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AMYLOGRAPHY PROFILE AND MICROSTRUCTURE OF BENENG TARO BANTEN (*Xanthosoma undipes* K. Koch) STARCH

Vega Yoesepa Pamela[1*], Winda Nurtiana[1], and Bayu Meindrawan[2]

[1]Food Technology Department, Faculty of Agriculture, Universitas Sultan Ageng Tirtayasa
Jalan Raya Jakarta Km 4 Pakupatan, Serang-Banten, Indonesia
[2]Food Technology Department, Bina Nusantara University, Indonesia
E-mail: vega.yoesepa@untirta.ac.id

ABSTRACT

High demand of flour import for food applications was a big threaten for food security in Indonesia. The utilization of carbohydrate sources from local food plants can be an alternative to overcome this problem. Beneng taro is a local food from Pandeglang, Banten Province that potential to be used as composite flour. The application of food products, Beneng taro can be used as starch. The purpose of this study is to analyze the characteristics of Beneng taro starch on the amylographic profile of the granules and their morphology. The extraction method used is wet extraction using distilled water. The ratio of taro and distilled water used is 1: 3. The optimum formulation (1: 3) was then tested for morphological properties using SEM instrument and amylograph profile using RVA instrument. SEM test results showed uniform starch granules and polygon-shaped granules. The amylographic profile shown a maximum viscosity of 1075cP with a temperature of 92.4oC at 270 seconds, a set back value of 186 cP and a break down of 214 cP. Based on the amylographic profile, beneng taro starch still has many weaknesses (large set back and break down) so it needs to be modified so that it can be applied to food products.

Keywords: beneng taro, starch, amylograph profile, microstructure

INTRODUCTION

An enormous number of Indonesia’s food products were made from carbohydrates, such as biscuits, bread, noodles, pasta, and others. However, these products use wheat flour as basic ingredient, which is still imported. This problem can have an impact on the weakness of food security in Indonesia due to the high use of flour. To reduce the use of flour, there is a need for other carbohydrate sources that can substitute flour for the manufacture of various food products. One source of carbohydrates is Beneng taro. It was a local Banten food which has an abundant presence in Juhut Village, Pandeglang Regency. Beneng taro was more applicable in food products in the form of starch.

Starch is a type of carbohydrate that is abundant in nature and can be obtained from various parts of the body of the plant such as seeds, roots, stems or cereals. Starch is used in the food, cosmetics and pharmaceutical industries. Some starches that are widely used in the food industry are cassava, corn, potatoes and wheat starch (Deka and Sit, 2016). In the farmer group in Juhut Village, Beneng taro is only made into flour and sold outside the region, so there are no data on the characteristics of the starch. The purpose of this study is to analyze the microstructure and amylography profile of Beneng taro starch. Moreover, the result of this study can provide information about the potency of Beneng taro starch in the food industry.

MATERIALS AND METHODS

The instruments used were Scanning Electron Microscopy (SEM) USA Zeiss EVO M10, set of kitchen tools (knives, cutting boards, basins, buckets), analytical balance, strainer, blender, baking pan, and oven for extracting and drying starch, oven, furnace, cup, desiccator, soxhlet, kjeldahl apparatus, UV-Vis spectrophotometer (Perkin Elmer), HPLC UV-Vis (Agilent), chromameter (Minolta CR-300), Rapid Visco Analyzer (Perten).

The main materials used in this study were Beneng taro obtained from Juhut Village, Karang Tanjung District, Pandeglang Regency, Banten Province, NaCl salt, aquades, hexane, H2SO4 (merck), HgO (merck), NaOH (merck), H3BO3 (Sigma Aldrich), HCl (merck), aquabidest, phenolphtalein (Sigma Aldrich), ethanol 95%, amylose (Sigma Aldrich), acetic acid (merck), iodine (merck), and sodium oxalate (sigma Aldrich).

