Physicochemical and Sensory Characteristics of Biscuits from Purple Sweet Potato Flour and Wheat Flour

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Abstract: Purple-fleshed sweet potato (PFSP) was the source of anthocyanin which provide the powerful antioxidant activity. The combination of PFSP flour and wheat flour for biscuits manufacturing will give benefits in terms of color and nutritional value. In this work, PFSP flour was combined with wheat flour in ratio of 100:0; 90:10; 80:20; 70:30; 60:40; 50:50; 40:60; 30:70; 20:80; 10:90; and 0:100. The physicochemical and sensory characteristics of biscuits were analyzed to evaluate the acceptability of biscuits. Biscuits containing 70% of PFSP flour had a higher anthocyanin content and accepted by consumers in all attributes of sensory characteristics. The biscuits from PFSP flour were not only had a higher nutritional value than those of made from 100% wheat flour (control), but also had an attractive color and high potential for accepting by consumers.

1 INTRODUCTION

Ipomoea batatas L., also known as sweet potato, is one of agricultural commodities with abundant production in Indonesia especially in North Sumatera. In Indonesia, the amount of sweet potato production in 2015 is around 2.297.634 tons (Statistics Indonesia, 2015). In 2017, sweet potato production in North Sumatra in 2017 was 92.380,3 tons, which is 848,9 tons higher than production in 2016 (Statistics of Sumatera Utara, 2017). Sweet potato contains a lot of carbohydrates, dietary fibers, folic acids, and minerals (International Life Science Institute, 2017; Zhang et al., 2009; Van Hall, 2000). Purple fleshed sweet potato (PFSP) is one of sweet potato genotypes which is contains anthocyanin pigment in their tubers (Bovell-Benjamin, 2007; Oki et al., 2002). Sweet potato now is widely used as human diet around the world (Kamal et al., 2013).

PFSP is a seasonal, perishable and bulky tuber (Kamal et al., 2013). In order to extend the shelf life, purple sweet potato needs to be processed into flour. PFSP flour can be utilized as wheat flour as a substitute for wheat flour in making various food products such as cakes (Hutasoit et al., 2018; Chuango et al., 2019; Azzahra et al., 2019), cookies (Ulfa et al., 2019), noodles (Julianti, et al., 2019), biscuits (Aziz et al., 2018) and bread (Santiago et al., 2015). Biscuit is a dry bakery product made of flour, oils/fats, with or without addition of other food ingredients and food additives with baking process. In Indonesia, 13.4 % of the population consume biscuits at least 1 time per day (Health Research and Development Agency, Ministry of Health Republic of Indonesia, 2013). The increasing number of biscuits consumption also increase wheat imports in Indonesia. Although many studies on the evaluation and utilization of sweet potato flour in many food products but a little information about improving PFSP flour quality by giving pretreatment on PFSP chips before drying and then the flour were used to make biscuits. The aim of this research was to determine the physicochemical and sensory characteristics of biscuit from various ratio of pretreated PFSP flour and wheat flour.

2 MATERIALS AND METHODS

Sweet potato with deep purple color flesh from Phakphak Bharat Residence North Sumatera, was used in the making of PFSP flour. Sodium

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metabisulphite was also used as antibrowning agent in the purple sweet potato flour making. Other materials such as margarine, sugar, salt and baking powder for biscuit making was purchased in some markets in Medan. Chemical reagents used in this research was chemical reagents for biscuit chemical analysis.

2.1 Purple Sweet Potato Flour Production

Purple sweet potato flour was produced by sorting and cleaning purple sweet potato tubers. Sweet potato tubers were peeled and sliced into chips with 2 mm thickness using a slicer machine. The sweet potato chips were pretreated by soaking in a 2000 ppm sodium metabisulfite solution for 15 minutes and washed with running water until the sodium metabisulfite washed off. The pretreated sweet potato chips were dried using a drying oven at a temperature of 55 °C for 18 hours until the chips dry completely. The PFSP flour was obtained by milling the dried chips using a milling machine and then sifted using 80 mesh sieving to gain the fine purple sweet potato flour. Fine PFSP flour was sealed in polyethylene bags and stored in room temperature.

