Utilization of purple sweet potato flour, starch, and fibre in biscuits making

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Abstract. Purple-fleshed sweet potato is one type of sweet potatoes that is in great demand as it has an attractive color, high starch, and fiber content, and excellent source of strong antioxidants, provide health beneficial effects. In this study, purple-fleshed sweet potato was processed into flour, starch, and fiber, and they were used as ingredients for making biscuits, with ratio of 100:0; 75:25:0; 75:20:5; 75:15:10; 75:10:15; 75:5:20; 75:0:25. The resulting biscuits were analyzed for their physicochemical properties and sensory evaluation were carried out to determine their acceptability by consumers. The results showed the ratio of flour, starch and fiber significantly affected the physicochemical characteristics of biscuits produced. Biscuits made from 75% flour, and 25% fiber of purple-fleshed sweet potato had good nutritional value, beneficial for health, and can also be accepted by consumers.

Keywords: Purple Sweet Potato, Biscuits, Starch, Flour, Fiber

1. Introduction

One of the potential commodity that can increase food security in Indonesia is sweet potato (Ipomoea batatas L.). The benefits are the affordable price, contain lots of energy and can be planted on infertile soil conditions, dry and high temperatures [1]. In North Sumatera, the production of sweet potato in 2015 was 122,362 tons than decreased 30,830.6 to 91,531.4 ton in 2016. The decrease of sweet potato production caused by the decrease in harvest area by 2,573.4 hectares. However, in 2017 the production of sweet potato increased by 849.9 tons to 92,380.3 tons. The increasing production of sweet potato caused by the increase in harvest effectiveness even though there was a decrease in harvest area [2].

To extend the shelf life of purple sweet potato, it can be processed into many products such as flour, starch, and fiber. Purple sweet potato flour made by slicing the sweet potato into chips, drying and milling it. During the process of starch production, it will conduce solid waste in the form of pulp. This pulp contains lots of nutrients, especially dietary fiber. Therefore, it can be used as wheat flour substitution and fortification dietary fiber on various bakery products [3]. Flour and starch of sweet potato have been used to diversify food products by processing it into cookies [4], cake [5–7], noodles [8], biscuit [9], and bread [10].
Biscuit is a bakery product made from flour, oil, sugar, and another food additive that permitted. Biscuit has a small and flat form. The process of biscuit making is mixing, cutting, and baking [11]. Biscuit flour is commonly made from wheat. Wheat flour obtained from wheat seed that must be imported because wheat can only flourish in the subtropical area, while Indonesia is a tropical climate [12].

Purple sweet potato flour has anthocyanin pigment which is one of the antioxidants that good for health. The addition of purple sweet potato starch was aimed to enhance carbohydrate content in the biscuit, while the addition of purple sweet potato fiber was aimed to enhance dietary fiber content in biscuit. Therefore, to reduce the wheat import, diversification biscuit making from other substitutions like flour, starch, and fiber from local resources like purple sweet potato is needed. Thus, the aim of this study was to determine the appropriate substitution level of selected purple sweet potato flour, starch, and fiber in biscuit making.

2. Materials and methods
The material used in this study is purple sweet potato with an optimal level of maturity that has a deep purple color. Sodium metabisulphite was used as a pretreatment agent for making purple sweet potato flour and starch. Other materials used for biscuit making are shortening, margarine, sugar, salt, and baking powder. Chemicals that used to analyzed biscuit product characteristics are ethanol, sulphite acid, distilled water, potassium sulphite, sodium hydroxide, chloride acid, potassium chloride, term amyl enzyme and boric acid.

2.1. Preparation of purple sweet potato flour
Purple sweet potato flour was produced by sorted purple sweet potato to get the uniform size, shape and color of tubers. Sweet potato tubers were peeled and sliced immediately with a thickness of 2 mm using a slicer machine to obtain sweet potato chips. The sweet potato chips were immersed in a 2000 ppm sodium metabisulphite solution for 15 minutes then drained, washed with running water. The sweet potato chips that have been treated were dried using a drying oven at a temperature of 55 °C for 12 hours until the chips become dry which is indicated by the sound of rustling when the chips are broken by hand. The dried chips were pressed using a disc mill and sifted using a mechanical sieve with a size of 80 mesh sieve. The resulting sweet potato flour was packaged in polyethylene plastic packaging before use.

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 metabisulphite 2000 ppm using 1:3 (w/v) was added. Then squeezed and filtered, pulp consisting of sweet potato fibers were dried in an oven at 60 °C, for 16 hours and then dry fibers were smoothed with a hammer mill, filtered with a size of 60 mesh mechanical sieve so that it can produce sweet potato fibers. 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 °C for 12 hours. This dried starch was milled again with a blender and filtered with a size of 80 mesh sieve.

