour substitution, and also to enable a better insight on the potential of potato flour substitute in the production of local-based food products. Therefore, this study aims to examine sensory characteristic such as organoleptic and hedonic acceptance, physical characteristic, also chemical content on fried dumpling skin as an effort to develop a product based on local ingredient. The percentages of potato flour to substitute the wheat flour are 0%, 10%, 20%, and 30%.

METHOD

This study uses Completely Randomized Design (CRD) with four treatments, they are T1 (0%), T2 (10%), T3 (20%), and T4 (30%). The reason for choosing the potato flour substitution percentage is based on previous research which indicated that substituting 30% potato flour in pasta product can increase the nutrition value. Substitution of more than 30% potato flour can also result in suboptimal quality parameters for the final product, particularly in the texture of fried dumpling skin (Christiningrum et al., 2021; Buzera, 2023). The process of making potato flour is peeling, washing, and slicing the potato, then soak in 0.5 g/L sodium bisulfite solution for 45 minutes. Potato sliced were then dried at 60ºC for 9.5 hours. The next step is grounding and sieving using an 80mesh sieve. Dumpling skin is made by mixing the wheat flour and potato flour according the treatments, and salt until the dough is homogenous, then adding oil and warm water, kneading and resting for 1 hour. The dough is rolled out to a thickness of 0.5 mm, cut them into 10 x 10 cm pieces, and fried at 170ºC for 3 minutes.

TABLE 1. Composition of fried dumpling skin substitute of potato flour with wheat flour

Material	0%	10%	20%	30%
Wheat flour	150 g	135 g	120 g	105 g
Potato flour	-	15 g	30 g	45 g
Salt	3 g	3 g	3 g	3 g
Oil	30 g	30 g	30 g	30 g
Warm water	70 g	70 g	70 g	70 g

Parameters that tested include sensory characteristic, based on color, aroma, texture, taste and overall liking, water, and kalium content. The organoleptic test was carried out with 9-point scale by 3 expert panelists to measure objective sensory characteristic, and hedonic test by 80 untrained panelists to show consumer preferences. To analyze physical characteristic on color aspect, using a digital camera and graphics software Adobe Photoshop with CIE $L^*a^*b^*$ color system. A generalized parametric test was used to analyze the statistical data. The Kolmogorov-Smirnoff test was

used to first evaluate the normality of the data. Then the homogeneity of the variances between groups was determined by Levene Test. As the result showed that the data satisfied the normality and homogeneity conditions ($p > 0.05$), then the ANOVA test and Duncan's Multiple Range Test was used to determine whether there were any significant difference between the treatments (Sari et al., 2024). Chemical contents were tested on PT. Saraswanti Indo Genetech (SIG) Semarang by Gravimetri method for the water content and Inductively Coupled Plasma (ICP) for kalium content analysis.

RESULTS AND DISCUSSION

Sensory Characteristic

Organoleptic Sensory Evaluation

Organoleptic test is a technique that is carried out by highly qualified to test the sensory qualities of a product. Organoleptic test is common to qualify the food, on food industry or other industries in agriculture products. This evaluation is based on human senses, sight, smell, taste, hearing, and touch, to test the sensual qualities of the product. This assessment can be very accurate at times (Susiwi, 2009 on Lamusu, 2018). In this study, the organoleptic test was done by 3 expert panelists to determine the factor of aroma, texture, and taste of the product, using 9-point scale. One-Way ANOVA was used to analyze and the summary result is provided in **TABLE 2.**

TABLE 2. One-Way ANOVA results of organoleptic test by expert panelist.

Sensory Attribute	F-value	p-value	Sensory Interpretation
Aroma	2.98	0.096	Not significantly different
Texture	2.24	0.161	Not significantly different
Taste	1.28	0.344	Not significantly different

Note: differences were considered statistically significant at $p < 0.05$

According to the organoleptic test by the expert panelists as shown in **TABLE 2**, there was no significant difference in aroma, texture, or taste on each treatment ($p > 0.05$). These results showed that the aroma aspect of the treatments were similar in an analytical sensory characteristic and did not reveal any notable variations. Additionally, the analysis of texture showed that they were similar in all treatments, implying that the changes in texture were not that considerable to be termed as significantly different. Similarly, the taste evaluation showed that the same levels of intensity on each treatment, indicating that the characteristics of the product were not significantly impacted by the formulation changes.

