Physical and Chemical Characterisics of Starch Nano crystal from Purple Sweet Potato var. Ayamurasaki

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ABSTRACT

The natural starch of purple sweet potato has the disadvantage of being easily hydrated, losing viscosity, and producing a fibrous and highly cohesive starch paste. Modification of starch in the form of nanocrystals will produce starch with low suspension viscosity at relatively high concentrations, high binding capacity due to the large active surface area. In this study, an evaluation was carried out on the physical and chemical characteristics of purple sweet potato starch nano crystals obtained by acid hydrolysis using 3 different acids, namely acetic acid, citric acid, and lactic acid. The results showed that the highest yield of starch nanocrystals was obtained from starch from acetic acid hydrolysis.

Keywords: Nanocrystal; Purple sweet potato; Acid hydrolysis; Starch; Food security

INTRODUCTION

Sweet potato (Ipomoea batatas L. (Lam)) is an important crop in many countries. In 2018 world sweet potato production reached 91,945,358 tons, and in Indonesia it was 1,806,389 tons. Indonesia ranks as the 5th largest sweet potato producing country in the world after China, Malawi, Nigeria, and Uganda [1]. Sweet potatoes also play an important role in meeting the world's food needs, reducing poverty, and increasing food security [2].

Sweet potatoes contain starch (58-76% on a dry basis), with characteristics similar to potato starch. The functional characteristics of starch such as viscosity, shear resistance, gelatinization, solubility, gel stability and retrogradation are largely determined by the amylose/amylopectin ratio of starch [3]. Purple sweet potato starch contains amylose ranging from 30-38% and amylopectin 20-28% [4]. Natural purple sweet potato starch has the disadvantage of being easily hydrated, losing viscosity, and producing a fibrous and highly cohesive starch paste [5]. Therefore, it is necessary to modify starch to overcome this weakness.

Modified starch is a process of changing the structure of starch by influencing the hydrogen bonds in a controlled manner. Usually starch degradation can be carried out by several methods such as physical changes, chemical degradation, enzymatic modification or genetic transformation [6]. Modification of purple sweet potato starch can be done by changing the particle size into nano size with a size ranging from 10-1000 nm. Starch nanocrystals can be made by nanoprecipitation, emulsification, and homogenization. The nanoprecipitation process is a simple and reproducible process, so it is more widely used [7]. Starch modification in the form of nanocrystal are expected to produce starch with low suspension viscosity at relatively high concentrations, high binding capacity due to the large active surface area. This study aims to evaluate the manufacturing process and characteristics of nanocrystals from purple sweet potato starch.

MATERIALS AND METHODS

Materials

The main ingredient of this research is purple sweet potato from farmers in Phak Phak Barat Regency. The chemicals used are chemicals for the manufacture of starch, namely sodium metabisulfite, chemicals for hydrolysis of starch and the manufacture of starch nanocrystals, namely citric, acetic, and lactic acids, NH3 and ethanol. Chemicals for analyzing the chemical characteristics of starch used were ethyl acetate, chloroform, methanol, hexane, aquadest, buffer (formic acid-sodium hydroxide), ascorbic acid, DPPH, phenolphthalein indicator, chloroform, KI, Na2SO3, KOH, HCl, lead (II) acetate.

Purple Sweet potato Production

Sweet potato starch extraction procedure refers to Julianti, et al.
Julianti E, et al.

[4]. The cleaned tubers were peeled manually with a stainless steel kitchen knife, the material was grated with a grater until the fine material became a slurry and diluted with a solution of starch isolating agent (0.2% sodium metabisulfite) with a ratio of slurry and solution 1: 3 w/v. The slurry is filtered using a filter cloth. The filtrate was allowed to settle for 12 hours at room temperature (27-30°C). The supernatant was discarded and resuspended in water for 3 hours and stored at room temperature for 3 hours to obtain starch. This process was repeated three times until a white starch sediment was obtained. The collected starch was dried in an oven at 50°C for 12 hours, cooled to room temperature. This coarse flour is then mashed using a blender and sieved with an 80mesh sieve. Sweet potato starch is produced and packaged in plastic tightly closed.

