Evaluation of Physicochemical Properties and Antioxidant Activity of Chicken Meatballs by Substitution of Tapioca Flour with Purple Sweet Potato

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ABSTRACT
Purple sweet potatoes are widely used as a source of antioxidants and natural dyes in food products. This study aimed to evaluate the physicochemical properties and antioxidant activity of substitution of tapioca flour with purple sweet potato flour. The treatments employed were the substitution of tapioca flour (T) with purple sweet potato (P) with a ratio of 20:0; 15:5; 10:10; 5:15, and 0:20 (meat weight basis). Variables measured were nutrient content, pH, cooking loss, water holding capacity (WHC), Colour, anthocyanin content, and scavenging activity. The results showed that the substitution of tapioca with purple sweet potato did not affect the nutritional content except for crude fiber content, and pH of chicken meatballs. However, it increased the cooking loss, anthocyanin content, redness, and scavenging activity, and decreased the WHC and brightness (L*). It could be summarized that the substitution of the tapioca flour with purple sweet potato increased the functional properties of the chicken meatball without any changes in nutritional, pH value, and physical properties of the chicken meatballs.

Keywords: *Meatball, Purple sweet potato flour, Scavenging activity.*

1. INTRODUCTION

Meatballs are the most demanded of processed meat products in Indonesia. In the manufacture, starch flour is added to increase the water holding capacity (WHC) and product yield. Commonly, the starch included is tapioca flour. The main components playing a role in the WHC of starch are amylose and amylopectin [1].

However, recently the consumer's perception of meat products has shifted to functional products with a healthy effect [2]. Increasing the functional properties of the meatballs could be employed through the ingredients used. The functional properties of food products that are currently in great demand are antioxidants [3,4]. The use of starch with these criteria is one of the efforts to enhance the functional properties of meatballs, namely purple sweet potato.

Purple sweet potato flour is one of the preferred starch sources by consumers because of its function as an antioxidant, antimutagenicity, anticarcinogen, and antihypertensive [5,6]. This flour contains 98.7% of starch and 19.74% of amylose (dry weight-based) with a medium granular size, 17 µm [7]. Purple sweet potato contains tocopherol (Vit. E), beta carotene, phenolic compounds, and anthocyanins [5,6]. Anthocyanins found in sweet potatoes are 0.4-0.6 mg/g (wet weight-based) or 6.23 mg/g (dry weight-based) that function as antioxidants and natural dyes [8,9]. Anthocyanins also show high stability during cooking [8,10].

The addition of purple sweet potato flour to food products in many countries has been widely employed, both as a source of antioxidants and natural dyes. Some studies reported that the use of sweet potato puree in frankfurter sausage could improve the tenderness and texture of beef sausage and retard lipid peroxidation, even some sweet potatoes including purple variety, are rich in microminerals [11]. The addition of this kind of sweet potato could also improve the sensorial properties of chicken sausage [12]. Purple sweet potato also could increase the antioxidant activity, suppress protein deterioration and enhance the textural properties of pork sausage [13]. However, information on the effect of substitution of tapioca with purple sweet potato on the physical properties and antioxidant activity of chicken meatballs is less studied. Therefore, this study is aimed to evaluate the physical characteristics and antioxidant activity of chicken meatballs by substituting tapioca flour with purple sweet potato flour.

2. MATERIALS AND METHODS

2.1. Meatballs preparation

Broiler meat was obtained from the local market in Makassar. The meat was filleted and grounded using a meat grinder. The ground meat was divided into 5 groups based on the treatment of tapioca (T) substitution with purple sweet potato (P) (20:0; 15:5; 10:10; 5:15; 0:20) of the meat weight. Each treatment was added 30% ice cubes, 0.3% phosphate 1.8% salt and a mixture of spices (pepper, 0.8%, 4% garlic, 1% flavoring). All ingredients of each treatment were ground and blended homogeneously and then added tapioca and purple sweet potato flour. The next step was to shape the dough into balls by hand and cook at 80°C for 20 minutes. The meatballs were cooled before observing their physicochemical properties and antioxidant activity.

2.2. Variables

2.2.1. Proximate analysis

Moisture, protein, ash, fat, crude fiber contents were determined in accordance with standard AOAC methods [14]. Protein determination involved a Kjeldahl assay (N x 6.25). Fatwas determined by extracting samples in a Soxhlet apparatus using petroleum ether as a solvent. Moisture was quantified by oven drying 10 g at 105°C overnight and expressed as percent (%). Ash was determined after incineration in a furnace at 500°C.