Hedonic Acceptance Evaluation

Hedonic testing refers to a mode of evaluation which the panelists are requested to respond the question by giving their answer whether they like or do not like the characteristic of the attributes being tested. The purpose of this test is to determine the degree of consumer acceptance or preference of a product based on sensations that the consumer perceive (Kartike et al., 1988 on Lamusu, 2018). In this study, the hedonic test was held by 80 untrained panelists, consisting of 40 females and 40 males. The evaluation was carried out using a 9-point scale, covering aspects such as aroma, texture, taste, and overall acceptance. This test used Duncan's Multiple Range Test to analyze differences between the treatments since the data was significant different on ANOVA test. The mean score of liking test for each sensory attributes are presented in **TABLE 3**.

TABLE 3. Duncan's Multiple Range Test results on sensory characteristic from hedonic test.

Treatment (T)	Mean Value ± SD				
	Color	Aroma	Texture	Taste	Overall
T1	7.37 ± 0.862^{b}	7.28 ± 0.927^{ab}	7.36 ± 1.214^{ab}	7.60 ± 1.186^{b}	7.46 ± 1.368^{b}
T2	7.57 ± 1.028^{b}	7.46 ± 0.980^{b}	7.74 ± 1.028^{c}	8.11 ± 0.900^{c}	7.96 ± 0.947^{c}
T3	7.54 ± 1.124^{b}	7.49 ± 1.191^{b}	7.61 ± 0.974^{bc}	7.61 ± 1.013^{b}	7.80 ± 1.048^{c}
T4	7.09 ± 1.138^{a}	7.14 ± 1.290^{a}	7.24 ± 1.285^{a}	7.14 ± 1.185^{a}	7.15 ± 1.332^{a}

Note: a, b, c = same superscript letter means there is no significant difference between those groups means ($p > 0.05$).

In order to visualize the variations in consumer preference among treatments, the mean of hedonic score of each sensory attribute are drawn in **FIGURE 1.**

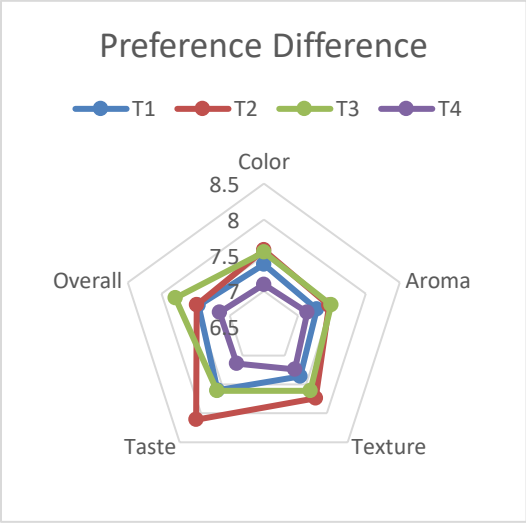

FIGURE 1. Average score of hedonic test.

According to the hedonic test outcome of color aspect, potato flour substitution significantly different on the panelist acceptance ($p < 0.05$). The highest substitution levels in the treatments T4, received less liking score and formed a homogeneous group as opposed to the other treatments. This color preference decrease means that a greater percentage of potato flour in fried dumpling skin was added, leading to darker fried since there was browner appearance, thus decreasing visual preference (Bao et al., 2021). By contrast, those products which had low to moderate substitution levels had a more a more acceptable color that was less distant with conventional fried dumpling skin and more accepted by panelist.

