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Increasing flour whiteness index on *Amorphophallus paeoniifolius* (Dennst.) Nicolson flour production by sodium metabisulfite

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ABSTRACT

This research aims to increase flour whiteness index to foot elephant yam (Amorphophallus paeoniifolius) flour along the production process. The chemical agents used in this research were sodium metabisulfite ($Na_2S_2O_5$) and ethanol. The corms were treated by soakeing in sodium metabisulfite 4% (w/v) for 3 hours, adding with ethanol 96% at a ratio of 1:2 and then blended with a speed of about 12,000 rpm for 5 minutes then filtered, and blanching into sodium metabisulfite 4% (w/v) for 3 minutes. The result showed that using $Na_2S_2O_5$ 4% (w/v) as a chemical agent on the initial production of Amorphophallus paeoniifolius flour was able to produce flour with the highest whiteness index. Therefore, this method will produce Amorphophallus paeoniifolius flour more applicable for the diversity of the food industry, especially noodles, biscuits, and bakery.

Keywords:
Amorphophallus paeoniifolius flour, Whiteness index, Sodium metabisulfite

1. Introduction

One of the big problems that hit several developing countries, especially in Indonesia, is food security, which is caused mainly by the decreasing and unfulfilled productivity of industrial raw materials, land conversion, and rapid population growth. Food diversification is one of the best solutions to break out of this problem. Thus, carbohydrate-based raw material, besides cereals, needs to be developed through food diversification in order to reduce the rate of imports, which will have an impact on improving foreign exchange and will lead Indonesia to food sovereignty.

Indonesia is a country that has a very large wealth of plant species. Many of those are well known and utilized by the native people. Generally, plants are consumed by the native as a source of nutrition, but consumption of containing carbohydrates plants as staple foods other than rice is still limited, even though tubers and corms content-rich in carbohydrates. Generally, the tubers and corms are only used by the native when the dry season comes. Some types of tubers and corms often consumed by the native people are sweet potato, cassava, arrowroot, canna, and taro, while Elephant foot yam (*Amorphophallus paeoniifolius*), as one of type of corms, is still rarely consumed [1].

Amorphophallus paeoniifolius syn. *A. campanulatus* (also known as elephant foot yam) is a source of carbohydrates from corm groups which rich in fiber content [2]. Several studies have reported that Elephant foot yam has a low glycemic index [3,4] which makes it safe for the diabetic diet. During storage, the quality of fresh corm chemical composition will decrease due to physiological activities. Therefore, to prevent this problem, tubers are usually processed into flour.

Several processing methods have been carried out to produce *Amorphophallus paeoniifolius* flour, but the resulting flour was brown. It makes it very limited for *Amorphophallus paeoniifolius* flour processed into food products that require bright product color as one of its quality parameters. The brightness level of food products is often measured as whiteness with an L value range of 1 to 100. Hasbullah et al. [5] have studied the whiteness of floured *Amorphophallus campanulatus* corms with the highest L value of 69.5. Moreover, Syah et al. [6] have reported that the highest L value and whiteness index for *Amorphophallus paeoniifolius* modified fermented flour was 76.87 and 74.50, respectively.

Several chemical agents can be used to prevent browning in food. One of them is sodium metabisulfite. These chemical agents can act as a binding agent with compounds which play an active role in oxidation reactions so that the rate of the browning reaction can be inhibited [7–10].

2. Materials and Methods

2.1. Materials

Amorphophallus paeoniifolius was obtained from North Bolaang Mongondow, North Sulawesi, Indonesia. The chemical agents used in this research were non-pro analysis of sodium metabisulfite (SMB) and ethanol 96%.