Methods

Beneng Taro Starch Extraction

The process carried out is to observe the diameter, length, weight, skin color, and tuber color of Beneng taro The next step is the extraction of Beneng taro starch begins with washing, sorting, stripping, slicing, soaking in 1% NaCl salt solution, crushing with water for 5 minutes, filtering, settling for 24 hours, starch, and water separation, drying at 50oC for 24 hours, and size reduction. This extraction process was carried out in five attempts and two repetitions. The ratio of talas and water used for extraction is 1:1, 1:2, 1:3, 1:4, 1:5.

Morphology Characteristic

Morphological structure was analyze using Scanning Electron Microscopy (SEM) Zeis EVO MA 10 instrument. A sample was cut 2mm x 2mm size and set on bronze visualization cross by double side tape. The sample surface was coated using thin gold layer. The sputter time and current were set on 60 s and 20 mA, respectively. Sample was inserted into SEM instrument and the surface picture was taken using SE (Secondary Electron) detector with working distance (WD) and electron high tension (EHT) voltage were 8.5 mm and 16.0 kV, respectively.

Functional Characteristic

Sample suspensions were prepared by mixing 3 g starch (dry basis) and water into total weight of 28.0 g. The suspensions were equilibrated at 50oC for 1 minute, then heated from 50 to 95oC at 6oC/min. A holding period at 95oc was conducted before cooling from 95 to 50 at 6oC/min and another holding phase at 50 for 2 minutes. The RVA pasting parameters which consisted of pasting temperature, peak viscosity, breakdown, final viscosity, and setback were computer recorded and reported. Determination of the best treatment based on the highest yield of starch. Data from Nurtiana, *et al* (2019) are used as the basis for determining the best treatment.

RESULTS AND DISCUSSION

Morphological characteristic

The morphological result of Beneng taro starch can be seen in Figure 1.

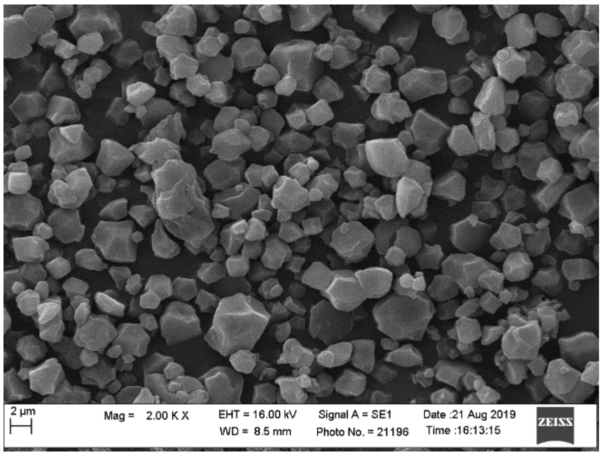

Figure 1. SEM results for beneng taro starch microstructure observation (magnification 2000 times)

Scanning Electron Microscopy results on Beneng Taro Starch showed the form of polygon starch granules. These results are similar to the study of Tattiyakul et al. 2006. Other studies even showed a round starch granule (Kartikasari *et al*, 2016) and irregular (Zeng *et al*, 2014). Starch granules have a variety of shapes and can be used to identify carbohydrate sources because each source has a different shape.The size of the granules on the Beneng Taro Starch is still relatively large because it has not been modified. In general, starch modification treatment can make starch granules smaller than pure starch granules.

Types of starch granules from various botanical sources vary both in terms of size (diameter ranging from about 0.1 to 200 mm), morphology (ellipsoidal, oval, round, polygonal, elongated, irregular, lenticular, and disk), size distribution (uni, bi-, or polymodal), and events in amyloplast (individually or as compounds) (Schimer *et al*, 2014).

Amylography Profile

Amylography profile of Beneng taro starch can be analyzed in various ways and can be adapted to the available instruments. Information obtained from the starch amylographic profile is a characteristic of starch paste, including pasting temperature and peak time, minimum viscosity (trough), maximum viscosity (peak), breakdown viscosity, setback viscosity, and final viscosity. These properties can be measured using Rapid Visco Analyzer (RVA) instrument. Measurement using the RVA instrument requires shorter testing time and a smaller number of samples compared to the Brabender Viscograph (Melissa, 2018). The results of RVA analysis on Beneng taro starch can be seen in Figure 2.

