Effect of Isolation Methods on Physicochemical Properties of Purple-fleshed Sweet Potato Starch

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Abstract: Pretreatment methods in starch manufacturing will influence starch properties. In the present study the purple-fleshed sweet-potato (PFSP) starch was produced with different isolation agents: distilled water, sodium metabisulfite, and citric acid, and their effect on yield and physicochemical properties of starch was evaluated. Isolation of PFSP starch by sodium metabisulfite yielded the greatest recovery of starch (12.12%). Isolation methods significantly affected the fat, total starch, amylose, amylopectin and crude fiber content of PFSP starch. The isolation methods gave no significant effect on the color (lightness) and whiteness of PFSP starch. The starch content of PFSP starches from distilled water, sodium metabisulfite and citric acid isolation were 58.49; 50.20; and 62.93% respectively, while amylose content and whiteness of PFSP starch varied from 20.69 – 28.34% and 64.09 – 66.93 respectively.

1 INTRODUCTION

Sweet potato (*Ipomoea batatas* L. Lam) is one of tuber crops that has been grown in many areas in Indonesia including in North Sumatera, since it has a high adaptability to a wide variety of climatic conditions. It does not require a lot of input and has a shorter harvest period than other crops (Horton, 1989). It also has high starch content with low in glycemic index {ILSI, 2008) and high fiber content (Zhang, 2009). The common locally varities of sweet potato in North Sumatera are purple-skin white-fleshed, yellow-skin purple-fleshed, yellow-skin yellow fleshed, yellow skin-orange fleshed, and purple-skin purple fleshed (Hutasoit, 2018). Purple-fleshed sweet potato (PFSP) had a high antocyanin content, and therefore it showed stronger antioxidant activity than other vegetable crops (Van Hall, 2000).

The most utilization of sweet potatoes in Indonesia are consumed fresh such as boiled, fried or processed into variety of snacks and cake. In the other hand, sweet potato tubers have high post-harvest losses, and these can be minimized if the tubers can be converted into non- perishable forms by drying or extracting the starch. The utilization of sweet potato starch was determined by its physicochemical and functional characteristics, where they depend on the processing technologies such as isolation methods of starch. The use of enzyme or chemical agents such as sodium metabisulfite, sodium hydroxide or citric acid) will help to inactivate the indigenous enzyme (e.g. polyphenol oxidase), so they can maintain the quality of sweet potato starch (Jangchud, 2003). This study was aimed to study the physicochemical properties of starch that was isolated by different isolation agents namely water, sodium metabisulfite and citric acid.

2 MATERIAL AND METHODS

PFSP tubers were obtained from farmers in Phak Phak Barat North Sumatera Province – Indonesia. Tubers were washed and cleaned to remove the soil and dirt by using tap water.

2.1 Isolation of PFSP Starch

Isolation of PFSP starch was done according to (Tharise, 2014) with modification in isolation agent of starch. This study uses the different isolation

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agents namely water, sodium metabisulfite, and citric acid. The cleaned tubers were peeled manually with stainless steel kitchen knife, shredded by a grating machine, diluted 1 : 3 w/v with different agents of starch isolation i.e. distillation water, 0,2% sodium metabisulfite, and 0,2% citric acid, and then filtered by using filter cloth. The filtrate was allowed to settle for 12 hours at room temperature (27-30 ºC). The supernatant was poured while the starch was collected and resuspended in water for 3 hours and kept at room temperature for 3 hours to settle. This process was repeated three times until the white starch sediment was obtained. The collected starch was dried in a convection oven at 50ºC for 12 hours, cooled to room temperature. Dry matter content of the resulting starch for each treatment was calculated to obtain the starch yield, and then finely ground, sieve through a 80 mesh sieve, packed and sealed in polyethylene plastic bags for further analyzed.

