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The Effect of Tapioca Flour Substitution with Purple Sweet Potato Flour (*Ipomoea batatas* Blackie) on the Organoleptic Testing of Beef Meatballs

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Abstract: The increasing demand for processed meat products has driven innovation toward offerings that are not only delicious and practical but also more nutritious. Beef meatballs are among the most popular processed meat products, but they often contain tapioca flour as a filler, which is low in fiber and antioxidants. This study aimed to evaluate the effect of substituting tapioca flour with purple sweet potato (Ipomoea batatas blackie) flour on the organoleptic quality of beef meatballs. The research was conducted in April 2025 at the laboratory of Universitas Islam Balitar using a completely randomized design (CRD) with four treatments and three replications: p0 (no substitution), p1 (10 g substitution), p2 (20 g substitution), and p3 (30 g substitution) of purple sweet potato flour. Organoleptic tests were carried out on color, aroma, taste, and texture parameters by 30 untrained panelists using a 1–4 hedonic scale. The results showed that purple sweet potato flour substitution had a significant effect ($p<0.05$) on all organoleptic parameters. p1 produced the highest scores for color (2.61) and taste (2.66), while the best texture was obtained in p3 (2.59). The highest aroma score was found in p0 (2.66). The trend indicated that increasing the concentration of purple sweet potato flour tended to decrease color, taste, and aroma scores, while texture tended to improve. Therefore, substitution up to 10% purple sweet potato flour was the optimal proportion that remained acceptable to consumers in terms of organoleptic aspects. This study highlights the potential use of local antioxidant-rich ingredients to enhance the functional value of processed meat products such as meatballs.

Keywords: Beef meatball; Organoleptic test; Purple sweet potato flour; Substitution; Tapioca flour.

Introduction

Animal-derived foods are among the primary sources of protein essential to the human body. Animal protein is high-quality because it provides a complete, easily digestible set of essential amino acids, which are crucial for growth, tissue repair, and immune system maintenance. Consuming animal-derived foods also helps improve the community's nutritional status, especially in developing countries like Indonesia, where malnutrition and micronutrient deficiencies remain prevalent. One of the most widely consumed animal-derived foods among Indonesians is meat. Beef, in particular, is a top choice due to its high nutritional content and its palatability, appealing to all age groups.

Fresh meat is generally processed into a variety of processed food products that are more practical and have a longer shelf life. One very popular processed meat product in Indonesia is bakso (meatballs). Bakso are round, ball-shaped foods typically made from a mixture of ground meat, fat, ice cubes, flour, and certain spices. According to Nurwantoro et al. (2013), meatballs are emulsified meat products produced by mixing meat with fillers and other additives to achieve a compact, chewy texture. This product is highly popular with the public due to its chewy texture, distinctive flavor, and relatively affordable price, and is readily available at street vendors and restaurants.

One essential ingredient in meatball processing is tapioca flour. This flour acts as a filler, increasing water-holding capacity and elasticity and improving the product's texture. However, the use of tapioca flour in large quantities raises several concerns. While it can enhance the product's physical characteristics, tapioca flour has a relatively low nutritional content, particularly in terms of dietary fiber and bioactive compounds. According to Winarno (2004), tapioca flour is primarily composed of simple carbohydrates, with minimal amounts of fiber, vitamins, and minerals. Therefore, excessive use of tapioca flour does not provide additional nutritional value and may even reduce the product's overall nutritional quality.

Given these issues, alternative tapioca flour substitutes are needed that not only function as binders and fillers but also offer higher nutritional value. One local ingredient with significant potential is purple sweet potato (Ipomoea batatas L.). Purple sweet potatoes are a regional food commodity that is readily available, relatively affordable, and offers promising nutritional value. The purple sweet potato variety Blackie has a high anthocyanin content. Anthocyanins are flavonoid compounds that act as powerful antioxidants, scavenging free radicals and helping prevent degenerative diseases such as cancer, heart disease, and diabetes.

In addition to being rich in anthocyanins, purple sweet potatoes also contain dietary fiber, vitamin C, beta-carotene, and minerals such as potassium and magnesium. Setyawati et al. (2018) stated that the use of purple sweet potato flour in processed food products can increase nutritional value while providing an attractive natural color. The purple color produced by anthocyanins also adds visual appeal, which can increase consumer interest, especially in the context of competition in processed food products. In the modern food industry, natural colors derived from raw materials are considered a value-added because they are safer than synthetic dyes. According to the Borneo Journal of Agricultural Science (BJAS), sweet potato flour has functional properties that can increase dough viscosity, enhance binding capacity, and contribute to a chewy texture in processed meat products.

Furthermore, research on broiler meatballs showed that adding up to 20% sweet potato flour significantly increased water-binding capacity, moisture content, chewiness, and texture ($P < 0.001$) without reducing consumer acceptance (Yuliyanti et al., 20129). This is in line with findings that the amylose and amylopectin content in purple sweet potatoes has good gelatinization and swelling properties, allowing them to bind water and form a compact texture in processed meat products (Haryanto & Suryanto, 2020).