2.2. Amorphophallus paeoniifolius Flour Preparation

Amorphophallus paeoniifolius was peeled, then washed, and sliced up to 1±0.5 mm thickness. 1 kg of Amorphophallus paeoniifolius slices was divided into 3 treatments, i.e., SMB= soaked in sodium metabisulfite 4% (w/v) for 3 hours; Ethanol= added with ethanol 96% at a ratio of 1:2 and then blended with a speed of about 12,000 rpm for 5 minutes then filtered; and SMBB= blanched into sodium metabisulfite 4% (w/v) for 3 minutes. Samples then dried to reach a water content about 11±2%. The dried *Amorphophallus paeoniifolius* slices were then ground and sifted through an 80-mesh sieve.

2.3. Analysis Methods

2.3.1. Ash and Moisture Contents

The ash moisture content analysis methods for samples were carried out based on the standard procedures recommended by AOAC [11].

2.3.2. L*, a*, b* Values and Whiteness Index

The Lightness (L*), redness-greenness (a*), and yellowness-blueness (b*) values of the samples were analyzed according to Tatirat et al. [12] by a Chroma Meters CR-400 Minolta, Japan. Dried samples were put in a quartz silica cylinder and the L*, a*, and b* values were measured. The L*, a*, and b* values were then used to calculate the whiteness index (WI) according to the Lohman et al. [13] method.

$$WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2} \quad (1)$$

2.3.3. Bulk Density

The bulk density of the flour samples was analyzed according to the method of Suriya et al. [14]. The 3 g of each flour sample were gradually placed in a 10 mL graduated cylinder, respectively. The base of the graduated cylinder was tapped on the laboratory bench several times until there was no further attenuation of the sample level. Bulk density was calculated by:

$$\text{Bulk Density } (g.ml^{-1}) = \frac{\text{Weight of flour (g)}}{\text{Volume taken by flour (ml)}} \quad (2)$$

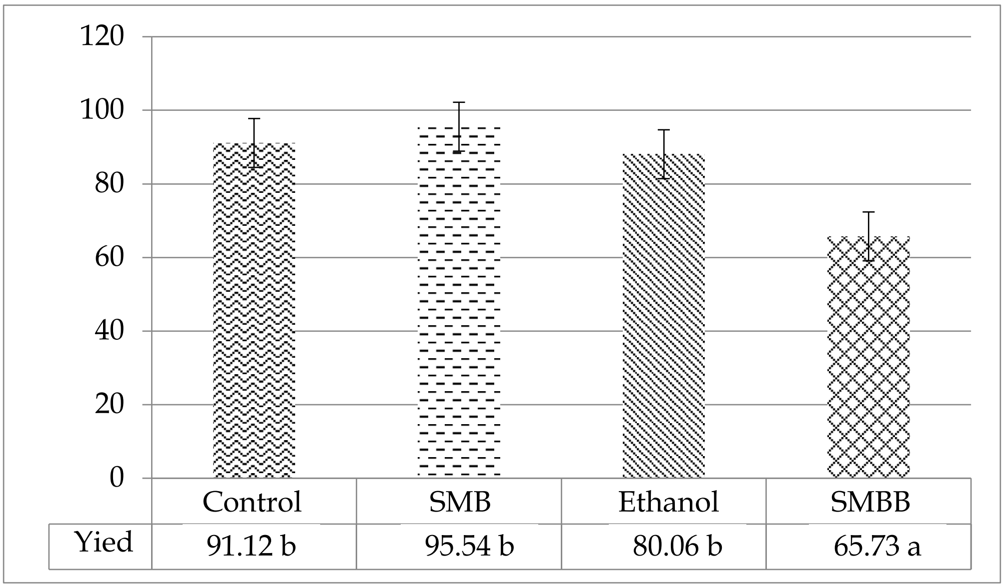
2.4. Statistics and Data Analysis

Analytical determinations were carried out in triplicates, and standard deviations were noted. The differences between the mean values of multiple groups were analyzed by one-way analysis of variance (ANOVA), with Duncan's multiple methods range tests. ANOVA data with a $p < 0.05$ were classified as statistically significant. PASW 18.0 statistics SPSS Inc. for Ms. Windows and Microsoft Excel 2013 program, were used.