2.2 Biscuits Production

Biscuits dough was prepared by using the following formula: 100 g flour (contain different combination of sweet potato flour and wheat flour (Table 1), 30 g sugar, 50 g margarine, 1.5 g baking powder, and 0.5 g salt. Biscuits were produced by creaming and doughing method. Margarine and sugar were mixed into cream. Flour, baking powder and salt were mixed separately and added to the cream. The ingredients were mixed using a low speed mixer. Various proportion of water (Table 1) were added for making required dough consistency, and mixing was continued until the dough was smooth. The smooth dough was then flattened into sheet using a rolling pin with 2 mm thickness. The sheet was formed into a round shape with a diameter of 4 cm and then baked in 165 °C preheated oven for 15 minutes. After baking, the biscuits were cooled and stored in room temperature in an air tight container.

2.3 Analysis of Biscuits Quality

Resulting biscuits were analyzed for their physical characteristics such as color profile (L*, a*, b*, and hue ($\tan^{-1}$ b/a)) (Hutchings, 1999) by using a Minolta Chromameter CR-400 (Minolta Camera Co.,Ltd.,Tokyo, Japan), and browning index (Jimenez et al., 2001) by using the following equation:

$$\text{Browning Index} = [100\ (x-0.31)] / 0{,}172 \quad (1)$$

x was calculated by using following equation:

$$x = (a + 1.75L^*) / (5.645L^* + a^* - 3.01b^*) \quad (2)$$

Table 1: Combination of sweet potato flour and wheat flour and proportion of water added for biscuit preparation.

Treatment	PSP flour	Wheat flour	Water
P_1	100	0	45
P_2	90	10	35
P_3	80	20	30
P_4	70	30	30
P_5	60	40	25
P_6	50	50	20
P_7	40	60	15
P_8	30	70	15
P_9	20	80	10
P_{10}	10	90	10
P_{11}	0	100	5

Specific volume of biscuits was carried out by using displacement test (AACC, 2000) and spread factor was observed according to Toan and Anh (2018). Texture profile (hardness, adhesiveness, and % deformation) were carried out by using Brookfield CT-3 Texture Analyzer. Chemical characteristics such as anthocyanin content was analysed according to Giusti and Wrostad (2001), and crude fiber content was determined according to AOAC (2012).

Sensory evaluation of resulting biscuits was analyzed using 7 points hedonic test (1= extremely dislike, 2= dislike, 3= quite dislike, 4= neutral, 5= quite like, 6= like, 7= extremely like) by 70 panelists both genders without training. Biscuits were cracked into quarter and identified by a three digits random number. The sample was offered to the panelists on a white plate at room temperature and drinking water provided. Panelists were asked to evaluate the color, aroma, taste, texture, and overall acceptance of the biscuits.

3 RESULTS AND DISCUSSION

3.1 Effect of Purple Sweet Potato Flour and Wheat Flour Ratio on Physical Characteristics of Biscuits

The results showed that the ratio of purple sweet potato flour and wheat flour had highly significant effect on all biscuits physical characteristics. The results can be seen in Table 2, Table 3, and Table 4.

Table 2: Effect of purple sweet potato flour and wheat flour ratio on biscuits hue, L*, a* and b* value.