2.3. Preparation of biscuit
The biscuit was made by mixing flour, starch, and sweet potato fiber according to the treatment. Other ingredients were prepared and weighed accurately as the formula in table 1. Dry ingredients such as flour, baking powder, and salt were stirred using a stirring spoon until homogeneous. Shortening and sugar were stirred to form a cream using a mixer. The dry ingredients mixture was put into the cream mixture and stirred with a medium speed mixer until a smooth mixture was formed. The dough was then formed into sheets using a rolling pin with a thickness of 3 mm, and shaped in a circle shape with a diameter of 4 cm, placed on a baking sheet that smeared with margarine, baked in a preheated oven until
the temperature was 165 °C for 20 minutes. After roasting, the biscuits were cooled to room temperature for 30 minutes, then put in an airtight jar.

2.4. Analysis of biscuit quality

Resulting biscuits were analyzed for their color and browning index by using a Minolta Chromameter CR-400 (Minolta Camera Co., Ltd., Tokyo, Japan). The specific volume of biscuits was measured using seed replacement test according to the approved method by AACC [13]. The spread factor of biscuit was measured according to the approved method by Toan and Thanh [14]. The texture of the biscuit was analyzed by using a Brookfield CT-3 Texture Analyzer, a parameter that was analyzed was adhesiveness, hardness and % deformation. Anthocyanin content of biscuit was measured according to the approved method by Giusti and Wrostad [15]. The crude fiber content of biscuit was measured according to the approved method by AOAC [16]. The sensory analysis was using hedonic scale on 7 points (1=dislike extremely, 2=dislike, 3=rather dislike, 4=neither like nor dislike, 5=rather like, 6=like, 7=like extremely) by 70 not trained panelists both genders. 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.

2.5. Statistical analysis

The data using completely randomized design was analyzed by analysis of variance method that is run by using software IBM SPSS statistics 22. The data reported in all tables are an average of triplicate observations. Least significant range (LSR) was used to compare differences among the mean value of confidence level of 0.05.

Table 1. Ingredient and blending ratio from purple sweet potato (PSP) flour, starch and fiber formulation.

| Ingredient         | Treatment |
|--------------------|-----------|
|                    | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
| PSP flour (g)      | 100| 75 | 75 | 75 | 75 | 75 | 75 | 0  |
| PSP starch (g)     | 0  | 25 | 20 | 15 | 10 | 5  | 0  | 0  |
| PSP fiber (g)      | 0  | 0  | 5  | 10 | 15 | 20 | 25 | 0  |
| Wheat flour (g)    | 0  | 0  | 0  | 0  | 0  | 0  | 100| 0  |
| Sugar (g)          | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Baking powder (g)  | 1.5| 1.5| 1.5| 1.5| 1.5| 1.5| 1.5| 1.5|
| Shortening (g)     | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Salt (g)           | 0.5| 0.5| 0.5| 0.5| 0.5| 0.5| 0.5| 0.5|
| Water (ml)         | 40 | 30 | 30 | 40 | 50 | 50 | 50 | 0  |

3. Results and discussion

3.1. Effect of purple sweet potato flour, starch and fiber ratio on physical properties of biscuit

The results showed that the ratio between purple sweet potato flour, starch and fiber had an effect on physical properties of biscuit. The results can be seen in table 2, table 3, and table 4.
Table 2 shows that there was a significant difference in the $\theta$ Hue, $a^*$ value and $b^*$ value, but there is no significant difference in the $L^*$ value among the sample. Table 2 shows the ratio of flour, starch and purple sweet potato fiber has no significant effect on the value of $a$ on biscuits $P_2$, $P_3$, $P_4$, $P_5$ and $P_6$. Table 2 shows that $P_1$ biscuit has a larger $a^*$ value that is 12.57 compared to the value of $a^*$ of $P_1$ biscuit (11.19). This is because the anthocyanin content of $P_1$ biscuits is greater than that of $P_2$ biscuits. The highest b value is $P_7$ biscuit. This is due to biscuits made from a mixture of 75% purple sweet potato flour and 25% purple sweet potato fiber. Purple sweet potato fiber has a paler color compared to purple sweet potato flour, so the value of $P_7$ biscuit $b^*$ value is higher.

Table 2 shows that biscuit $P_5$ has the highest score of 70.10 and $P_1$ (100% purple sweet potato flour) has the lowest value of $\theta$ Hue which is 1.81. The high value of the $P_5$ biscuit is due to the biscuit was made from 100% flour which produces yellow-red biscuits whose value is between 54$^\circ$ - 90$^\circ$. $P_1$ - $P_7$ biscuits have a red-purple biscuit color because the value is between 342$^\circ$ - 18$^\circ$. The value that is getting closer to 18$^\circ$, the color of the biscuits are getting reddish. Whereas the value of the $\theta$ Hue is getting closer to 342$^\circ$, the color of the biscuits is getting purplish. The red-colored biscuit was due to the material that used is purple sweet potato flour which has a purplish red color, indicating the presence of anthocyanin in the material [17].