3. Results and Discussion

3.1. Yield

The yield of *Amorphophallus paeoniifolius* flour produced from the processing of *Amorphophallus paeoniifolius* corms is expressed in percent. The yield is the percentage of the prepared flour weight and the weight of dried raw materials.



Different letters (a–c) in the same raw indicate a significant difference ($p < 0.05$) using analysis of variance and Duncan's multiple range test analysis. SMB= Sodium metabisulfite; SMBB= Blanched in sodium metabisulfite

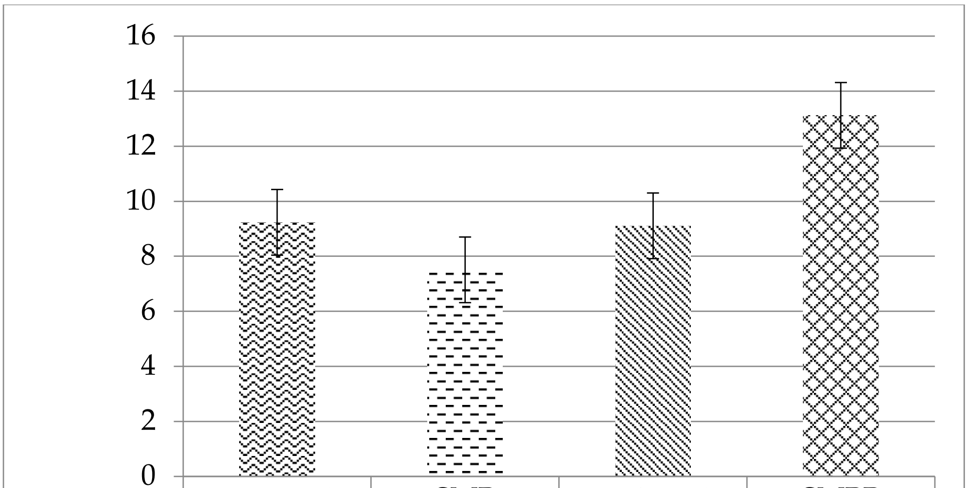
Figure 1. Yield of *Amorphophallus paeoniifolius* flour

The yield resulted from all treatments that were prepared from raw material to flour was 91.12%, 95.54%, 88.06%, 65.73% for control, SMB, ethanol, and SMBB treatments, respectively. All treatments showed no significant difference with control, except SMBB (Fig. 1). Several researchers have studied about *Amorphophallus campanulatus* flour. Richana et al. [15] and Hasbullah et al. [5] reported that the yield of *Amorphophallus campanulatus* flour production was 18.4% and 11.01–23.2%, respectively, that calculated from the percentage of wet corms.

3.2. *Moisture and Ash Content*

3.2.1. *Moisture Content*

The results showed that the water content obtained in the control, SMB, ethanol, and SMBB treatment was 9.23%, 7.51%, 9.11%, and 13.12%, respectively. It can be seen that the SMBB treatment has high water content. It could be affected by blanching for 3 minutes at a temperature of about 100 ˚C. Prabasini et al. [16] reported that high temperatures can cause the swelling of starch granules but do not break so that the diffusivity of the water decreases causing the water content to be higher. The water content bar chart can be seen in Fig. 2. Moreover, they reported that the water content of pumpkin with soaking for 10 minutes with blanching was 13.22%. The water content produced by soaking for 10 minutes was higher than the other treatments which reached 16.11%. This was probably due to the immersion for 10 minutes caused water to seep into the cells which led to higher water content.