Treatment	hue (°)	L*	a*	b*
P_1	329.80 ±1.18^{f}	24.67 ±0.31^{f}	15.00 ±0.20^{bc}	-8.73 ±0.31^{a}
P_2	329.97 ±1.32 ^{f}	26.40 ±1.25^{f}	15.80 ±0.40^{ab}	-9.13 ±0.31^{a}
P_3	330.54 ±2.19 ^{f}	30.20 ±0.40^{e}	14.40 ±0.53^{cd}	-8.13 ±0.50^{b}
P_4	332.94 ±0.74^{e}	31.20±0. 92d^{e}	15.53 ±0.95^{ab}	-7.93 ±0.31^{b}
P_5	336.95 ±0.32^{d}	31.60 ±0.87^{de}	16.67 ±0.61^{a}	-7.07 ±0.31^{c}
P_6	342.81 ±0.95^{c}	32.13 ±0.31^{d}	15.80 ±0.60^{ab}	-4.87 ±0.23^{d}
P_7	342.90 ±0.72^{c}	34.73 ±2.32^{c}	15.87 ±0.76^{ab}	-4.87 ±0.12^{d}
P_8	348.99 ±0.61^{b}	38.87 ±0.76^{b}	16.13 ±0.46^{ab}	-3.07 ±0.23^{e}
P_9	353.06 ±0.01^{a}	40.53 ±0.58^{b}	16.00 ±1.04^{ab}	-1.93 ±0.12^{f}
P_{10}	354.54 ±0.64^{a}	50.67 ±0.83^{a}	13.40 ±0.69^{d}	-1.27 ±0.12^{g}
P_{11}	85.72 ±0.42	72.00 ±0.87	3.33 ±0.31	44.27 ±0.95

Values in the table are averages of 3 replications, ± standard deviation. Different letter notations in the same column show significantly different effect at 5% level.

The results showed that the ratio of purple sweet potato flour and wheat flour had highly significant effect on biscuits hardness, adhesiveness, and % deformation. As shown in Table 3, biscuit hardness, adhesiveness, and % deformation were increasing as the decreasing of purple sweet potato flour used and increasing of wheat flour used in biscuits making. Wheat flour contains a water-insoluble protein called gluten which consists of gliadin and glutenin components which produce viscoelastic properties and can affect the compactness of biscuits. Gliadin will cause gluten to be elastic while glutenin will cause the dough to be strong to hold the gas and determine the structure of the product (Shewry et al., 2002).

Table 3: Effect of purple sweet potato flour and wheat flour ratio on biscuits hardness, adhesiveness, and % deformation.

Treatment	Hardness (g)	Adhesiveness (gs)	Deformation (%)
P_1	582.25 ±68.23^{c}	-0.52±0.01^{c}	25.88±0.23^{e}
P_2	724.25 ±35.00^{c}	-0.42±0.04^{c}	25.91±1.28^{e}
P_3	1086.25 ±44.90^{b}	-0.39±0.01^{b}	27.69±1.14^{de}
P_4	1099.25 ±20.15^{b}	0.22±0.01^{b}	29.31±2.91^{ce}
P_5	1023.25 ±44.19^{b}	-0.18±0.01^{ab}	31.46±0.84^{bcd}
P_6	1144.50 ±101.82^{b}	-0.15±0.01^{ab}	32.42±1.92^{bc}
P_7	1155.50 ±133.64^{b}	-0.08±0.01^{ab}	32.82±3.03^{bc}
P_8	1170.50 ±118.09^{b}	-0.05±0.01^{ab}	33.52±2.93^{bc}
P_9	1189.50 ±42.43^{b}	-0.04±0.01^{ab}	33.85±0.73^{bc}
P_{10}	1451.00 ±10.61^{a}	-0.02±0.00^{a}	35.58±0.52^{b}
P_{11}	1520.50 ±55.86^{a}	0.01±0.01^{a}	45.03±2.45^{a}

Values in the table are averages of 3 replications, ± standard deviation. Different letter notations in the same column show significantly different effect at 5% level.

Table 4 shows that the highest specific volume was obtained by P_{11} biscuits with 0.376 and the lowest was obtained by P_1 biscuits with 0.284. The specific volume of biscuits were increasing with the increasing use of wheat flour in biscuits making. This is because wheat flour contains gluten which can cause the biscuits bind each other tighter and capture the gases so that the biscuits expanded and the volume increased (Shewry et al., 2002).