2.2.2. Cooking Loss

The cooking loss was determined as the loss in weight during cooking and expressed as a percent of pre-cooking weight

2.2.3. Water Holding Capacity (WHC)

The water holding capacity was determined according to the method of Jung and Jo [15]. Yield (%) was measured by weighting the product before and after centrifugation. Ten grams of samples were mixed with 40 ml distilled water in a tube and were incubated in a water bath at 30°C for 30 min. The mixture was then centrifuged at 3000 rpm for 30 min and the supernatant was pipetted before additional incubation for 10 min and was removed by pipetting again. Results are expressed as a percentage of fluid release.

$$\text{WHC (\%)} = \frac{A}{B} \text{ x } 100$$

where WHC = Water holding capacity, A = weight of the sample after removing supernatant, B = weight of sample mixed with distilled water.

2.2.3. pH Value

The pH of the samples was measured using a digital portable pH-meter (HI 99163, Hanna Instruments, Eibar, Spain), equipped with a penetration probe.

2.2.4. Color determination

Measurement of color values (L*, a*, and b*) were carried out using the Tes-135A color meter (Test Electrical Electronic Corp. Taipei, Taiwan). Before being used, the instrument was calibrated with a standard plate (L*=95.27, a*=0.915, b*=2.646). The measurement was conducted at room temperature (23±2°C) with 3 measurements for each sample. The L*, a* (+, red; - , green) and b* (+, yellow; -, blue) color coordinates are determined according to the CIELab coordinate color space system. American meat science association guidelines for color measurements were followed by Hunt, *et al* [16].

2.2.5. Total Anthocyanin.

The total anthocyanin (TAC) in chicken meatballs was quantified spectrophotometrically as monomeric anthocyanin by the pH differential method [17].

2.2.6. Scavenging activity

The antioxidant activity of the meatballs was assessed by the *1,1-diphenyl-2-picrylhydrazyl* (DPPH) radical scavenging method [18]. A-1 g of the meatball was extracted with 5 mL of methanol for 24 h at room temperature. A-400 µl of the extract was reacted with 3.6 mL of 0.1 µM DPPH, then homogenized and stored in a dark room for 30 minutes. The percent inhibition against DPPH was calculated as the percentage reduction in absorbance at a wavelength of 517 nm.

2.3. Statistical analysis.

The data reported in all the tables were means ± standard deviation (means ± SD). The one-way analysis of variance (ANOVA) by Tukey's test was evaluated using the SAS Statistical Software Program.

3. RESULTS AND DISCUSSION

3.1. Nutritional content of chicken meatballs

The nutritive value of chicken meatballs by substituting tapioca with purple sweet potato flour is presented in Table 1. The substitution of tapioca flour with purple sweet potato flour had no significant effect on the moisture, ash, protein, and fat, but was remarkable fiber content of the meatballs. The increase of crude fiber content of the meatballs was mostly caused by the content of crude fiber in the purple sweet potato. This result confirmed the result of Marconato et al. [19] that the use of purple sweet potato peel enhanced the content of dietary fiber of the hamburger. Most the sweet potatoes contain 9-16% of crude fiber [20], whereas, cassava flour contains a total fiber of less than 2.5% [21].

3.2. Cooking loss, WHC, and pH

The effect of substitution of tapioca with purple sweet potato flour on cooking loss, WHC, and pH of chicken meatballs is shown in Table 2. Substituting tapioca with purple sweet potato flour affected significantly on cooking loss percentage. The significant effect of increasing the cooking loss was indicated by the 100% substitution of tapioca with purple sweet potato. These results exerted that purple sweet potato increased the cooking loss.

This phenomenon was most probably caused by the different types of starch. Sweet potato flour contains more amylose proportion than tapioca flour [22,23]. The amylose molecular structure is straight, so that it is easier to make a parallel position and approach each other closely to form hydrogen bonding between adjacent chains. As a result, the water affinity of amylose is reduced [23]. The ratio between amylose and amylopectin in tapioca flour and purple sweet potato affects starch granule swelling and starch solubility [1]. Another study also reported that amylose could cause water retention higher than amylopectin in Kojac glucomannan gel products [24].

When heating, starch will swell and hydrate and it reflects the size of the interaction between starch chains. The extent of the interaction is affected by the ratio of amylose and amylopectin. The ratio results in various swelling power and starch solubility. The amylose can act as an inhibitor of starch granule swelling and hinder the disruption of amylopectin double helices [1]. During cooking, amylose and amylopectin form a gel so that the free water in the meatball product is bound by hydrogen resulting in an increase in water holding capacity and the gel structure becomes stronger affecting the value of the cooking loss. The value of cooking loss decreases along with the decrease in the ability to bind water.

The pH value of chicken meatballs is presented in Table 2. The pH value of meatballs ranged from 6.20 to 6.23. Substitution of tapioca with purple sweet potato flour did not show a significant difference (P>0.05) to the pH value of meatballs among treatments. This result indicated that the kind of flour did not affect on the pH value of meatballs. A similar result was also reported by Öztürk and Turhan [25] that the range of pH value of meatballs was 6.07-6.22 for meatballs in which the tapioca was substituted by other kinds of flour.