	Control	SMB	Ethanol	SMBB
MC	9.23 a	7.51 a	9.11 a	13.12 a

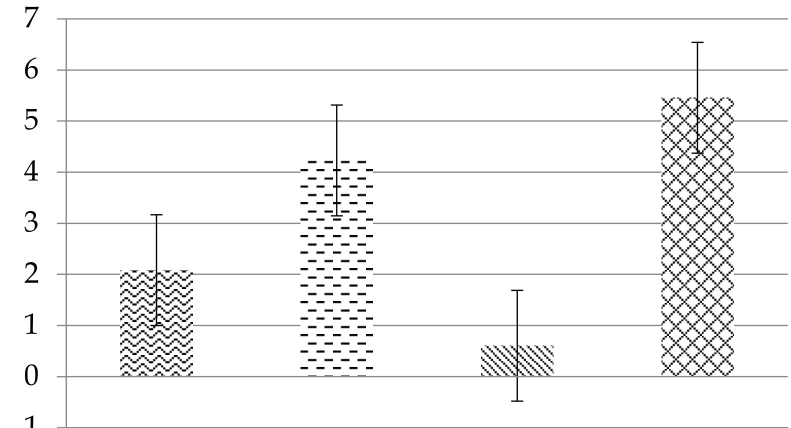
Different letters (a–c) in the same row indicate a significant difference ($p < 0.05$) using analysis of variance and Duncan's multiple range test analysis. MC= Moisture content; SMB= Sodium metabisulfite; SMBB= Blanched in sodium metabisulfite

Figure 2. Moisture Content of *Amorphophallus paeoniifolius* flour

Septiani et al. [17] stated that the temperature and duration of immersion had an effect on the moisture content of the sample. The results obtained showed that a large amount of water content was found in the sample treated with a drying temperature of 50 ˚C and an immersion duration time of 4 minutes, which was 7.58%. In addition, Kusumawati et al. [18] also reported that the increase in water content was probably due to the blanching process which caused swelling of starch, causing greater ability of food materials to absorb water.

3.2.2. Ash Content

The results showed that the ash content obtained in control, SMB, ethanol, and SMBB treatment was 2.08%, 4.23%, 0.60%, and 5.46%, respectively. These results showed no significant difference statistically (Fig. 3). The increasing ash content of the resulted flour may be caused by the contribution of sodium metabisulfite residue that was added in the initial flour preparation process made it increase in ash content as shown in Figure 3, clearly on SMB and SMBB treatment results, regardless it was not significant. These results agree with several studies on *Amorphophallus paeoniifolius* flour, such as Richana et al. [15] and Hasbullah et al. [5], where the ash content ranged between 3.09 to 5.68%. Septiani et al. [17] and Faridah [3] reported that the ash content of *Amorphophallus paeoniifolius* flour was 3.32% and 4.7%, respectively.



	Control	SMB	Ethanol	SMBB
Ash	2.08 a	4.23 a	0.60 a	5.46 a

Different letters (a–c) in the same row indicate a significant difference ($p < 0.05$) using analysis of variance and Duncan's multiple range test analysis. SMB= Sodium metabisulfite; SMBB= Blanched in sodium metabisulfite

Figure 3. Ash Content of *Amorphophallus paeoniifolius* flour

3.3. Color and Whiteness Index

The results showed that the whiteness index obtained in control, SMB, ethanol, and SMBB treatment was 71.31, 86.80, 68.84, and 82.92, respectively. The results obtained indicate that *Amorphophallus paeoniifolius* flour treatment by soaking in sodium metabisulfite solution will tend to produce flour with a higher whiteness index than others (Table 1). It even can be seen clearly by the naked eye (Fig. 4).

The a* and b* values describe redness-greenness and yellowness-blueness. Redness and yellowness range from 0 to 60 while greenness and blueness range from 0 to -60. The results show that the a* and b* values of all treatments tend to redness and yellowness (Tabel 1). It describes that the flour produced tends to brown and it can be seen clearly in figure 4. The lowest a* and b* values were in the SMB treatment such as 3.53 and 5.40, respectively that were significantly different from the control treatment values such as 5.55 and 8.92, respectively. It implies that the SMB treatment was effective to use as chemical agents to prevent the browning reaction along with the Amorphophallus paeoniifolius flour production. Nurdyansyah [19] reported that the Amorphophallus Campamulatus flour in Central Java had an average a* value of 3.30 and b* values ranged from 11.86 to 16.63 that prepared without initial treatment.