As shown in Table 4, the highest biscuit browning index was P_{11} biscuits with a value of 91,98 and the lowest biscuit browning index was P10 with a value of 20,54. Biscuits browning index were gradually decreased from P_1 to P_{10} and then went up to the highest in P_{11} biscuits.This shows that ohue and browning index of biscuits had and inverse correlation. Table 4 also shows that the spread factor of biscuits were decreasing with the increasing use of wheat flour in biscuits making. Biscuit dough with higher gluten protein will be more solid than biscuits with less gluten protein and will affect biscuits compactness so that the spread factor of biscuits were decreasing gradually from P_1 to P_{11} treatments. The decrease in spread factor with increasing protein content was also reported by Toan and Anh (2018).

Table 4: Effect of purple sweet potato flour and wheat flour ratio on biscuits specific volume, browning index, and spread factor.

Treatment	Specific volume (mL/g)	Browning index	Spread factor
P_1	0.284±0.011^{e}	84.29±2.61^{b}	12.69±0.09^{a}
P_2	0.286±0.022^{e}	82.44±3.34 ^{b}	12.69±0.07^{a}
P_3	0.3.18±0.006^{d}	63.66±1.93^{c}	12.39±0.40^{a}
P_4	0.339±0.022^{cd}	63.11±4.94^{c}	11.81±0.16^{b}
P_5	0.341±0.024^{bcd}	60.51±2.93^{c}	11.66±0.09^{b}
P_6	0.342±0.025^{bcd}	49.21±1.04^{d}	11.58±0.20^{b}
P_7	0.367±0.014^{abc}	46.02±4.32^{d}	10.77±0.39^{c}
P_8	0.371±0.015^{ab}	35.33±1.67^{e}	10.21±0.18^{d}
P_9	0.371±0.010^{ab}	31.25±1.75^{e}	9.82±0.25^{de}
P_{10}	0.375±0.009^{a}	20.54±1.01^{f}	9.68±0.22^{ef}
P_{11}	0.376±0.011^{a}	91.98±3.18^{a}	9.40±0.17^{f}

Values in the table are averages of 3 replications, ± standard deviation. Different letter notations in the same column show significantly different effect at 5% level.

3.2 Effect of Purple Sweet Potato Flour and Wheat Flour Ratio on Chemical Characteristics of Biscuits

The results showed that the ratio of purple sweet potato flour and wheat flour had highly significant effect on all biscuits chemical characteristics. The results can be seen in Table 5. Table 5 shows that the anthocyanin content of biscuits were decreasing gradually as the decreasing of purple sweet potato flour used in biscuits making. Purple sweet potato flour gives the biscuit a purple color due to the presence of a natural purple sweet potato pigment called anthocyanin (Zhang et al., 2009).

Table 5 also shows the biscuit's crude fiber content were decreasing as the decreasing of purple sweet potato flour used in biscuits making. The highest crude fiber content of biscuits was obtained by P_1 biscuits (made from 100% sweet potato flour) with a value of 4,64 % and the lowest crude fiber content was obtained by P_{11} biscuits (made from 100% wheat flour) with a value of 1,63 %. This was because the crude fiber content in wheat flour is lower than purple sweet potato flour crude fiber content so that the more purple sweet potato flour was used in biscuits making, the higher the crude fiber content was (Toan and Anh, 2018; Srivastava et al., 2012).

3.3 Effect of Purple Sweet Potato Flour and Wheat Flour Ratio on Sensory Characteristics of Biscuits

The effect of purple sweet potato flour and wheat flour ratio on biscuits color, aroma, taste, texture and overall acceptance hedonic value results can be seen in Table 6.

Table 5: Effect of purple sweet potato flour and wheat flour ratio on biscuits anthocyanin content and crude fiber content.

