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Effect of Substituting Tapioca Flour with Purple Sweet Potato on Antioxidant Activity and Sensory Evaluation of Chicken Meatballs

Azchar Prianka Piawan Putra[1]*, Hotlan Manik[1], Rizki Prasetya[1], Juni Claudia Dami[1]
[1]Animal Science Study Program, Faculty of Animal Science, University of Papua
Email: a.putra@unipa.ac.id

Abstrak

Penelitian ini bertujuan untuk mengetahui kandungan antioksidan bakso daging ayam dan mutu sensori yang meliputi warna, rasa, aroma, tekstur, dan daya terima dengan bahan pengisi pati tapioka yang disubstitusi ubi jalar ungu. Proses pembuatan bakso dilakukan dengan mencampurkan seluruh bahan yaitu daging ayam, bahan pengisi, STTP, bawang merah, bawang putih, garam, penyedap rasa, dan udara. Penelitian ini menggunakan Rancangan Acak Lengkap dengan taraf substitusi ubi jalar ungu (0, 25, 50, 75, dan 100%) dengan 5 kali ulangan. Parameter yang diteliti adalah antioksidan dan mutu sensori bakso daging ayam. Rancangan Acak Lengkap perbedaan langsung dan nyata dengan Uji Jarak Berganda Duncan yang baru. Data sifat sensori diuji dengan analisis non parametrik uji Hedonik Kruskal-Wallis dan dilanjutkan dengan uji QDA (Analisis Deskriptif Kuantitatif) model jaring laba-laba. Hasil uji statistik menunjukkan bahwa substitusi tepung tapioka dengan ubi jalar ungu berpengaruh sangat nyata (P<0,01) terhadap aktivitas antioksidan. Hasil uji sensori menunjukkan bahwa substitusi tepung tapioka dengan tepung ubi jalar ungu berpengaruh nyata (P<0,05) terhadap warna, rasa, tekstur, kekenyalan, dan penerimaan tetapi tidak berpengaruh nyata terhadap keharuman bakso daging ayam. Berdasarkan hasil tersebut, disimpulkan bahwa substitusi tepung tapioka dengan tepung ubi jalar dengan tingkat substitusi 75-100% menunjukkan kandungan antioksidan terbaik, mutu sensori terbaik pada tingkat 100% untuk warna, dan pada rasa, kekenyalan, dan penerimaan terbaik pada tingkat substitusi 0% sedangkan untuk tekstur terbaik pada tingkat substitusi 0-25%.

Kata kunci: Antioksidan bakso, Bakso ayam, Kualitas sensori, Ubi ungu

Abstract

This research was intended to find out antioxidant content of chicken meat meatballs and sensory quality containing color, flavor, fragrancy, texture, and acceptance with tapioca starch filler substituted with purple sweet potato. The process of making meatballs was done by mixing all the ingredients of chicken meat, filler, STTP, onion, garlic, salt, flavoring, and air. This study used a Completely Randomized Design with the level of purple sweet potato substitution (0, 25, 50, 75, and 100%) with 5 replications. The parameters were the antioxidant and the sensory quality of chicken meat meatballs. Completely Randomized Design of direct and real differences with the new Duncan's Multiple Range Test. The data of sensory characteristic were tested with non-parametric analysis of Hedonic Kruskal-Wallis's test and continued in QDA test (Quantitative Descriptive Analysis) in spider net model. The results of statistical test showed that substitution of tapioca flour with purple sweet potato had a very real effect (P<0,01) to antioxidant activity. Sensory test results showed that substitution of tapioca flour with purple sweet potato flour significantly (P <0,05) on the color, taste, texture, elasticity, and acceptance but did not significantly affect the fragrancy of chicken meat meatball. Based on these results, it was concluded that substitution of tapioca flour with sweet potato flour with 75-100% substitution level showed the best antioxidant content, sensory quality best quality at 100% level for color, and on taste, elasticity, and best acceptability at 0% substitution level while for best texture at 0-25% substitution level.