The brown of the flour produced can be caused by an enzymatic browning reaction in the corms during the processing, stripping, twisting, and drying processes. It is due to the reaction between polyphenol oxidase and oxygen [8,20]. This enzyme will be active if there is a wound on the *Amorphophallus paeoniifolius* corm. When this enzyme reacts with oxygen, it will produce melanoidin compounds that cause enzymatic browning.

Soaking with sodium metabisulfite affects increasing the L* value and whiteness index. Sodium metabisulfite can prevent enzymatic browning reactions because the sulfite groups in sodium metabisulfite bind to the carbonyl groups in the flour which prevent the formation of melanoidin compounds that cause browning, so that a better color is obtained, which has a higher lightness and whiteness. This results agree with Slamet [21] research, where the *Canna edulis* flour produced by soaking in sodium bisulfite solution has a better color (lighter). This is because sulfite can inhibit the browning reaction catalyzed by the phenolase enzyme and can block the reaction of the formation of 5 hydroxyl metal furfural compounds from D-glucose which causes browning.

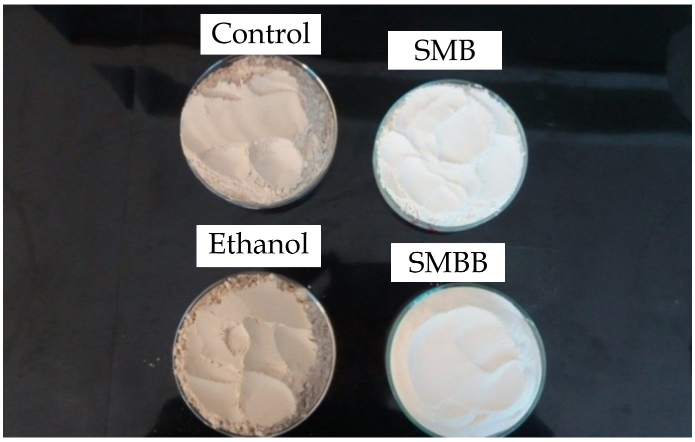
Furthermore, the browning reaction also can be caused by the Millard reaction. This reaction is possible during the drying and milling process of *Amorphophallus paeoniifolius* flour [22]. Millard reaction involves a reaction between an amino group contributed by free amino acid or a protein and the carbonyl group of a reducing sugar such as glucose, resulting in both soluble and insoluble brown melanoidin pigments. The amount of reducing sugar can influence the rate of the Maillard reaction when food is stored at 45 °C, where the rate of brown pigment formation will increase linearly [23,24]. It can be seen clearly by the naked eye in Figure 4, that the control and the ethanol treatments, melanoidin was formed during the flour preparation process. Soaking with sodium metabisulfite in the initial preparation was proven to prevent the formation of melanoidin compounds along with the production of *Amorphophallus paeoniifolius* flour.

Table 1. Whiteness index and L*, a*, b* values of *Amorphophallus paeoniifolius* flour

Treatments	Whiteness Index	L*	a*	b*
Control*)	71.31±0.17 c	73.30±0.11 c	5.55±0.10 a	8.92±0.23 a
SMB*)	86.80±1.02 a	88.49±1.05 a	3.53±0.30 c	5.40±0.08 c
Ethanol*)	68.84±1.54 d	71.04±1.32 d	5.40±0.17 a	10.13±0.91 a
SMBB*)	82.92±0.51 b	85.29±0.22 b	4.46±0.23 b	7.43±0.90 b

