Physicochemical and Sensory Characteristics of Bread from Flour, Starch, Fiber, and Anthocyanin of Purple Sweet Potato

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Abstract: Purple fleshed sweet potato (PFSP) is a plant with many health benefits such as anthocyanin content with high antioxidant activity, fiber, starch, and mineral. The focus of this study was to evaluate the effect of ratio of PFSP flour and starch, fiber (solid waste of PFSP starch processing), and anthocyanin pigment (liquid waste of PFSP starch processing) on the physicochemical and sensory characteristics of bread. Ratio of flour : starch : fiber : anthocyanin pigment used in making breads were 73:25:0:2; 73:20:5:2; 73:15:10:2; 73:10:15:2; 73:5:20:2; and 73:0:25:2. The results showed that flour, starch, fiber, and anthocyanin pigments enhanced the color and nutritional value when incorporated into the bread formulation. Bread with the best quality and more accepted by consumers was the bread made from a ratio of 73 g of purple sweet potato flour, 25 g fiber and 2 g anthocyanin pigment. Based on these results, flour, fiber, and anthocyanin pigments can be used as natural colorant and functional food ingredients.

1 INTRODUCTION

Sweet potato (*Ipomoea batatas* L) is one of the most important tubers in the world with a production of 133 million tons and is included in seven important plants as a source of carbohydrates (CIP). In North Sumatra, sweet potato production in 2016 was 91.531,4 tons, and in 2017 there was an increase to 92.380,3 tons (Statistics of Sumatera Utara, 2017). In addition to carbohydrates as its main ingredient, sweet potatoes contain vitamins, minerals, antioxidants (β-carotene and anthocyanin) and fiber (pectin, cellulose, hemicellulose) (ILSI, 2008) (Zhang, et al., 2009). The purple fleshed sweet potato (PFSP) has a high anthocyanin content which shows an intense purple color (Van Hall, 2000) and provide some biological functions such as antioxidant activity, anticarcinogenic activity and antihypertensive effects (Oki, et al., 2002) (Yang, and Gadi, 2008).

Sweet potato is very potential to be used as a material for making flour, starch and functional food (Phomkaivon, et. al., 2018) (Jangchud, et al., 2003). Application of flour and starch of sweet potato have been widely studied in making various food products such as puffed-starch based snacks (Phomkaivon, et al., 2018), cakes (Hutasoit, et al., 2018) (Chuango, et al., 2019) (Azzahra, et al., 2019), noodle (Julianti, et al., 2019), biscuits (Aziz, et al., 2018), cookies (Ulfa, et al., 2019), and breads (Santiago, et al., 2015) (Hathorn, et al., 2008).

In the PFSP starch processing, the fiber and anthocyanin pigments were discharged as waste. Therefore, the integrated processing of PFSP starch was being necessary to produce starch, utilization its solid waste as a source of fiber and its liquid waste as a source of anthocyanin pigment. Starch, fiber, fiber and anthocyanic pigments produced can be used in making bread.

Usually, breads are made from wheat flour. The use of whole sweet potato flour or starch in making bread is limited because the lack of gliadin and glutenin proteins that resulted in inferior bread making quality (Hathorn, et al., 2008). In this study, bread was made by using the composite flour from PFSP flour, starch, solid waste of PFSP starch processing that then was processed into fiber rich flour, and liquid waste of PFSP starch processing as a coloring agent. The purpose of this study was to determine the effect of comparison of flour, starch, solid and liquid waste from processing purple sweet potato on the physicochemical and sensory characteristics of sweet bread.

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2 MATERIALS AND METHODS

Material used in this study is purple sweet potato with optimal level of maturity that have deep purple color from sweet potato farmer in Phak-Phak Barat Regency, North Sumatera. Sodium metabisulphite was used as pretreatment agent for making purple sweet potato flour, starch, solid and liquid waste. Other materials that used for bread making are sugar, shortening, margarine, bread improver, yeast, egg, liquid full cream milk, and xanthan gum. Chemicals that used to analyzed sweet bread product are ethanol, methanol, sulphite acid, distilled water, sodium hydroxide, hydrochloride acid, potassium chloride acid, acetic acid buffer pH 4.5, trichloro acetic acid.