Regarding aroma, the results of hedonic test revealed that substitution of potato flour had a great impact on the preference of the panelist ($p < 0.05$). Intermediate substitution on T3 produced the best aroma liking score implying that the aroma of the potato was detached but at the same time balanced and acceptable. On the other hand, the increased amount of substitution was more likely to generate stronger aroma of the potato that resulted in reduced aroma acceptance because the intensity was beyond the choice limit of the panelists (Xin et al., 2025).

Potato flour substitution also had a significant different on the texture aspect ($p < 0.05$). The treatments T2 and T3 with low to moderate substitution had a greater hedonic score, which confirmed the optimum balance between firmness and crispness. The following texture attributes were regarded as optimal since the products were neither too brittle, nor too hard. While T4 as the highest substitution level of treatment had While T4 had the lowest preference score, in contrast, which was recorded as a harder texture. This observation has been observed to match to the earlier studies that indicate that the substitution level of non-wheat flour in dumpling skin products is optimized at 25% because the higher levels might lead to increase the absorption of water and disrupted gluten matrix, which will lead to lower extents of dough elasticity (Christiningrum et al., 2021; Buzera et al., 2024).

On the taste aspect, T2 held the greatest mean hedonic score of taste, but T4 had the lowest score. As T3 and T1 were on the same homogenous subset, there was no significant difference between those two treatments. The high taste preference ratio in T2 indicated that the potato flavor was well-balanced and did not overpower the dumpling skin's original flavor at this degree of substitution. However, the significant substitution on T4 might have caused the potato taste too dominate, which would reduce the overall approval of taste. According to these results, a reasonable amount of potato flour should be substituted in order to achieve the optimal taste profile (Xin et al., 2025).

In terms of overall acceptance, T2 got the highest mean score, based on Duncan's Multiple Range Test, also followed by T3 and T4. There was no significant difference between T1 and the others. The highest overall acceptance obtained in T2, and this formulation provided the optimum balance of sensory characteristic, including color, aroma, texture, and taste. On the other side, lower sensory characteristic, such a darker color and rougher texture, was caused

by T4's reduced acceptability. These findings validate the fact that a moderate percentage level of potato flour substitution produces the most consumer acceptance to the fried dumpling skin product (Buzera, 2023).

Physical Characteristic

The physical characteristic test was caried out to examine the color changes on the appearance of fried dumpling skin when it was substituted by potato flour. The digital camera was used to take picture of the product and analyzed by Adobe Photoshop software. The color parameters that were analyzed included *L** for lightness (0 is black – 100 is white), a* for greenness (-60) – redness (60) and b* for blueness (-60) – yellowness (60), based on CIE *L*a*b** color system (Bernalte et al., 2003 on Buzera, 2023).

TABLE 4. Result of color analysis.

Treatment (T)	*L**	*a**	*b**
T1	57	3	34
T2	53	8	40
T3	48	11	43
T4	37	17	46

Note: the value from color analysis result by CIE *L*a*b** color system using Adobe Photoshop

Based on the **TABLE 4,** the color characteristics of *L*a*b** were affected when potato flour was substituted in fried dumpling skin. Higher levels of potato flour substitution resulted in a progressive darkening of the product, as indicated by the reduction of *L** values, and the rise of *a** and *b** values, which indicate an increase in reddish and yellowish color, respectively. The change of the color on fried dumpling skin reveals that the hue was browner with higher percentages of potato flour. This is mainly caused by the Maillard reaction from the starch of potato flour with reducing sugar and amino compounds in the dough during frying. Maillard reaction is the result of the formation of brown pigments, called melanoidin, which produce darker and more intense coloring. Deep-fat frying is expected to reach temperatures above 150^{o}C, where this reaction has been observed to occur (Dangal et al., 2024). As a result, substituting more potato flour creates more reactive chemicals, which improve non-enzymatic browning and give the fried food a darker, browning and give the fried food a darker, brownish-yellow color (Buzera, 2023).

Chemical Content

Chemical content test was done to identify the water and kalium content of the product. Gravimetri method and Inductively Coupled Plasma (ICP) method were employed to get data on the water and kalium content of the treatments. The water and kalium content in the product showed differences between the treatments. The test is expected to offer data on the chemical content of the products based on the parameters. **TABLE 5** displays the results of the analysis.

