Physicochemical characteristics of fiber rich flour from solid waste of purple sweet potato starch processing

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Abstract. Sweet potato starch processing produces liquid waste and solid waste. Solid waste from sweet potato starch processing contains a high concentration of fiber so that it can be used for making fiber flour, which can be used as material for food fiber fortification in foods. This study aims to evaluate the characteristics of fiber flour derived from the solid waste of purple-fleshed sweet potato (PFSP) starch processing. Starch processing is carried out using 3 different types of extracting ingredients, namely distilled water, 2000 ppm sodium metabisulfite solution, and 2000 ppm citric acid solution. The results showed that the yield of fiber flour produced was 4.07-5.11%. The resulting fiber flour has soluble and insoluble fiber content between 1.20-1.63 and 13.53-21.91% respectively. The results of this study indicate that fiber-rich flour from the solid residue of PFSP starch processing can be used as a fiber fortification agent in special food products for people with obesity.

1. Introduction
Sweet potato is the 6th important food commodity in the world [1]. Sweet potato plant has a high tolerance in various temperatures and soil conditions such as infertile and dry soil [2], so they have the potential to be developed as a staple food source. In North Sumatra, sweet potato production in 2020 was 97,989.38 tons, an increase of 5,434.83 tons compared to production in 2018. This increase in production was due to an increase in harvested area by 10% or around 541.5 hectares [3].

Sweet potato is a nutritionally rich tuber, because it is rich in carbohydrates, vitamins, minerals such as Fe and Ca. Fresh tubers of sweet potato have 80-90% carbohydrates in dry basis and 50-80% of which is starch or 50% more than potatoes [4,5]. Another characteristic of sweet potatoes is that they have a high sugar content so they are higher in sweetness than other source of carbohydrate.

The flesh color of sweet potatoes varies, and one of them was a purple-fleshed sweet potato (PFSP). According to Huang [6], the dietary fiber and anthocyanin content of PFSP make it considered a functional food. Its anthocyanins have antioxidant, anticarcinogenic, antimutagenic, hepato-protective, anti-hyperglycemic, and anti-hypertensive activities [7,8,9,10]. The dietary fiber in sweet potato roots ranged in 1.9-26.6% dry basis [11]. Dietary fiber (DF) is used to reduce the postprandial glucose response and can influence the blood lipid [12]. DF also helps to prevent type 2 diabetes, cardiovascular and coronary heart disease [13].
Most of the sweet potato production in Indonesia is used for starch products and liquid sugar syrup (glucose syrup or high fructose syrup). During the processing of starch from purple sweet potato, a large amount of solid and liquid waste is generated. Solid waste from starch processing still contains several nutrients including dietary fiber, while liquid waste still contains anthocyanin pigments. This waste will be a problem for the surrounding environment if it is not utilized. Much of the research currently being conducted focuses on the utilization of starch processing waste as a source of biomass used as an energy source (bioethanol) [14] and animal production [15], while its use as a source of food fiber is still small.

Recently, a lot of research has been done to find gluten-free and dietary-rich food products. The solid waste of purple sweet potato starch processing is expected to be used as an ingredient to produce fiber-rich products. To achieve this purpose, a study was conducted on the characteristics of fiber-rich flour from the solid residue of PFSP starch processing using different starch isolation agents.

2. Material and methods

PFSP tubers were purchased from farmers in Phak Phak Barat Regency, North Sumatra Province, Indonesia. Chemicals used for starch extracting were distilled water, sodium metabisulfite, and citric acid as well as chemicals for quality analysis of purple sweet potato fiber.

2.1. Sampel preparation

PFSP tubers are washed, peeled using kitchen knife, and grated using grater machine to obtain tuber pulp. Starch was isolated from the tuber pulp following the procedure of Tharise [16], but with the modification in the isolation, agents used namely distilled water, solution of 2000 ppm sodium metabisulphite, and 2000 ppm citric acid. Tuber pulp and isolation agent were mixed in the ratio 1:3 (w/v), squeezed and filtered through filter cloth until the filtrate and solid residue was obtained. The solid residue was dried in drying oven at 60 °C for 12 hours, then ground using a home blender, sieved through a 60 mesh sieve, then packaged in low-density polyethylene packaging.