Table 3 shows that there was a significant difference in the browning index, spread factor and specific volume among the sample. The ratio of flour, starch and purple sweet potato fiber has no significant
effect on the value of the browning index on biscuits P_2, P_3, P_4, P_5 and P_6. Table 3 shows that P_1 biscuit has a larger browning index value that is 31.33 compared to the browning index value of P_7 biscuit which is 31.22. The more fiber addition, the higher the biscuit browning index value. In the processing of purple sweet potato fiber, the temperature that used to dry fiber is higher than the drying of purple sweet potato flour and purple sweet potato starch, thus further accelerating the browning reaction [18]. Table 3 shows that P_7 biscuit has the highest spread factor value that is 12.86 and the biscuits which have the lowest value is P_5 biscuit which is 9.98. This is because spread factors are strongly influenced by the characteristics of the raw materials used in making biscuits, and related to their thickness. The lower protein content in sweet potato flour, starch and fiber will decrease the spread factor of biscuits [19]. The protein content of flour will affect the formation of the gluten web, increase the viscosity and the dough flow will stop, and therefore the biscuits made from wheat flour have a lower spread factor [20].

Table 3 shows the ratio of flour, starch and purple sweet potato fiber has no significant effect on the specific volume on biscuits P_1 until P_7. Table 3 shows that P_8 biscuit has the largest specific volume that is 2.4. This is because the P_8 biscuit is made from 100% wheat flour, wheat flour has gluten in it so that it can cause bakery products to form a net framework that binds to each other and captures gas from fermentation so that the product expands and volume increases. Biscuits with the lowest specific volume value are P_1 biscuit (100% purple sweet potato flour) and P_2 (75% purple sweet potato flour:25% purple sweet potato starch) which is 1.47. This is because there is no addition of wheat flour so there is no gluten in it and causes the product not to expand [21]. This is also caused by the presence of fibre in sweet potato flour and fiber which might interfere with the matrix structure and decrease the capacity of gas retention in dough [22].

Table 4. Effect of blending ratio of purple sweet potato flour, starch and fiber on the texture of the biscuits.

| Treatment | % deformation (%) | Hardness (g) | Adhesiveness (gs) |
|-----------|-------------------|--------------|-------------------|
| P_1*      | 25.84±1.52^d      | 703.25±10.25^c | 0.07±0.04^a       |
| P_2       | 25.85±1.21^d      | 549±16.26^c   | 0.13±0.01^a       |
| P_3       | 26.29±0.95^cd     | 690±18.38^c   | 0.41±0.04^b       |
| P_4       | 28.96±2.67^bcd    | 1065.75±39.24^b| 1.24±0.04^d       |
| P_5       | 29.66±1.8^abcd    | 1444±74.95^a  | 2.54±0.03^c       |
| P_6       | 31.82±0.51^ab     | 1535.75±224.51^a| 0.14±0.01^a       |
| P_7       | 32.75±2.92^a      | 1572.25±20.15^a| 1.00±0.15^e       |
| P_8**     | 24.17±0.67        | 583.75±7.42   | 0.33±0.16         |

*) P_1(*) = 100% purple sweet potato flour (control1), P_2 = 75:25:0, P_3 = 75:20:5, P_4 = 75:15:10, P_5 = 75:10:15, P_6 = 75:5:20, P_7 = 75:0:25, P_8(**) = 100% wheat flour (control2). The values are expressed as the mean of three replications ±standard deviations. Means followed by different letter in the same column are significantly different 5% using LSR test.

Table 4 shows that there was a significant difference in % deformation, hardness and adhesiveness among the sample. Table 4 shows that the % deformation biscuits which have the highest value is P_7 biscuit (75% purple sweet potato flour:25% purple sweet potato fiber) which is 32.75%. This is because P_7 biscuits have the hardest texture compared to other biscuits. Table 4 shows that P_7 biscuits (75% purple sweet potato flour:25% purple sweet potato fiber) have the highest value of hardness that is 1572.25 g. Specific volume was the best index of biscuits texture, since the lower specific volume means higher textural value [23].