TABLE 5. Duncan's Multiple Range Test results on chemical content .

Treatment (T)	Mean Value ± SD	
	Water (% wb)	Kalium (mg/100 g db)
T1	4.16 ± 0.091^{a}	122.89 ± 3.401^{a}
T2	4.60 ± 0.113^{b}	241.60 ± 2.708^{b}
T3	4.84 ± 0.028^{b}	344.45 ± 1.732^{c}
T4	5.33 ± 0.454^{c}	480.48 ± 3.471^{d}

Note: a, b, c = same superscript letter means there is no significant difference between those groups means ($p > 0.05$).

Water

Duncan's Multiple Range Test results on **TABLE 5** indicated that the substitution of potato flour had a significant effect on the water content of fried dumpling skin ($p < 0.05$). T4 had the highest water content, while T1 had the lowest water content. The rise of water content was about 10.58%. The increase has been explained to the potato flour has a greater water-holding capacity since it has starch elements that are able to bind and hold water during processing.

The amount of amylose in the potato flour is closely related to this growth. For amylose molecules could hold the water throughout the preparation and processing of the dough. The higher the amylose content, the higher the water absorption capacity. Potato flour has a better water holding capacity than wheat flour because it contains 21% amylase. As a result, when the amount of potato flour increased, then the amount of water that was retained in the fried dumpling skin also increased (Hidayat, 2009; Wicaksono, 2008 on Oktafia et al., 2024). The quality reference used SNI 01-4380-1996, even though the water content of 1% (w/w), which is required for the dumpling skin. According to this criterion, a crispy appearance and a pleasing texture are associated with reduced water content. Therefore, fried dumpling skins should be crispier the lower the water content of the treatment, conversely, a higher water content tends to reduce crispness and negatively affect sensory qualities.

Kalium

The amount of kalium was greatly affected by the substitution of potato flour level as indicated by the Duncan's Multiple Range Test outcomes on **TABLE 5**. Based on the result, each treatments had significant differences. T1 had the lowest kalium concentration, then followed by T2, T3, and T4 has the highest amount of kalium. The rise of kalium content was about 96.6%. According to the result, the increase in kalium levels may be caused by adding potato flour. This pattern indicates that kalium content in the product increases with the degree of potato flour substitution. The increase is specifically related to the usage of potato flour, which has kalium content of 156.3 mg/100g, which is higher than whet flour's (Kemenkes RI, 2019b). Based on Indonesian recommended dietary allowance (AKG), kalium intake for adults aged (19-29) at 4700 mg/day (Kemenkes RI, 2019a). Kalium intake helps the regulation of blood pressure through vasodilation and increases sodium excretion as well as fluid and electrolyte balance. This is congruent with the same findings by Sadikin et al. (2025), which showed that sufficient kalium consumption protected against hypertension, while poor kalium consumption was highly correlated with higher blood pressure.

CONCLUSION

This study can be concluded that the substitution of potato flour on fried dumpling skin improves sensory and physical characteristics, also chemical contents. From the result of organoleptic, there was no different on each treatment, whereas on the hedonic acceptance, there was different on each treatment. The best result based on the hedonic assessment or panelist acceptance is on the 10% substitution of potato flour on fried dumpling skin. The CIE *L*a*b** color analysis revealed a decrease of lightness and a rise of redness and yellowness, making its appearance darker and more yellow-brown. These findings demonstrate that substituting wheat potato by potato flour enhances the sensory qualities of product and provide nutritional benefits. However, the degree of substitution should be considered to maintain the quality of products. Water and kalium content were significantly increased by 30% potato flour substitution, and it could be used to improve the chemical content.

This study is able to make a great impact on the innovation of the local-based product since it examines how the local food ingredients can be used to enhance the quality also the nutrition value of the processed product. The practical implication is for the food industry, that substitution of potato flour can be an affordable, nutritious option, and also a new method of processing a local-based product that offers a healthier and more favorable to the consumers.

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