Table 1. Nutritional properties of chicken meatball

Formula	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Crude Fiber (%)
T20:P0	70.25±0.25	1.87±0.19	17.43±2.00	1.15±0.20	$0.25±0.05^{b}$
T15:P5	70.48±0.97	1.92±0.28	17.68±1.24	1.03±0.35	$0.36±0.03^{b}$
T10:P10	70.55±1.20	1.97±0.28	17.65±0.98	1.17±0.19	$0.39±0.04^{b}$
T5:P15	70.08±0.75	2.03±0.16	17.66±1.18	1.19±0.23	$0.44±0.22^{b}$
T0:P20	70.16±0.64	2.17±0.22	17.51±1.21	1.17±0.26	$0.78±0.15^{a}$
Average	$70.30±0.20^{ns}$	$1.99±0.11^{ns}$	$17.58±0.11^{ns}$	$1.14±0.06^{ns}$	0.44±0.20

T = Tapioca flour, P = Purple sweet potato, a-b = Different letters in the same column indicate significantly different (P<0.05), ns= non significant (P>0.05)

Table 2. The cooking loss and water holding capacity and pH of chicken meatballs

Formula	Cooking loss (%)	WHC (%)	pH
T20:P0	$3.06±0.30^{b}$	$34.37±0.74^{a}$	6.22±0.16
T15:P5	$3.22±0.66^{b}$	$34.15±1.55^{a}$	6.23±0.07
T10:P10	$3.73±0.30^{b}$	$32.22±0.71^{ab}$	6.20±0.15
T5:P15	$4.05±0.16^{b}$	$30.95±1.87^{b}$	6.21±0.06
T0:P20	$6.03±0.31^{a}$	$29. 43±0.60^{b}$	6.23±0.07
Average	4.10±1.14	32.22±2.10	$6.22±0.01^{ns}$

T = Tapioca flour, P = Purple sweet potato, a-b = Different letters in the same column indicate significantly different (P<0.05), ns= non significant (P>0.05)

3.3. Color

The color parameters of the meatballs were determined by using CIE Lab. The results are presented in Table 3. The lightness (L*) and yellowness (b*) of the meatballs tended to decrease by the increase of the substitution of tapioca with purple sweet potato ($P<0.054$). However, the redness value of the meatballs increased ($P<0.05$) by the substitution of tapioca with purple sweet potato.

The increase of redness of the meatballs was probably due to the anthocyanin content of the purple sweet potato. Chen *et al*. [26] reported that purple sweet potato was rich in anthocyanin. This substance is responsible for the color development of the product incorporated. In general, anthocyanins are reddish in acidic, pink in neutral, and blue in basic conditions [27]. This study indicated that the pH value of the products was lower than neutral pH. This result also confirmed the previous study reported by Yetim *et al*. [28] by adding the natural colorant to the pastirma, a Turkish dry cured meat product, resulting in the L* value being decreased. Kammerer *et al*. [29] reported that the addition of natural colorants decreased the lightness of the products.

3.4. Anthocyanin Content

The result of the study showed that the substitution of tapioca flour with purple sweet potato flour markedly affected the anthocyanin content of the chicken meatballs (Figure 1). The higher proportion of the purple sweet potato the higher content of the meatballs anthocyanin. The availability of the anthocyanin in the meatballs was mostly due to the purple sweet potato's anthocyanin. It was indicated by the zero content of meatballs' anthocyanin in meatballs with 100% tapioca.

Purple sweet potatoes are high in anthocyanin content [26], so that it influenced the meatballs incorporated with this sweet potato. Total anthocyanin content is stable by heating processes such as boiling, steaming, and microwaving although frying and baking reduce the anthocyanin content [30]. Meatball is a meat processed product applying boiling process so that it does not decrease the anthocyanin content of the meatballs.

3.5. Scavenging Activity

The scavenging activity indicator of the product is important for functional food. Natural agents have been studied by many researchers to enhance this purpose.

Table 3. Color (L*, a* b*) of chicken meatballs in which the tapioca substituted with purple sweet potato.