The stability of anthocyanins in processed products processed at high temperatures is also a concern. Although this compound is quite sensitive to oxidation and pH changes, several studies have shown that anthocyanins from purple sweet potatoes can survive moderate heating. Haryanto and Suryanto (2020) explained that anthocyanins exhibit good stability at low pH.

Materials and Methods

This study used an experimental method with a Completely Randomized Design (CRD). The study was conducted in April 2025 at the Balitar Islamic University Laboratory. This study used a combination of experimental and questionnaire methods. The experimental procedure used a completely randomized design with four treatments and three replications. The following details the treatment of tapioca flour with purple sweet potato flour at different percentage levels, consisting of: P0 (100 grams of tapioca flour without purple sweet potato flour substitution), P1 (90 grams of tapioca flour with 10 grams of purple sweet potato flour substitution), P2 (80 grams of tapioca flour with 20 grams of purple sweet potato flour substitution), and P3 (70 grams of tapioca flour with 30 grams of purple sweet potato flour substitution).

The tools used for the study include: a blender, knife, spoon, tray, pan, plate, scissors, basin, cutting board, stove, scale, and stationery. The equipment used for testing includes a questionnaire.

Preparation Process

1. Fresh beef is first cleaned of fat and dirt, then cut into small pieces for easy grinding.
2. The beef pieces are ground using a food processor or grinder until smooth. During the grinding process, ice cubes or ice water are added to keep the mixture cool and maintain its texture.

3. Once the meat is smooth, ingredients such as ground garlic, ground pepper, and salt are added to the mixture.
4. Tapioca flour and purple sweet potato flour are then added according to the instructions, then stirred until all ingredients are evenly mixed and a smooth dough forms.
5. The homogenized dough is then formed into balls using your hands or a meatball mold.
6. The formed meatballs are placed in hot water (around 90-95°C) and boiled until they float, indicating they are cooked.
7. Once cooked, the meatballs are removed and drained.
8. The finished meatballs can be served immediately or stored in a closed container for further testing or processing.

Data Analysis

The data obtained were analyzed using a Completely Randomized Design (CRD) with one-way ANOVA. If there were significant or highly significant differences in the analysis of variance, a Duncan test was performed in IBM SPSS Statistics 22 to determine the differences between treatments.

Results and Discussion

Result and discussion must be written in the same part. They should be presented continuously start from the main result to the supporting results and equipped with a discussion. Avoid the supporting results that have been written on the introduction section. Unit of measurement used should follow the prevailing international system. All figures and tables placed separately at the end of manuscript pages and should be active and editable by editor. Written in Times New Roman 12 Font Size, and single space line.

Organoleptic Testing

Organoleptic testing was conducted to determine panelists' preference for beef meatballs supplemented with purple sweet potato flour (Ipomoea batatas Blackie). The organoleptic testing was based on color, taste, aroma, and texture across four treatments. These treatments were P0 (100 grams of tapioca flour, 0 grams of purple sweet potato flour), P1 (90 grams of tapioca flour, 10 grams of purple sweet potato flour), P2 (80 grams of tapioca flour, 20 grams of purple sweet potato flour), and P3 (70 grams of tapioca flour, 30 grams of purple sweet potato flour).

Table 2. Overall Results Based on Likert Scale

Treatment	Color	Flavor	Aroma	Texstur	Total Weight	Precentase
P0	$2,48 \pm 0,43^{bc}$	$2,41 \pm 0,38^{a}$	$2,66 \pm 0,25^{b}$	$2,47 \pm 0,23^{bc}$	10,02	25,6
P1	$2,61 \pm 0,37^{c}$	$2,66 \pm 0,31^{b}$	$2,56 \pm 0,37^{b}$	$2.31 \pm 0,27^{a}$	10,14	25,9
P2	$2,34 \pm 0,39^{ab}$	$2,31 \pm 0,35^{a}$	$2,37 \pm 0,36^{a}$	$2,45 \pm 0,27^{b}$	9,47	24,2
P3	$2,21 \pm 0,55^{a}$	$2,38 \pm 0,44^{a}$	$2,32 \pm 0,33^{a}$	$2,59 \pm 0,26^{c}$	9,50	24,3
		Total			39,13	100

Description: Scores are based on a Likert scale (1-3); Description: Different superscripts (^{abc}) in the same column indicate a significant difference (P<0.05).

Based on the organoleptic test results using a Likert scale, treatment P1 achieved the highest total score of 10.14, corresponding to 25.9%. This value was slightly higher than P0, which had a total weight of 10.02 (25.6%). Treatment P3 had the highest total weight of 9.50 (24.3%), while P2 had the lowest at 9.47 (24.2%).

Looking at each parameter, P1 scored the highest color score (2.61), while P3 scored the lowest (2.21). For taste, P1 also scored the highest (2.66), while P2 scored the lowest (2.31). For aroma, P0 scored the highest (2.66), while P2 scored the lowest (2.37). For texture, P3 scored highest

(2.59) and P1 lowest (2.31). Overall, the total weight of all treatments reached 39.13, equivalent to 100%.

These results indicate that panelists preferred treatment P1 for color and flavor, while P0 excelled in aroma and P3 in texture. These differences are likely influenced by the composition of the tapioca flour and purple sweet potato flour used in each treatment, which affects the final product's sensory characteristics.