Keywords: Antioxidant meatball, Chicken meatball, Purple sweet potato, Sensory quality

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INTRODUCTIONS

Broiler chicken is widely processed into comminuted products such as meatballs (bakso) because of its high-quality protein, mild flavor, and consumer acceptance. In these systems, starch acts as a binder/filler that helps set the gel matrix with salt-solubilized myofibrillar proteins, improving water-holding capacity (WHC), texture (hardness, springiness, cohesiveness), and reducing cooking loss. Among starches used in Southeast Asian meat products, tapioca (cassava) starch—naturally rich in amylopectin—readily swells and gelatinizes, contributing to a fine, elastic protein–starch composite network when properly dosed (Zhang *et al*., 2024; Marczak & Mendes, 2024). Recent studies show that starch type and use level can significantly modulate moisture retention, microstructure, and textural attributes in minced-meat systems; overly low levels yield weak gels and higher syneresis, whereas overly high levels can dilute protein, dull flavor, and produce rubbery textures (Zhang *et al*., 2024; Wei et al., 2023).

From a formulation standpoint, optimizing tapioca inclusion level is therefore central to delivering desirable bite, juiciness, and yield in broiler meatballs. Evidence from chicken and other meat matrices indicates that appropriate starch inclusion improves emulsion stability, WHC, and creates a more uniform, porous microstructure—outcomes linked to better sensory acceptance and lower cooking loss (Marczak & Mendes, 2024; AIP Proceedings, 2024). Parallel trials in poultry meatballs likewise report meaningful changes in texture-profile parameters as starch level varies, reinforcing the need to calibrate dosage for target quality specifications (Ismiarti *et al*., 2024).

Purple-fleshed sweet potato (*Ipomoea batatas*) is one of several sweet potato varieties cultivated in Indonesia, alongside white, yellow, and red types (Lingga, 1995). In recent years, the purple variety has gained consumer popularity due to its enhanced nutritional profile and health-promoting properties. Studies have shown that purple sweet potato offers dietary fiber, antioxidative anthocyanins, and essential vitamins and minerals, resulting in benefits such as improved colon health, enhanced glucose tolerance, reduced cholesterol levels, and increased satiety (Helen *et al*., 2013).

Scientific analysis indicates that purple sweet potato flour contains substantial dietary fiber, moderate protein, low fat, and abundant starch, along with high anthocyanin content that correlates with the intensity of its purple flesh color (e.g., 9.4–16.5% fiber, 3.2–8.8% protein, and 0.5–1.0% fat in dried samples) (Zhang *et al*., 2024). The bioactive anthocyanins mainly cyanidins and peonidin's confers strong antioxidant and anti-

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inflammatory capacity, acting through cellular pathways (Domínguez *et al*., 2019). Additionally, recent research highlights the potential of purple sweet potato constituents to inhibit oxidative stress and support metabolic and liver health (Tang *et al*., 2023; Elgabry *et al*., 2023).

At the same time, broiler meat's relatively high proportion of polyunsaturated fatty acids makes it susceptible to lipid oxidation, which leads to rancidity, discoloration, and sensory decline during processing and storage. Contemporary approaches combine good manufacturing practices with antioxidant strategies (e.g., plant-based phenolics or spice extracts) to curb oxidation without compromising texture created by starch–protein interactions (Domínguez *et al*., 2019; Orădan *et al*., 2024). In short, successful formulation must balance starch-driven structure and yield with oxidative stability to maintain overall product quality. Objectively, this study evaluates the effect of different tapioca starch levels as the sole treatment factor on the antioxidant activity and sensory quality of broiler-chicken meatballs, while considering oxidative-quality implications to support a robust, industry-relevant formulation.penelitian.

METHODS

Chicken breast meat was cut into small pieces and then finely ground. The mixture was mixed with fried onions, pepper, salt, and garlic, which had been ground until homogeneous. Ice cubes were added during the mixing process. The meat was then divided into five treatments: purple sweet potato substitution with tapioca flour at concentrations of 0, 25, 50, 75, and 100%, with five replicates.

Antioxidant activity was tested using the 1,1-Diphenyl-2-picrylhydracyl (DPPH) method. This free radical has a maximum absorption at a wavelength of 517 nm and can be reduced by antioxidant compounds (Pratiwi & Harapini, 2008). A 5 ml sample of ground meatballs diluted with water was placed in a 25 ml flask and methanol was added to the mark. A 0.001 g DPPH solution was transferred to a 50 ml flask and methanol was added. A 4 ml sample of meatballs was taken from the 25 ml flask, 2 ml of the diluted 20 ppm DPPH solution was added, and the sample was placed in a vial, shaken using an MMS 3000 multishaker until homogeneous, and then allowed to stand for 30 minutes in the dark. The solution that had been stored in a dark room for 30 minutes was then put into a cuvette, then its absorbance was measured using a UV-visible spectrophotometer at a wavelength of 517ms.