NANOCRYSTAL STARCH OF PURPLE SWEETPOTATO PRODUCTION

The procedure for making starch nanocrystals refers to Angellier [8] which was modified by acid hydrolysis. A suspension of starch was made in various types of acids (acetic acid, lactic acid, citric acid) with an acid concentration of 7.5% (w/V) with a ratio of starch and acid 1: 5 (w/w). The starch suspension was incubated at room temperature (30°C) for 7 days while stirring with mechanical stirring at 500 rpm using a magnetic stirrer. The starch suspension that had undergone acid treatment was then centrifuged and washed with distilled water. After that, it was neutralized using NH₃ until neutral (pH 7.0), followed by ultrasonication at 13000 rpm for 2 minutes. After that, it was washed with ethanol and then dried at 40°C for 24 hours. After drying, the starch is ground and filtered and then sieved and stored in the freezer until use.

Starch and starch nano crystals from purple sweet potato were observed for physicochemical characteristics including water content, ash content, protein content, fat content, starch content, amylose content, amyllopectin content, and crude fiber content. Starch nano crystals were also observed using SEM, color, solubility, Swelling power, amylose content, digestibility, degree of crystallinity (XRD), and starch paste characteristics.

RESULTS AND DISCUSSION

Physicochemical Characteristics of Natural Starch from Purple Sweet potato

The physical and chemical characteristics of natural purple sweet potato starch can be seen in Table 1. The starch yield that can be obtained from purple sweet potato is 14.13%. The value of L* color indicates the brightness level of the starch, and the value of L* color of the resulting starch is 88.88. When compared with research conducted by Thai and Noomhorn [9] and Babu and Parimalavalli [10], the resulting L* value is much lower, because the results of the research show that the L* value of sweet potato flour color ranges from 90.27-93.65. This difference is due to the different types of sweet potatoes used. In this study, the sweet potato used was purple sweet potato which contains high anthocyanin pigments.

Table 1 shows the moisture content (% w/w) of purple sweet potato starch, which is 14.40%. The water content of sweet potato starch is 11-17% [11]. Variations in the value of starch moisture content are caused by several different factors such as climate and the environment where it is grown.

Table 1 shows the ash content (%w/w) of purple sweet potato starch, which is 0.08%. The ash content of starch from sago, cassava, taro, and sweet potatoes ranged from 0.02 to 0.49% [11]. The lower ash content of sweet potato starch used can be caused by the repeated extraction, washing, and filtering processes using water in the manufacture of starch. This process can cause the minerals contained in the tubers and pith to be dissolved by water so that the mineral content is also wasted along with the pulp.

Table 1 shows the fat content (%w/w) of purple sweet potato starch, which is 0.27%. Starch fat content ranged from 0.176 to 0.317% [11]. The value of the fat content of starch is quite low due to the fat that is dissolved with water and some is also wasted during washing the starch water and is wasted with the dregs.

Table 1 shows the protein content (%w/w) of purple sweet potato starch, which is 0.09%. The low protein content in starch is caused by the process of making starch which can cause the protein to dissolve in water and there is also protein in the dregs that is also wasted [11].

Table 1 shows the results of carbohydrate content (%w/w) of sweet potato starch, which is 85.16%. Carbohydrate content can be related to the water content of purple sweet potato starch. Carbohydrate content is also related to water content [12]. The lower the water content of the material, the higher the dryness of the material, so that it can cause the carbohydrate content to rise and vice versa. The water content of sweet potato starch is 14.40%. Polnaya, et al. [11] stated that the water content of sweet potato starch was 11-17%. Variations in the value of starch moisture content can be caused by several different factors such as climate and the environment in which it grows.

Table 1 shows the crude fiber content of purple sweet potato starch, which is 0.91%. Sweet potato starch contains 0.05-1.3% crude fiber [11]. Table 1 shows the purple sweet potato starch content of 88.91%. Sweet potato starch content ranged from 59.2-80.76% [13]. The difference in starch content in sweet potatoes is thought to be because each variety has a different starch content.

Table 1 shows that purple sweet potato contains lower amylose content than the amyllopectin content of purple sweet potato starch. Starch consists of two components, namely amylose and amyllopectin. In general, the amount of amylose is 20% and the amount of amyllopectin is 80% of the total starch [11].
The functional characteristics of starch observed included water absorption, oil absorption, swelling power, and viscosity characteristics of starch paste and gelatinization temperature as shown in Table 2. The swelling power value of purple sweet potato starch was 8.22%. The results of research by Dewi et al. [14] stated that the swelling power value of sweet potato starch ranged from 6.408 to 9.518%. The higher the swelling power value, the higher the starch swelling power. Budiyati, et al. [15], stated that increasing amylopectin levels can cause swelling power to increase, while amyllose and fat can inhibit swelling power. The peak viscosity, because the increase in the size of the granules causes more sensitivity to the applied force.