Color

The results of the organoleptic test on color showed that treatment P1 (90% tapioca flour + 10% purple sweet potato flour) had the highest average value of 2.61, indicating that the panelists preferred it over the other treatments. This shows that the addition of 10% purple sweet potato flour has not altered the distinctive color of the beef meatballs, and instead provides an attractive, natural visual effect. On the other hand, a higher concentration of purple sweet potato flour, as in P3 (30% of the color of the meatballs becomes darker), due to increased anthocyanin levels, significantly decreases the preference score to 2.21.

This aligns with Cahya (2020), who found that high anthocyanin levels in purple sweet potatoes lead to significant changes and affect sensory acceptance, particularly color. This is in line with the findings of Rosida (2014), who reported that anthocyanins in purple sweet potatoes reach 110.51mg/100g, which can affect the visual appearance of the final product. The decrease in scores in P2 and P3 can be explained by the color change, which is too contrasting compared to the color of conventional meatballs. This aligns with consumers' expectations of seeing bright gray meatballs. The dark color of high-substitute meatballs is considered something foreign or less fresh by some panelists.

Therefore, purple sweet potato flour can be added at levels up to 10% without affecting visual color. Research by Fitriyani et al. (2017) found that increasing the level of purple sweet potato flour increases the intensity of the purple color in processed fish, thereby decreasing the color score. The color of food products influences consumers' initial perceptions of quality and taste, because visual appearance is the first indicator assessed before tasting. Therefore, color that falls short of expectations can reduce interest even when the aroma and taste remain good.

Flavor

The organoleptic test results for the taste variable showed that treatment P1 ranked highest again, with a score of 2.66, indicating that beef meatballs with a 10% substitution of purple sweet potato flour had the most preferred taste among panelists. The low substitution allowed the distinctive flavors of beef and spices to remain dominant, unobtrusively overshadowed by the purple sweet potato flour. In treatments P2 and P3, the significant decrease in taste scores was due to the higher concentration of purple sweet potato flour, which altered the beef's distinctive flavor to a milder one, to the point that some panelists considered it inconsistent with expectations for meatballs in general. These results align with Siska (2013), who reported that substitution with purple sweet potato flour at 5-10% was still well received organoleptically, but concentrations of 20% and above significantly decreased the taste score. Hastri et al. (2018) also found that the distinctive flavor of purple sweet potato flour began to dominate at the 20% level and reduced consumer acceptance of nugget products.

Panelists generally preferred the savory, salty meatballs, which had a strong beefy flavor. Purple sweet potato flour, while neutral with a slightly sweet taste, produced little change in flavor when added in large amounts. Therefore, the recommended substitution rate is 10% to maintain the product's distinctive beef meatball flavor.

Aroma

The organoleptic test results for the aroma variable showed differences. Treatment P0 (100% tapioca flour) received the highest score of 2.66, indicating that the meatball aroma was most preferred when purple sweet potato flour was not used. Treatment P1 was still quite preferred with a score of 2.56. Higher levels of purple sweet potato flour, such as in P3 (30% purple sweet potato flour substitution), with a score of 2.32, resulted in a decrease in the aroma score. This may be due to the purple sweet potato beginning to dominate the seasoned meat's aroma. Cahya (2020) stated that the higher the concentration of purple sweet potato flour, the stronger the distinctive sweet potato aroma that emerges, which tends to decrease the aroma acceptance of food products such as meatballs and sausages. Research by Hasri et al. (2018) also found similar results, indicating a significant decrease in aroma scores for processed products with 30% purple sweet potato flour.

Panelists generally preferred the pungent aroma of meat and meatball spices. When the purple sweet potato aroma is present, especially at high concentrations, it can interfere with the distinctive smell of meatballs. Therefore, although purple sweet potato offers nutritional and antioxidant benefits, its use should be limited to avoid reducing consumer preference.

Texture

The organoleptic test results differ from the previous variables. In the texture parameter, the highest value was obtained with treatment P3 (30% purple sweet potato flour substitution), with a value of 2.59, indicating that high substitution provides meatball texture results most preferred by panelists. This is because purple sweet potato flour has a high amylose and amylopectin content, which affects gel formation and the elasticity of meatball dough. Montolalu et al. (2013) stated that the levels of amylose and amylopectin in purple sweet potato flour support the formation of a chewy and compact texture in processed meat products. Elasticity is one of the main texture characteristics used to assess the quality of meatballs.

Purple sweet potato flour can act as a good binding agent, increasing water-binding capacity and producing a dense yet elastic texture. The control treatment (P1) received a lower texture value than P3, namely 2.31. Therefore, in terms of texture, the use of purple sweet potato flour is advantageous, especially at high substitution levels. Research by Fitriyani et al. (2017) concluded that the use of purple sweet potato flour increases the elasticity and binding power of fish ball dough.

Conclusion

Substitution of tapioca flour with purple sweet potato flour significantly affected all organoleptic parameters. Treatment P1 (10% substitution of tapioca flour with purple sweet potato flour) showed the best overall results and was most preferred by panelists.

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