Treatment	Anthocyanin content (ppm)	Crude fiber content (%)
P_1	62.79±1.51^{a}	4.64±0.15^{a}
P_2	51.46±1.51^{b}	3.92±0.12^{b}
P_3	45.06±2.68^{c}	3.54±0.08^{c}
P_4	42.73±0.87^{c}	3.22±0.05^{d}
P_5	36.05±1.32^{d}	2.93±0.17^{e}
P_6	33.14±0.88^{e}	2.87±0.15^{e}
P_7	27.33±1.33^{f}	2.51±0.14^{f}
P_8	17.73±1.33^{g}	2.40±0.17^{f}
P_9	11.05±0.50^{h}	2.04±0.06^{g}
P_{10}	5.81±050^{i}	1.84±0.09^{gh}
P_{11}	-	1.63±0.14^{h}

Values in the table are averages of 3 replications, ± standard deviation. Different letter notations in the same column show significantly different effect at 5% level.

Table 6: Effect of purple sweet potato flour and wheat flour ratio on biscuits color, aroma, taste, texture and overall acceptance hedonic value**.**

Treatment	Color	Aroma	Taste	Texture	Overall acceptance
P_1	5.50± 0.16^{a}	5.00± 0.15^{b}	4.95± 0.06^{bc}	4.75± 0.12^{cd}	5.21± 0.17^{abc}
P_2	5.26± 0.39^{abc}	4.75± 0.45^{b}	4.55± 0.73^{c}	4.65± 0.56^{dC}	5.10± 0.56^{abc}
P_3	5.40± 0.04^{ab}	5.06± 0.18^{b}	4.82± 0.21^{bc}	4.75± 0.18^{cd}	5.18± 0.19^{abc}
P_4	5.27± 0.17a^{bc}	5.19± 0.10^{ab}	5.22± 0.19^{ab}	5.15± 0.13^{abc}	5.31± 0.18^{ab}
P_5	5.35± 0.15^{ab}	5.12± 0.17^{ab}	5.05± 0.15^{bc}	4.92± 0.27^{bcd}	5.37± 0.02^{ab}
P_6	4.83± 0.09^{cd}	4.77± 0.36^{b}	4.83± 0.47^{bc}	5.14± 0.28^{abc}	5.00± 0.25^{bc}
P_7	4.95± 0.20^{bcd}	5.11± 0.16^{ab}	5.09± 0.16^{bc}	4.94± 0.10^{bcd}	5.08± 0.07^{abc}
P_8	4.65± 0.16^{d}	4.90± 0.04^{b}	5.15± 0.09^{ab}	5.20± 0.25^{abc}	5.03± 0.18^{bc}
P_9	4.58± 0.07^{d}	5.14± 0.14^{ab}	5.35± 0.32^{ab}	5.30± 0.18^{ab}	5.10± 0.10^{abc}
P_{10}	4.07± 0.59^{e}	4.90± 0.22^{b}	5.28± 0.18^{ab}	5.32± 0.10^{ab}	4.80± 0.31^{c}
P_{11}	5.45± 0.13^{a}	5.48± 0.20^{a}	5.72± 0.09^{a}	5.59± 0.09^{a}	5.55± 0.14^{a}

Values in the table are averages of 3 replications, ± standard deviation. Different letter notations in the same column show significantly different effect at 5% level.

Table 6 shows that the panelists quite like the color, aroma, taste, texture and overall acceptance of the biscuits. The results showed that the ratio of purple sweet potato flour and wheat flour had highly significant effect on biscuits color and texture hedonic value. The results also showed that the ratio of purple sweet potato flour and wheat flour had

significant effect on biscuits aroma and taste hedonic value, but had no significant effect on biscuits overall acceptance.

4 CONCLUSIONS

This research concluded that the substitution of wheat flour with purple sweet potato flour produce a more attractive color of biscuits, and also have better health benefits due to the presence of anthocyanin components and higher fiber content. The best physicochemical and sensory characteristics of biscuits from purple sweet potato flour and wheat flour was produced with the ratio of purple sweet potato flour and wheat flour of 70:30.

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