2.1 Preparation of Purple Sweet Potato Flour

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 Preparation of Purple Sweet Potato Starch and Fiber

The extraction process was carried out by cleaning purple sweet potatoes and then peeling and shredding with a mechanic grater then sodium metabisulfite 2000 ppm using 1: 3 (w / v) was added. Then squeezed and filtered, pulp consisting of sweet potato solid waste which is rich in fiber were dried in an oven at 60 ºC, and then dry solid waste were smoothed with a hammer mill, filtered with a size of 60 mesh mechanical sieve so will obtained fiber rich solid waste of sweet potato. The filtrate was collected and allowed to stand undisturbed for 3 hours, so the liquid (supernatant) and starch were obtained. The starch was washed until the water is clear. The starch was dried in an oven at 50 ºC for 12 hours. This dried starch was milled again with a blender and filtered with a size of 80 mesh sieve. Then, the supernatant is filtered and concentrated using a waterbath at 50ºC until the volume becomes half of the initial volume, and the resulted product was anthocyanin rich liquid waste of sweet potato.

2.3 Preparation of Sweet Bread

The sweet potato bread was made by mixing flour, starch, solid waste and liquid waste from the processing of purple sweet potato mixed according to treatment. Other ingredients were prepared and weighed according to the formula in Table 1. Dry ingredients as flour, instant yeast, sugar, salt, xanthan gum, and bread improver were stirred using a low speed mixer until homogeneous, then added eggs and liquid full cream milk little by little and stirred with a mixer to form a mixture. Shortening is added while still stirring until a smooth dough is formed. Next the dough is weighed. After that, divided by a weight of 50 g each and formed a circle. Then the mixture is put into a baking sheet that has been smeared with margarine. Then let it rest for 30 minutes. The bread dough with its baking sheet is put in an oven at 165 °C for 25 minutes, and cooled to room temperature for 30 minutes, after which it is packaged with polyethylene plastic before analysis.

2.4 Analysis of Sweet Bread Quality

Resulting biscuits were analyzed for their physical characteristics such as color profile (L*, a*, b*, and ohue ($\tan^{-1}$ 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 :

$$\text{Browning Index} = [100\ (x-0{,}31)] / 0{,}172 \quad (1)$$

where x was calculated by using following equation:

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

Specific volume by using displacement test (AACC, 2000) and chemical characteristics such as anthocyanin content (Giusti and Wrostad, 2001) and crude fiber content (AOAC, 2012).

Sensory evaluation of resulting biscuits were 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 was asked to evaluate the color, aroma, taste, texture, and overall acceptance of the sweet breads.

Table 1: Sweet bread making formula.

Ingredients	Treatment							
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
PSP flour (g)	100	73	73	73	73	73	73	0
PSP starch (g)	0	25	20	15	10	5	0	0
PSP solid waste (g)	0	0	5	10	15	20	25	0
PSP liquid waste (g)	0	2	2	2	2	2	2	0
Wheat flour (g)	0	0	0	0	0	0	0	100
Sugar (g)	30	30	30	30	30	30	30	30
Instant yeast (g)	2	2	2	2	2	2	2	2
Shortening (g)	10	10	10	10	10	10	10	10
Liquid full cream milk (g)	60	60	60	60	60	60	60	60
Salt (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Bread improver (g)	5	5	5	5	5	5	5	5
Egg (g)	30	30	30	30	30	30	30	30
Xanthan Gum (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0

3 RESULTS AND DISCUSSION

3.1 Effect of Purple Sweet Potato Flour, Starch, Solid and Liquid Waste Ratio on Physical Properties of PFSP Bread

The results showed that ratio between PFSP flour, starch, solid and liquid waste affected the physical properties of bread as shown in Table 2 and Table 3.

Table 2 shows that there were significant differences in the L*, a*, b* values but there was no significant difference in the ^{o}hue value among the sample. Tabel 2 shows that P_1 bread had a lowest L* and b* value (22.67 and -0.63) and highest a* value (8.98). This is caused of P_1 bread was made from 100% PFSP flour. The higher L* value caused a brighter color of bread, while the lower L* value will produce a darker color of bread (Hutchings, 1999).