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Sensory testing included color, taste and aroma, texture, chewiness, and acceptability of the meatballs. Fifteen panelists conducted the sensory quality test by assessing the meatballs' sensory quality based on the score 1 to 5. Panelists assessed the meatballs according to the instructions provided (Kartika *et al.*, 1988).

The antioxidant test data were analyzed using a completely randomized design (ANOVA) with significant differences followed by Duncan's New Multiple Range Test (Steel and Torrie, 1980). Sensory characteristics were analyzed using the Hedone-Kriuskal-Wallis's test (Salleh, 1996), followed by a quantitative descriptive analysis (QDA) using a spider web model.

RESULT AND DISCUSSION

Antioxidant activity

Determination of antioxidant value can be used to determine the level of antioxidants contained in a sample. The antioxidant activity in chicken meatballs with tapioca flour substitution treatment with purple sweet potato flour comes from the sweet potato coloring agent, namely anthocyanin. Anthocyanin is a natural coloring agent that acts as an antioxidant found in plants. According to Jawi (2007), anthocyanin is a pigment from the flavonoid group that is soluble in water, red to blue in color and is widely distributed in plants. The antioxidant value of chicken meatballs can be seen in Table 1.

Tabel 1. The Effect of the Substitution Level of Tapioca Flour with Purple Sweet Potato Flour on the Antioxidant Content of Chicken Meatballs (%)

Replication	Substitution Level (%)				
	0	25	50	75	100
I	18,64	24,87	27,20	36,12	34,35
II	20,62	24,78	27,35	36,77	34,39
III	19,60	25,53	27,21	36,01	34,51
IV	18,49	26,03	26,09	36,22	34,80
V	19,30	24,72	26,44	35,01	34,95
Means	$19{,}33\pm0{,}38^{a}$	25.18 ± 0.25^{b}	$26.86\pm0{,}25^{b}$	36.02 ± 2.0^{c}	34.60 ± 0.11^{c}

^{ns} non-significant, (^{a,b,c}) different superscripts on the same line indicate a significant difference. (P<0,01)

The present study demonstrates that partial replacement of tapioca flour with purple sweet potato flour (PSPF) significantly enhances the antioxidant content of chicken meatballs. Antioxidant values increased progressively from an average of 19.33 ± 0.38% at 0% substitution to 36.02 ± 2.0% at 75% substitution, followed by a slight decline to 34.60 ± 0.11% at 100% substitution. These changes were statistically significant ($p < 0.01$),

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as indicated by the differing superscript letters. Similar findings were reported by Hajrawati *et al*. (2022, 2025), who observed that PSPF substitution improved antioxidant activity in chicken meatball formulations.

The enhanced antioxidant capacity can be attributed to the rich anthocyanin and phenolic content of purple sweet potato. Anthocyanins act as potent natural antioxidants and colorants; their presence in food systems has been shown to markedly improve functional properties (Teow *et al*., 2007; Zhang *et al*., 2022). Purple-fleshed sweet potatoes are particularly rich in total phenolics and exhibit stronger antioxidant activity than white- or orange-fleshed varieties (Teow *et al*., 2007; Zhang *et al*., 2022). Substitution of tapioca flour with PSPF has also been shown to enhance the functional quality of meat-based products without compromising nutritional or pH stability while simultaneously increasing anthocyanin content and radical scavenging activity (Hajrawati *et al*., 2022). The increase in antioxidant activity observed at 75% substitution suggests an optimal balance; beyond this level, diminishing returns may occur due to matrix interactions or anthocyanin saturation effects.