2.2. Analysis of physical, chemical, and functional properties of fiber-rich flour

Analysis of fiber-rich flour quality includes yield, color values in Hunter System (L*, a*, b*, and °hue) using a chromameter (Minolta CR 400, Japan), water content by oven method [17], water absorption and solubility were measured by the Niba et al [18] and Li and Yeh methods [19] respectively. Total, insoluble, and soluble dietary fiber (TDF, IDF, and SDF) content were analyzed by AOAC [17] methods using α-amylase, amyloglucosidase, and protease enzymes to digest the sample.

2.3. Data analysis

The influence of starch isolation agents on the physical properties, chemical composition, and functional properties of fiber-rich flour from solid residues of PFSP starch processing was evaluated using Completely Randomized Design and Analysis of Variance. Determination of differences in the range of physical, chemical, and functional properties of fiber-rich flour was carried out by using the smallest significant difference test (BNT) at the 95% confidence level (p<0.05).

3. Results and discussion

3.1. Yield and color

The influence of starch isolation agent on yield and color of fiber-rich flour from the solid residue of PFSP starch processing is shown in Table 1. The yield of fiber-rich flour ranged from 4.07-5.11%. Different types of isolation agents will produce different starch yields [20] so that the resulting solid residue yields are also different.

Table 1 shows that fiber-rich flour obtained from the solid residue starch isolation agent only has a significantly different effect on the lightness value (L*) of the fiber-rich flour produced, while the redness (a*), yellowness (b*), and °hue values are not significantly affected. Fiber-rich flour from starch processing using citric acid solution has a higher L* value, indicates that the flour is more bright. °Hue
value ranged from 70.02–73.24 indicates that the color of fiber-rich flour was yellow-red [21]. PFSP has a purple color due to the anthocyanin content, and it contains peonidin and cyanidin [22]. The peonidin gives a red color while the cyanidin gives a blue color [23].

**Table 1.** The influence of starch isolation agents on yield and color of fiber-rich flour from the solid residue of PFSP starch processing.

| Parameters | Distilled water | 2000 ppm Sodium metabisulfite | 2000 ppm Citric acid |
|------------|----------------|-------------------------------|---------------------|
| Yield (%)  | 5.11±1.15\(^a\) | 4.07±0.92\(^ab\) | 3.23±0.13\(^b\) |
| Color      |                |                               |                     |
| L\(^*\)    | 53.20±3.03\(^b\) | 59.17±2.32\(^a\) | 60.37±2.18\(^a\) |
| a\(^*\)    | 3.37±1.36\(^a\)  | 3.30±1.10\(^a\)  | 3.70±0.10\(^a\)  |
| b\(^*\)    | 10.00±3.74\(^a\) | 10.57±2.32\(^a\) | 12.60±2.18\(^a\) |
| *Hue       | 70.02±8.56\(^a\) | 72.79±3.69\(^a\) | 73.24±2.82\(^a\) |

\(^*) Values in the table are means from triplicate data ± standard error, and the same superscript letters follow the number in the same row indicates did not different significantly (p>0.05)

3.2. Moisture and dietary fiber content

Table 2 shown the moisture content, TDF, IDF, and SDF content of fiber-rich flour from the solid residue of PFSP starch processing, as affected by the isolation agents. The moisture, TDF, IDF, and SDF contents of fiber-rich flour from various isolation agents of starch used in starch processing od PFSP were significantly different. Fiber-rich flour derived from starch processing using sodium metabisulfite has a higher moisture content than those derived from starch isolated by using distilled water and citric acid. This result is in line with a previous study [20], which showed the moisture content of starch isolated with sodium metabisulfite was also higher than those in starches isolated by distilled water and citric acid. Moisture content was an important parameter of food since it can influence the stability and shelf life of foods. It can also affect the physical, chemical, and functional properties of food [24]. However, the moisture content of fiber-rich flour in this study was at a safe level for storing.