Table 3 shows that bread made from 100% wheat flour had the higher browning index than those in PFSP bread. P_1 bread has the highest value of browning index (29.32 g/mL) and P_2 has the lowest value of browning index (21.79) among the PFSP bread. Browning index of breads were determined by protein content and reducing sugars, the higher protein and reducing sugars content will promote the Maillard reaction and resulting in the increasing of browning index of bread (Goesaert, et al., 2009).

Table 2: Effect of blending ratio of flour, starch, solid and liquid waste on the color value of the PFSP breads.

Treatment	L*	a*	b*	^{o}*hue*
P_1	22.67±0.33^{cd}	8.89±0.38^{a}	-0.63±0.02^{a}	355.92±0.13
P_2	25.67±0.58^{a}	7.33±0.58^{d}	-0.53±0.03^{c}	355.82±0.45
P_3	24.78±0.51^{a}	7.44±0.19^{d}	-0.54±0.01^{c}	355.88±0.14
P_4	24.78±0.51^{ab}	7.56±0.19^{bc}	-0.55±0.01^{c}	355.85±0.03
P_5	24.22±0.38^{b}	7.89±0.38^{bc}	-0.58±0.02^{b}	355.82±0.30
P_6	23.67±1.00^{bc}	7.89±0.38^{bc}	-0.61±0.02^{a}	355.54±0.34
P_7	22.44±0.69^{d}	8.22±0.51^{ab}	-0.62±0.01^{a}	355.65±0.29
P_8	66.2±0.84	7.00±0.58	19.02±0.19	69.79±1.67

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 3: Effect of blending ratio of flour, starch, solid and liquid waste on the browning index and specific volume of the PFSP breads.

Treatment	Specific Volume (g/mL)	Browning Index
P_1	2.00±0.12^{cd}	24.94±2.03^{a}
P_2	2.60 ±0.10^{b}	2209±0.21^{d}
P_3	2.56±0.17^{b}	23.14±1.27^{d}
P_4	2.24±0.14^{c}	26.58±1.16^{cd}
P_5	2.17±0.14^{c}	25.50±1.16^{bc}
P_6	2.13±0.15^{c}	25.37±1.36^{b}
P_7	1.86 ±0.15^{d}	25.78±1.06^{a}
P_8	3.78±0.25^{a}	41.07±1.75

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 3 shows that P_8 bread has highest value of specific volume that was 3.78(g/mL). The presence of gluten affects the power of development, and the specific volume of bread. Gluten functions to form a skeleton of bread because of its ability to expand and hold the gas produced during fermentation (Shewry, et al., 2002).

3.2 Effect of Purple Sweet Potato Flour, Starch, Solid, and Liquid Waste Ratio on Chemical Properties of Sweet Bread

Table 4 shows that there were as significant differences in anthocyanin content and crude fiber content among the PFSP bread samples. Table 4 shows that P_7 sweet bread had the highest crude fiber content of 4.20%, while the lowest crude fiber content was found in whole wheat (P_8) bread which is 2.59%. The more addition of solid waste from PFSP starch

processing, it will increase the crude fiber content of breads. Wheat flour had a lower crude fiber content than sweet potatoes, so that the fiber content of bread made from wheat flour is also lower than those in PFSP breads. This result is in agreement with the report of (Oluwalana, et al., 2012) who found that bread made from composite with more sweet potato flour had a higher fiber content than bread with more wheat flour.

Table 4: Effect of blending ratio of flour, starch, solid and liquid waste on the anthocyanin and crude fiber of the PFSP breads.

Perlakuan	Anthocyanin (ppm)	Crude Fiber (%)
P_1	55.54 ± 4.44^{a}	4.15 ± 0.10^{a}
P_2	39.30 ± 3.87^{b}	2.71 ± 0.16^{e}
P_3	39.44 ± 3.20^{b}	3.01 ± 002^{d}
P_4	39.50 ± 2.97^{b}	3.28 ± 0.12^{c}
P_5	39.93 ± 0.88^{b}	3.42 ± 0.20^{bc}
P_6	41.99 ± 1.40^{b}	3.57 ± 0.13^{b}
P_7	42.26 ± 3.00^{b}	4.20 ± 0.20^{a}
P_8	-	2.59 ± 0.08^{e}

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. P_8 sweet bread anthocyanin content was not analyzed because P_8 was considered to have no anthocyanin content.