*) Means ± standard deviation
Different letters (a–c) in the same column indicate a significant difference ($p < 0.05$) using analysis of variance and Duncan's multiple range test analysis. SMB= Sodium metabisulfite; SMBB= Blanched in sodium metabisulfite

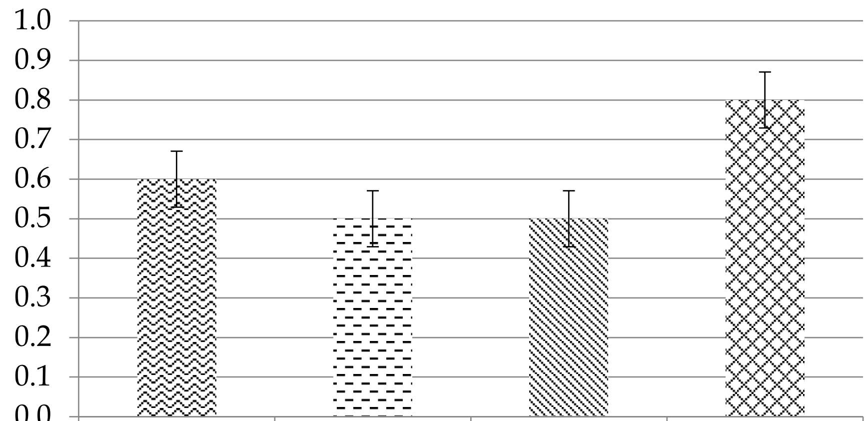
Moreover, normally, powder lightness value depended on its particle size. The lightness of small particle size was normally higher than that of large particle size [12]. According to the bulk density of the resulted flour (Figure 5), the SMB and ethanol treatments should be lower in lightness value, however, the SMB treatment did not show that. It is implied that sodium metabisulfite had acted as a binding agent to the carbonyl groups in the flour which prevent the formation of melanoidin compounds that caused the browning reaction of flour.



SMB= Sodium metabisulfite; SMBB= Blanched in sodium metabisulfite

Figure 4. ***Amorphophallus paeoniifolius*** **flour**

The results obtained in this study indicate that the L* value is much higher than the previous research conducted by Ferdiansyah et al. [25]. They reported that suweg (*Amorpophalus oncophilus*) flour has L* values ranging from 83.03% to 84.23% with a concentration of sodium metabisulfite solution was 2-3% for sample treatment.



	Control	SMB	Ethanol	SMBB
BD	0.6	0.5	0.5	0.8

BD= Bulk Density; SMB= Sodium metabisulfite;
SMBB= Blanched in sodium metabisulfite

Figure 5. Bulk density of ***Amorphophallus paeoniifolius*** **flour**

3.4. *Bulk Density*

Bulk density is the weight ratio of the volume occupied by the material, including the space between the granules of material. The results showed that the bulk density obtained in control, SMB, ethanol, and SMBB treatment was 0.6 $g.ml^{-1}$, 0.5 $g.ml^{-1}$, 0.5 $g.ml^{-1}$, and 0.8 $g.ml^{-1}$, respectively (Fig. 5). These results showed no significant difference statistically. Similar results have been reporting by Hasbullah et al. [5]. They reported that the bulk density of *Amorpophalus campanulatus* flour in Central Java ranges from 0.38 to 0.65 $g.ml^{-1}$. Compared with the bulk density of sweet potato flour (6.83 $g.ml^{-1}$) [26], *Amorphophallus paeoniifolius* flour is much lower. It indicates that the granules of *Amorphophallus paeoniifolius* flour obtained in this study were larger than sweet potato flour.

4. Conclusion

This study showed that using 4% Sodium Metabisulfite was effectively used to produce Amorphophallus paeoniifolius flour with a high lightness value and whiteness index. This method is more effective than others that have been conducted before to prepare brightness flour. It will contribute to more applicable of Amorphophallus paeoniifolius flour to the diversity in the food industry, especially noodles, biscuits, and bakery.

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