**Table 2.** The influence of starch isolation agents on moisture content, TDF, IDF, and SDF content of fiber-rich flour from the solid residue of PFSP starch processing.

| Parameters | Distilled water | 2000 ppm Sodium metabisulfite | 2000 ppm Citric acid |
|------------|----------------|-------------------------------|---------------------|
| Moisture content (%) | 6.14±0.06\(^b\) | 8.16±0.73\(^a\) | 6.73±0.54\(^b\) |
| TDF (%)    | 14.73±0.76\(^b\) | 23.54±1.29\(^a\) | 22.51±0.33\(^a\) |
| IDF (%)    | 13.53±0.57\(^b\) | 21.91±1.29\(^a\) | 20.91±0.31\(^a\) |
| SDF (%)    | 1.20±0.19\(^b\)  | 1.63±0.16\(^a\)  | 1.60±0.04\(^a\)  |

\(^*) Values in the table are means from triplicate data ± standard error, and the same superscript letters follow the number in the same row indicates did not different significantly (p>0.05)

The TDF was an important component in fiber-rich flour, and it consists of IDF and SDF. The TDF content ranged from 14.73 – 23.54. The previous study reported TDF content of sweet potato residual flour ranged from 20.63–31.48% [25]. The highest IDF and SDF were found in fiber-rich flour derived from starch processing using sodium metabisulfite as an isolation agent. This is due to the processing of PFSP starch using sodium metabisulfite resulting in lower starch content [20] so that the amount of solid residue is higher. The ratio of IDF: SDF of fiber-rich flour from the solid residue of PFSP starch processing ranged from 11.28-13.44. Both IDF and SDF are important components for the health of the human digestive system. Several studies have been demonstrated that dietary fiber can reduce the risk
of obesity, diabetes, and hypertension [26]. The recommended daily intake of dietary fiber up to 25-30 g for a 2000 kcal diet [27].

3.3. Water absorption index (WAI) and solubility

WAI and solubility in water were the important functional parameters of fiber-rich flour. The functional parameters of fiber-rich flour depend on dietary fiber composition. WAI and solubility of fiber-rich flour from the solid residue of PFSP starch processing as affected by isolation agents were shown in Figure 1 and Figure 2.

![Image of WAI and Solubility](image)

**Figure 1.** WAI of fiber-rich flour from solid residue of PFSP starch processing as affected by starch isolation agents.

| Starch Isolation Agents | Water Absorption Index (g/g) |
|-------------------------|------------------------------|
| Distilled Water         | 3.49                         |
| Sodium Metabisulfite    | 3.19                         |
| Citric Acid             | 3.27                         |

**Figure 2.** Solubility of fiber-rich flour from the solid residue of PFSP starch processing as affected by starch isolation agents.

| Starch Isolation Agents | Solubility (%) |
|-------------------------|----------------|
| Distilled Water         | 6.90b          |
| Sodium Metabisulfite    | 6.66b          |
| Citric Acid             | 12.56a         |

WAI value of fiber-rich flour in different starch isolation agents did not differ significantly. WAI is the flour’s ability to absorb water and for improving its consistency and give body to food [28]. Figure 2 shows that the solubility of fiber-rich flour obtained from the solid residue of PFSP starch processing with the citric acid solution as isolation agents was significantly higher than the other isolation agents. The solubility of fiber-rich flour relates to the presence of soluble molecules [29]. According to Dinghra et al [30] the components of the water soluble fiber were pectin, gum, and mucilages.
4. Conclusions
There were significant differences in yield, lightness, moisture content, TDF, IDF, SDF, and solubility of fiber-rich flour from the solid residue of PFSP starch processing as affected by starch isolation agents. The highest yield of fiber-rich flour was obtained from the solid residue of PFSP starch processing by using distilled water, but the highest TDF, SDF, and IDF were obtained from starch processing using sodium metabisulfite as an isolation agent. According to this finding, it is concluded that solid residue from PFSP starch processing has a great advantage and prospect to develop as raw material for the dietary fiber-rich food product.

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