Table 4 shows that the anthocyanin content of bread made from 100% PFSP flour (P_1) is higher than other breads. Higher starch composition in bread formulation will reduce anthocyanin contents. Bread with higher levels of solid waste of PFSP starch processing (P_7) had a higher anthocyanin content. PFSP had a natural pigmen called anthocyanin that give a purple color in products (Zhang, et al., 2009).

3.3 Effect of Purple Sweet Potato Flour, Starch, Solid and Liquid Waste Ratio on Sensory Properties of Sweet Bread

Table 5 shows that in general panelist acceptance of the color, aroma, taste, texture and overall acceptance of bread made from purple sweet potato is lower than bread made from wheat flour (P_8). Among breads made from composite flour of PFSP flour and starch, and waste products from the processing of PFSP starch, bread made from 100% PFSP flour (P_1) is preferred by consumers in terms of color, texture and general acceptance. But statistically, there is no significant difference between P_1 and P_7 bread in terms of consumer acceptance for aroma, texture, taste and overall acceptance. The lower organoleptic value of PFSP bread than that of wheat flour bread can be caused of unpleasant odor a bitter after taste in PFSP breads that affects the panelist assessment of the organoleptic value. Sweet potatoes contain polyphenol compounds that can cause an unpleasant odor and a bitter taste (Yang and Gadi, 2008).

Table 5: Effect of blending ratio of flour, starch, solid and liquid waste on the anthocyanin and crude fiber of the PFSP breads.

Treatment	Color	Aroma	Taste	Texture	Overall Acceptance
P_1	5.32 ± 0.06^{b}	4.76 ± 0.1^{b}	4.67 ± 0.08^{c}	4.82 ± 0.6^{b}	4.83 ± 0.07^{b}
P_2	5.07 ± 0.07^{de}	4.80 ± 0.0^{b}	4.85 ± 0.02^{b}	4.60 ± 0.0^{bc}	4.70 ± 0.08^{bc}
P_3	5.04 ± 0.04^{e}	4.84 ± 0.1^{b}	4.84 ± 0.16^{b}	4.49 ± 0.0^{bc}	4.88 ± 0.03^{b}
P_4	5.17 ± 0.04^{cd}	4.83 ± 0.2^{b}	4.82 ± 0.12^{bc}	4.46 ± 0.0^{bc}	4.74 ± 0.15^{bc}
P_5	5.22 ± 0.07^{bc}	4.80 ± 0.0^{b}	4.78 ± 0.05^{bc}	4.55 ± 0.0^{bc}	4.77 ± 0.17^{bc}
P_6	5.29 ± 0.08^{b}	4.63 ± 0.1^{b}	4.73 ± 0.05^{bc}	4.37 ± 0.1^{c}	4.58 ± 0.24^{c}
P_7	5.31 ± 0.08^{b}	4.85 ± 0.0^{b}	4.70 ± 0.02^{bc}	4.63 ± 0.0^{bc}	4.78 ± 0.06^{bc}
P_8	5.51 ± 0.05^{a}	5.50 ± 0.1^{a}	5.20 ± 0.02^{a}	5.42 ± 0.0^{a}	5.40 ± 0.08^{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.

4 CONCLUSIONS

This study results have demonstrated the potential utilization of purple sweet potato flour and starch, solid and liquid waste of purple sweet potato starch processing as composite flour in bread making. Physical properties of bread made from 100% wheat flour was better than those in bread from sweet potato composite flour, but certain chemical properties of bread from composite flour such as anthocyanin and fiber content were found higher than that of bread from wheat flour. Although bread from whole wheat flour is more liked by consumers, but in general bread made from 100% of PFSP flour and bread made from 73% PFSP flour, 25% solid waste and 2% liquid waste of PFSP starch processing is still accepted by consumers. The PFSP bread had a lower specific volume, so treatment is needed to increase its the specific volume。

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