2.2 Determinonati Physicochemical Properties of PFSP Starch Samples

Determination of starch yield (SY) was done by using the following formula :

$$SY\ (\%) = \frac{\text{Extracted starch}}{\text{Total amount of raw PFSP tubers}} \times 100 \quad (1)$$

The starch color was determined by using a Minolta Chromameter CR-400 type and the Hunter color values (L*,a *, b*) were obtained. The whiteness of starches were calculated as described by Thao and Noomhorn (2011) by using following formula :

$$\text{Whiteness} = 100 - [(100\text{-}L^2) + a^2 + b^2]^{1/2}$$

The chemical properties of PFSP starches including moisturem protein (N x 6,25), crude fat, ash, and crude fiber were determined by using AOAC methods (AOAC, 1995). The determination of starch content was done by acid hydrolyzing the PFSP starch samples with 25% HCl for a period 2.5 hours in water bath at 100ºC. The quantification was performed using 3.5 dinitrosalicylic acid (DNS) spectrophotometric methods at 490 nm, using glucose as standard (Dubois, 1956). Amylose content (%) was determined by using IRRI method (IRRI, 1996). Amylopectin was calculated by difference method as follows :

$$\text{Amylopectin (\%)} = (100 - \text{Amylose})$$

2.3 Analysis of Data

A completely randomized design and analysis of variance were employed to study the effect of isolation agents on the physicochemcial properties of PFSP starch. Least significant different (LSD) tests at 95% confidence level ($p<0.05$)was used to determine the differences between the ranges of physicochemcial properties of PFSP starch.

3 RESULTS AND DISCUSSIONS

3.1 Starch Yield and Physical Properties

The isolation methods gave no significant effect on starch yields, lightness and whiteness of PFSP starch as shown in Table 1. The highest starch yield was obtained by sodium metabisulfite isolation (12.12%). The starch yiels obtained in this study was similar to the study of (Soison, 2015) and reporting the starch yield of 6-13% from four varieties of sweet potato. But this result differ from previous studies (Babu and Parimalavalli, 2014), showing that starch isolation by using distillation water produced higher starch yields than sodium metabisulfite.

Table 1: The effect of isolation agents on starch yield, lightness and whiteness of PFSP starch.

Parameters a),b)	Isolation Agents of Starch		
	Distillation Water	Sodium Metabisulfite	Citric Acid
Starch yield (%)	11.53 ±0.44	12.12 ±1.18	10.38 ±0.96
Color			
L*	64.33 ±2.80	65.60 ±3.31	67.43 ±1.19
a*	-1.17 ±0.45[b]	0.70 ±0.36[a]	-1.53 ±0.46[b]
b*	3.70 ±1.84	3.33 ±1.05	5.50 ±0.36
Whiteness	64.09 ±2.96	65.42 ±3.35	66.93 ±1.24

a) Value reported as the mean ± Std. Dev. of three replications

b) Means followed by same letter superscripts within a row are not significantly different ($p<0.05$)

Color was the most important characteristics for determining the successful starch applications in food products. The starch color was determined by polyphenolic compounds and anthocyanin content of PFSP starch (Glavez and Resureccion, 1993). There was no significant difference observed for PFSP starch color isolated by difference methods in terms of lightness (L*), yellowness (b*) and whiteness but there was slight difference in greenness (a*). However PFSP starch which isolated by citric acid found to be more lightness and whiteness followed by sodium metabisulfite and distillation water. The lightness and whiteness of PFSP starch observed in this research were lower than those obtained by Thao and Noomhorm (2011) and Babu and Parimalavalli (2014). In their studies they found that the lightness and whiteness of sweet potato starch were ranged from 90.27-93.66. The lower of the lightness and whiteness of PFSP starch obtained in this research were due to anthocyanin pigment is carried over the starch product during the starch isolation (Glavez and Resureccion, 1993).

3.2 The Chemical Composition of PFSP Starch

Table 2 showed that there was a significant difference ($p<0.05$) in the moisture, crude fat, starch, amylose, amylopectin and crude fiber content of PFSP starch, but there is no significant difference ($p>0.05$) in the protein and ash content among the samples. Moisture content of PFSP starch ranged from 8.52-14.86% similar to the results of Babu and Parimalavalli (2014), and it was within the range of recommended moisture content of commercial starch i.e. 10-10% (Soni, 1993). Starch isolation by using citric acid produced PFSP starch with the lowest moisture content. However, basically the starch moisture content depends mainly by the drying methods and time, and also by the surrounding humidity (Lawal, 2004).