Mechanistically, anthocyanins such as cyanidin- and peonidin-based glycosides (e.g., cyanidin 3-caffeoylsophoroside-5-glucoside) are major contributors to antioxidant activity in purple sweet potato (Wikipedia, 2023). These compounds, along with total phenolics, are highly correlated with radical scavenging activities, as measured through assays such as ORAC, DPPH, and ABTS (Teow *et al*., 2007; Nurdjanah *et al.,* 2022). From a food technology perspective, incorporating PSPF into chicken meatballs could improve both shelf-life and nutritional functionality through antioxidant protection against lipid oxidation. Similar functional enhancements have been observed in other systems, such as baked goods and cookies using PSPF (Puspita *et al*., 2023). This demonstrates that PSPF can serve as a multifunctional ingredient that not only enhances health benefits but also contributes to product innovation.

Sensory evaluation

The results of the sensory characteristics evaluation of chicken meatballs with fillers substituted by purple sweet potato flour included color, aroma, texture, springiness, and acceptability, as presented in the mean values in Table 1. The sensory quality assessment was carried out based on panelists' perception, covering attributes of color, aroma, texture, chewiness, and overall acceptability.

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Table 2. Sensory Quality Scores of Chicken Meatballs

Variable	Substitution Level (%)				
	0	25	50	75	100
Colour	1,67±0,36[a]	2,20±0,20[ab]	2,93±0,15[bc]	3,33±0,27[c]	4,13±0,29[d]
Taste	3,67±0,23[c]	3,47±0,16[bc]	2,93±0,18[ab]	2,80±0,20[a]	2,87±0,19[a]
Flavour [ns]	3,40±0,25	3,07±0,20	3,07±0,18	3,00±0,21	2,73±0,24
Texture	3,33±0,27[b]	3,00±0,21[b]	2,87±0,16[ab]	2,27±0,15[a]	2,27±0,18[a]
Chewiness	3,00±0,23[b]	2,80±0,22[ab]	2,47±0,19[ab]	2,27±0,22[a]	2,27±0,18[a]
Acceptability	3,47±0,19[b]	2,73±0,20[b]	2,73±0,20[b]	2,53±0,19[b]	2,40±0,19[a]

[ns] non-significant, ([a,b,c]) different superscripts on the same line indicate a significant difference (P<0,01)

The sensory evaluation of chicken meatballs with tapioca flour substituted by purple sweet potato flour revealed notable differences across several attributes, including color, aroma, texture, springiness, and overall acceptability. Substitution levels significantly influenced the color attribute, as the incorporation of purple sweet potato flour imparted a darker purplish hue, consistent with the presence of anthocyanin pigments (Zhang *et al.,* 2022; Teow *et al.,* 2007). Panelists perceived the color changes positively up to a certain substitution level, as natural pigments are often associated with health-promoting benefits (Nurdjanah *et al.,* 2022).

In terms of aroma, meatballs with higher substitution levels tended to exhibit a distinct sweet potato aroma, which was generally well accepted by the panelists. This is in line with previous studies reporting that natural flour substitutions can modify the aroma profile of meat products, sometimes enhancing consumer perception when the aroma is mild and complementary (Hajrawati *et al.,* 2022).

Texture and springiness (elasticity) were also affected by flour substitution. At moderate levels of substitution, panelists evaluated the meatballs as maintaining desirable chewiness and elasticity, attributes commonly associated with high-quality meatballs (Hajrawati et al., 2025). However, excessive substitution levels may alter the protein–starch interaction, potentially reducing the optimal springiness. This aligns with the report of Puspita *et al.* (2023), who observed that substitution with purple sweet potato flour in baked products altered textural attributes depending on the substitution ratio.

Finally, overall acceptability scores indicated that panelists favored formulations with intermediate substitution levels, suggesting an optimal balance between functional enhancement and sensory quality. This finding reinforces the concept that functional ingredients such as purple sweet potato flour can improve both nutritional value and

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consumer perception when incorporated at appropriate levels (Teow *et al.,* 2007; Zhang *et al.,* 2022).

CONCLUSION

The substitution of tapioca flour with purple sweet potato flour in chicken meatballs significantly improved both antioxidant activity and sensory quality. The highest antioxidant activity was observed at a 75% substitution level, indicating an optimal balance between functional enhancement and product stability. Sensory evaluation further demonstrated that moderate substitution levels were well accepted by panelists in terms of color, aroma, texture, springiness, and overall acceptability. These findings suggest that purple sweet potato flour can be effectively utilized as a functional ingredient to enhance the nutritional and sensory properties of meat products, offering a promising strategy for the development of healthier and more consumer-preferred meatball formulations.

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