Parameters	Substitution of tapioca with purple sweet potato (%)				
	T20:P0	T15:P10	T10:P10	T5:P15	T0:P20
L* (Ligthness)	71.73±0.25^{a}	60.13±1.76^{b}	55.27±0.46^{c}	52.23±1.57^{cd}	48.64±0.85^{d}
a* (Redness)	0.90±0.33^{a}	5.20±0.69^{b}	6.17±0.31^{c}	7.43±0.21^{c}	8.83±0.31^{d}
b* (Yellownes)	11.33±0.75^{a}	5.35±0.19^{b}	4.80±0.44^{bc}	4.04±0.57^{bc}	3.47±0.83^{c}

T = Tapioca flour, P = Purple sweet potato, a-b = Different letters in the same row indicate significantly different ($P<0.05$)

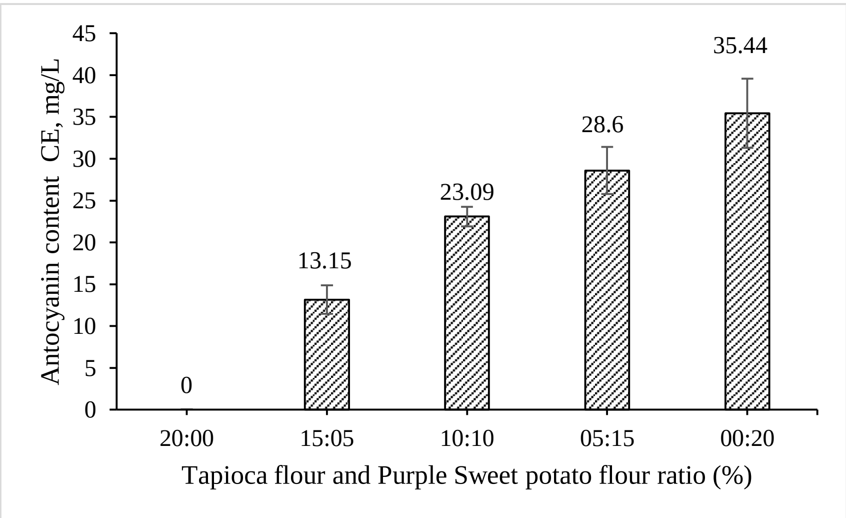

Figure 1. Anthocyanin content of chicken meatballs in which the tapioca substituted with purple sweet potato. T = Tapioca flour, P = Purple sweet potato, a-b = Different letters indicate significantly different ($P<0.05$).

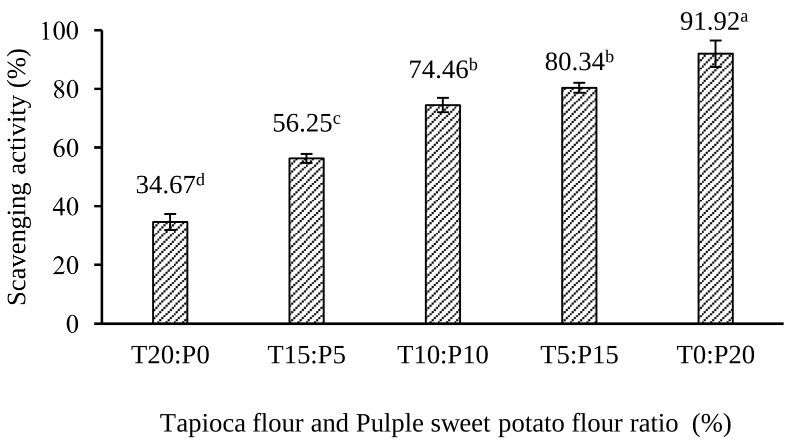

Figure 2. Scavenging activity of chicken meatballs in which the tapioca is substituted with purple sweet potato. T = Tapioca flour, P = Purple sweet potato, a-b = Different letters indicate significantly different ($P<0.05$)

The increased proportion of the purple sweet potato could improve the scavenging activity of the meatballs. The data are illustrated in Figure 2.

This result indicated that the increase of scavenging activity was mostly caused by the purple sweet potato substitution. Chen *et al*. [26] stated that purple sweet potatoes are high in anthocyanin content. Roy and Rhim [27] explained that anthocyanins have biological and functional properties related to oxidation such as antioxidant activity and free radical scavenging activity. Jiao *et al*. [31] reported that extracts of anthocyanin from purple sweet potato could inhibit lipid peroxidation compounds.

4. CONCLUSION

It can be summarized that the substitution of tapioca flour with purple sweet potato flour resulted in an increase in red color with the lower lightness of the meatballs. The substitution of 15% could improve the scavenging activity without any decreased physical properties of the chicken meatballs. The enhanced scavenging activity is an advantage associated with the antioxidant activity of the products.

AUTHORS' CONTRIBUTIONS

Hajrawati Hajrawati contributed to coordinating and leading the research, experiment, interpreting data, and drafting the manuscript, while Ratmawati Malaka acted in the experiment and interpreted the result. Fatma, and Norma Novita, simultaneously, conducting the experiment and analyzing data, and formatted the manuscript. Muhammad Rachman Hakim, and Suharyanto Suharyanto contributed to the drafting, interpretation of results and discussion, and finalization of the manuscript.

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