Table 4 shows that the highest adhesiveness value is on P_3 biscuits, which is 2.53 gs and the lowest is P_1 biscuits which is 0.07 gs. This is because the addition of starch on P_3 biscuits starts to decrease so that the lower amylose content causes the gel structure to form weakened and the dissolved solids increase, the higher the stickiness formed [24].
3.2. Effect of purple sweet potato flour, starch and fiber ratio on Chemical properties of biscuit

Table 5 shows that there was a significant difference in anthocyanin content and crude fiber content among the sample. Table 5 shows the ratio of flour, starch and purple sweet potato fiber which has no significant effect on anthocyanin content on biscuits P1 to P7. Table 5 shows that P1 biscuit (100% purple sweet potato flour) has the highest anthocyanin content that is 30.33 ppm. This is because purple sweet potato flour has higher levels of anthocyanin compared to purple sweet potato fiber. The more addition of purple sweet potato fiber, the higher the level of anthocyanin. However, the more addition of starch, the less anthocyanin levels [18].

Table 5 shows the ratio of flour, starch and purple sweet potato fiber which has no significant effect on crude fiber content on biscuits P1, P2, P3, P4, P5, P6 and P7. Table 5 shows that the biscuits P1 (100% purple sweet potato flour) have the highest crude fiber content that is 3.37% then the crude fiber content continues to drop sequentially from biscuits P1 to P2. This decrease in crude fiber content was due to a decrease in the amount of purple sweet potato fiber and increased purple sweet potato starch from P7 to P2. Where purple sweet potato flour has a higher crude fiber content compared to purple sweet potato starch [19].

| Treatment | Anthocyanin content (ppm) | Crude fiber content (%) |
|-----------|---------------------------|------------------------|
| P1*       | 30.33±1.79^a             | 3.37±0.21^a            |
| P2        | 23.45±2.09^b             | 2.39±0.21^b            |
| P3        | 23.85±2.16^b             | 3.05±0.21^a            |
| P4        | 24.13±1.22^b             | 3.12±0.28^b            |
| P5        | 24.40±1.34^b             | 3.18±0.01^a            |
| P6        | 23.69±2.07^b             | 3.21±0.22^a            |
| P7        | 24.82±1.33^a             | 3.27±0.17^a            |
| P8**      | -                        | 2.24±0.23^b            |

*) P1 (control1) = 100% purple sweet potato flour, P2 = 75:25:0, P3 = 75:20:5, P4 = 75:15:10, P5 = 75:10:15, P6 = 75:5:20, P7 = 75:0:25, P8 (control2) = 100% wheat flour. The values are expressed as the mean of three replications ±standard deviations. Means followed by different letter in the same column are significantly different 5% using LSR test.

3.3. Effect of purple sweet potato flour, starch and fiber ratio on Sensory properties of biscuits

Table 6 shows that the ratio of purple sweet potato flour, purple sweet potato starch and purple sweet potato fiber had no significant effect (p>0.05) on all organoleptic biscuit parameters. In general, the value of consumers' acceptance on sweet potato biscuits in the rather like range.

| Treatment | Color     | Aroma     | Taste    | Texture   | General acceptance |
|-----------|-----------|-----------|----------|-----------|--------------------|
| P1        | 5.23±0.28 | 5.03±0.29 | 4.71±0.35| 5.20±0.33 | 4.97±0.29          |
| P2        | 4.68±0.29 | 4.73±0.13 | 4.58±0.17| 5.06±0.2  | 4.77±0.06          |
| P3        | 4.89±0.08 | 4.95±0.2  | 4.50±0.3 | 4.92±0.22 | 4.75±0.14          |
| P4        | 4.89±0.21 | 4.72±0.44 | 4.67±0.72| 5.12±0.34 | 4.82±0.47          |
| P5        | 5.01±0.63 | 4.79±0.13 | 4.82±0.24| 5.16±0.15 | 4.93±0.23          |
| P6        | 5.13±0.31 | 5.04±0.32 | 4.77±0.29| 5.16±0.35 | 4.94±0.31          |
| P7        | 5.17±0.4  | 5.01±0.12 | 4.82±0.2 | 5.14±0.15 | 5.04±0.17          |
| P8        | 4.89±0.09 | 4.88±0.06 | 5.27±0.32| 5.05±0.3  | 5.21±0.17          |

*) P1 (control1) = 100% purple sweet potato flour, P2 = 75:25:0, P3 = 75:20:5, P4 = 75:15:10, P5 = 75:10:15, P6 = 75:5:20, P7 = 75:0:25, P8 (control2) = 100% wheat flour. The values are expressed as the mean of three replications ±standard deviations.
4. Conclusion

In this research, the ratio of sweet potato flour, starch, and fiber in biscuits making gave a significantly different effect on the physicochemical properties of biscuits. Biscuits produced from 75% flour and 25% fiber of sweet potato flour had a good physical and chemical quality and can be accepted by consumers. Biscuits from flour and fibers of purple sweet potato have anthocyanin content and higher fiber content than biscuits from wheat flour.

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Acknowledgment
Authors wishing to thanks for funding this research from Directorate General of Research Strengthening and Development, Ministry of Research, Technology and Higher Education Republic of Indonesia through “Penelitian Terapan 2019” project.