The fat content was found to be 0,68% in sodium metabisulfite isolation, 0,62% in citric acid isolation and 0,50% in distillation water isolation, and these values were similar with Thao and Noomhorm (2011) studies i.e. 0.06-0.07%. The fat content in PFSP starch that isolated by sodium metabisulfite and citric acid were higher than distillated water isolation. Ash content of PFSP starch ranged from 0.26 – 0.36, and the same result was found by (Babu and Parimalavalli 2014) and (Abegunde, 2012). The variation in the values of ash and fat content could be attributed to extraction method and degree of homogenization for isolation of starch (Kale, 2017).

Table 2 shows that the protein content of PFSP starch ranged from 0.14-0.17%. The protein and fat content of PFSP starch were lower than PFSP flours that had 1.9-2.6% protein and 0.4-0.7% fat (Jangchud, 2003). The high content of protein, lipid and ash indicated the low purity of starch (Thao and Noomhorm, 2011).

Table 2: Effect of isolation agents on chemical composition of PFSP starch

Parameters [a),b)]	Isolation Agents of Starch		
	Distillation Water	Sodium Metabisulfite	Citric Acid
Moisture (%)	14.86 ±3.83 [a]	16.93 ±0.82[a]	8.52 ±0.46[b]
Crude fat (%)	0.50 ±0.05[b]	0.68 ±0.03[a]	0.62 ±0.04[a]
Ash (%)	0.26 ±0.01	0.28 ±0.04	0.36 ±0.11
Protein (%)	0.17 ±0.03	0.14 ±0.08	0.16 ±0.04
Starch (%)	58.49 ±1.84[a]	50.20 ±2.80[b]	62.93 ±0.70[a]
Amylose (%)	37.79 ±0.94[a]	30.87 ±2.72[b]	34.59 ±0.62[ab]
Amylopectin (%)	20.70 ±2.98[b]	20.85 ±1.17[b]	28.34 ±1.07[a]
Crude Fiber (%)	0.25 ±0.11[b]	0.56 ±0.16[b]	2.59 ±1.15[a]

[a)] Value reported as the mean ± Std. Dev. of three replications
[b)] Means followed by same letter superscripts within a row are not significantly different ($p<0.05$)

The isolated PFSP starch had the lower starch content (50.20-62.93%) than those in previous studies i.e. 97-99% (Soison, 2015) and 92-96% (Abegunde, 2013). The differences of starch content may be due to a difference in variety and extraction methods. PFSP starch isolated by citric acid significantly had the higher purity of starch followed by distillation water isolation and sodium metabisulfite isolation had the lowest purity (Table 2).

Amylose content ranged from 30.87-37.79%, while amylopection content ranged from 20.70-28.34%. Isolation of PFSP starch by using distillation water produced the high amylose content of starch followed by citric acid isolation, and the highest amylopectin content was found in citric acid isolation. Various studies showed that the amylose content of sweet potato starches varied greatly with range of 8.5 to 38% (Abegunde, 2013; Collado., 1999; Tian, 1991;Takeda, 1987). The difference in amylose content of the PFSP starches will affect the physicochemical properties of starches and technological quality of starch-based foods (Ngoc, 2017). Amylose content in starch influences the pasting properties and strength of starch gel, because of rapid retrogradation. The association and interaction to lipids and amylopectin in forming helical complex gave the strong structure of gel. The high content of amylose in starches were desired for manufacture of starch noodles (Tan, 2009; Jane, 1999).

Crude fiber content of PFSP starch from citric acid isolation significantly was higher than those in distillation water and sodium metabisulfite isolation. The crude fiber content of PFSP starch ranged from 0.25-2.59%. Sweet potato was a significant source of dietary fibre (Collins and Walter, 1982) and therefore it plays a role in reducing the ocurence of certain diseases such as diabetes, coronary heart disease, colon cancer and various digestive disorders (Augustin, 1978).

4 CONCLUSIONS

The physicochemical properties of PFSP starch isolated from different kind of isolation agent (distillation water, sodium metabisulfite, and citric acid) were evaluation in this study. The result showed that, each isolation method had its own physicochemical characteristics, which affect the end-use quality of starch based foods. The sodium metabisulfite isolation produced the highest yield of starch with higher lightness and whiteness of PFSP starch color, but it had a lowest starch and amylose content. While starch isolation by using citric acid isolation produced the lowest yield of starch but had the highest starch content. The isolation PFSP starch by using distillation water produced the starch with the lowest lightness and whiteness of color, but it had the highest amylose content. It may be concluded that purple fleshed sweet potato starch can be applied for the development of food products.

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