Hot paste viscosity (HPV) is the viscosity value of the paste after it reaches a temperature of 95°C (heating stage). This criterion is used to determine the ability of starch granules to maintain viscosity during heating. The HPV value of purple sweet potato starch produced was 2079 cp, and this was in accordance with the results of the study of Tsakama, et al. [20] which showed the HPV values of 11 sweet potato varieties ranged from 1541-2049 cp. HPV from flour/starch which is high tend to be resistant to heat during the cooking process [21].

Final viscosity (FV) is the viscosity value of the paste after the final cooling stage, where the paste has reached a temperature of 50 °C. This viscosity is used to indicate the quality of starch, the stability of starch paste when cooked, and the ability of starch to form a paste or gel after cooking [23]. In this study, the final viscosity value of starch paste was 2860 cp, while the results of Tsakama, et al. [20] showed that the FV values in 11 sweet potato varieties ranged from 2303-2762. The linear structure of amyllose is easier to bond with fellow amyllose through hydrogen bonds and the hydrogen bonds formed are stronger than amylopectin so that the gel viscosity is getting thicker [22].

The breakdown viscosity (BD) shows the level of stability of the starch paste against the heating process. The BD value of purple sweet potato starch in the study was 1586, while the research of Tsakama, et al [20] showed the BD value for 11 varieties of sweet potato was 221.67-889.33 cp. The high breakdown viscosity value indicates that the swollen flour granules are brittle as a result of not being able to withstand the heating process, resulting in a decrease in the viscosity of the paste.

The setback viscosity (SB) indicates the retrogradation ability of starch molecules in the cooling process. The SB value in this study was 782 cp. The high setback viscosity value indicates that the paste tends to harden at the end of the cooking process, so the processed product is not easily destroyed [21].

Starch Nanocrystal from Purple Sweet potato

The manufacture of nanoparticles can be carried out in several ways consisting of top-down and bottom-up processes. The top-down process is intended as a process of breaking particles into smaller sizes to produce nanoparticles. While the bottom-up process is carried out by assembling or combining molecules thermodynamically under controlled conditions. The process of making nanoparticles more often uses a top-down process because the bottom-up process tends to produce large particle sizes, which are above 100 nm and this is not expected in the manufacture of nanoparticles. The technology for making nanoparticles that are bottom-up in the form of nano precipitation [23,24] and cross-linked emulsion. According to Le Corre et al. [26], there are three ways of forming starch nano crystals/nanoparticles, namely acid or enzymatic hydrolysis, regeneration and mechanical treatment [25].

In this study, nano crystals from purple sweet potato starch were obtained through acid hydrolysis with 3 different acids, namely acetic acid, citric acid and lactic acid. Starch yields were 82.67%, 84.68% and 75% respectively for the yields produced by hydrolysis of citric, acetic, and lactic acids, respectively. These results indicate that hydrolysis using acetic acid produces the highest starch yield.

| Table 2: Functional characteristics of purple sweet potato starch. |
|-------------------------|----------------|
| Water Absorption Capacity (g/g) | 0.71 ± 0.03      |
| Oil Absorption Capacity (g/g)   | 1.17 ± 0.08      |
| Swelling Power (g/g)           | 8.22 ± 0.27      |
| Solubility (%)                 | 0.95 ± 0.09      |
| Paste Clarity                  | 16.93 ± 0.40     |
| Peak Viscosity (PV) (cp)       | 3644             |
| Hot Paste Viscosity (HPV) (cp) | 2079             |
| Final Viscosity (FV) (cp)      | 2860             |
| Breakdown Viscosity (BD = VPVPP) (cp) | 1586     |
| Setback Viscosity (SB = FV/VP) (cp) | 782       |
| Gelatinization Temperature (°C) | 69.23            |

*) The value is an average from 3 replicates data ± standard deviation
CONCLUSION

Nano crystalline starch products from purple sweet potato can be carried out by acid hydrolysis. The highest nano crystal starch yield was obtained in the hydrolysis process using acetic acid.

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Conflict of Interest

“Conflict of Interest: None to report.”

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