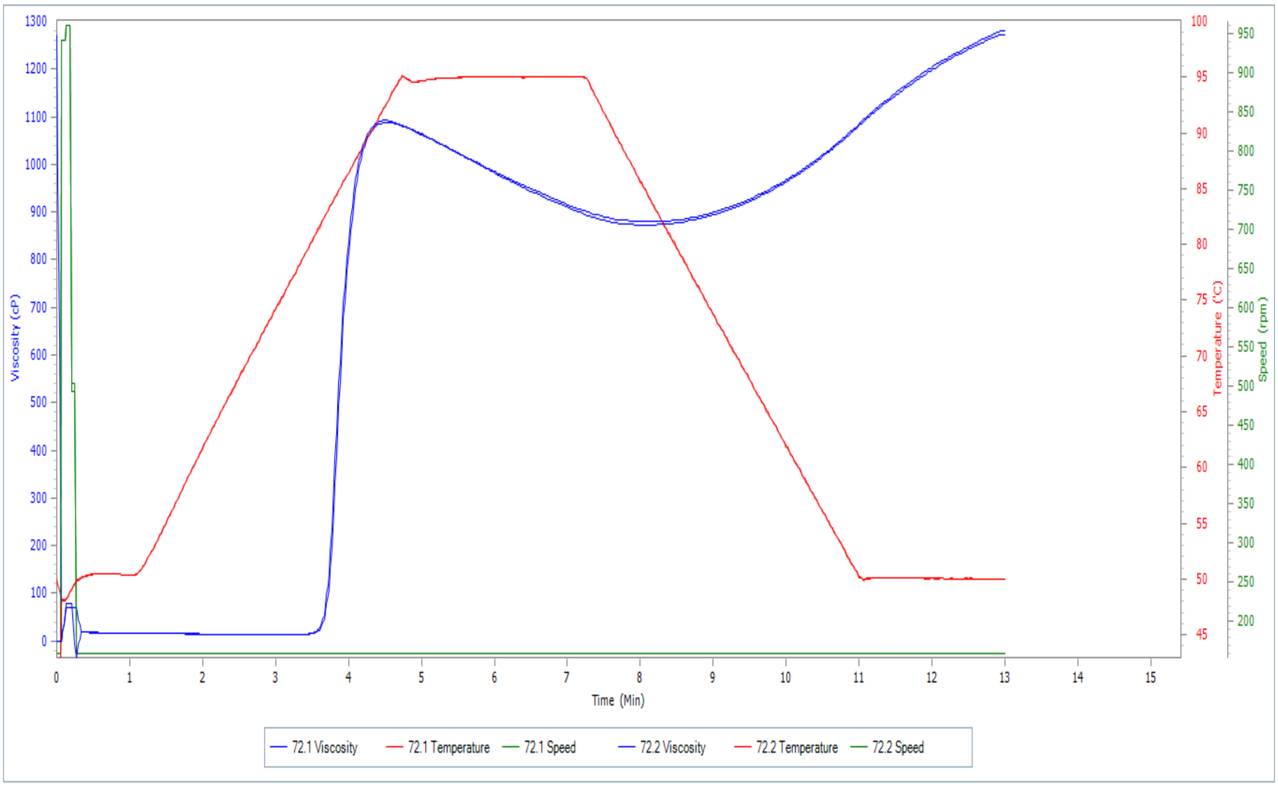

Figure 2. Amylographic profile of beneng taro starch

The results of the Rapid Visco Analyzer on the Beneng taro starch showed a high-temperature gelatinization of 81.9oC, meaning that it needed a temperature high enough for the starch to start gelatinization. The initial temperature of gelatinization or pasting temperature (PT) is the temperature at which viscosity begins to form and indicates starch begins to absorb water (Fetriyuna et al, 2016). The temperature of starch gelatinization is the temperature at which the starch forms a gel completely becomes transparent.

Gelatinization is the process of breaking bonds between starch molecules in the presence of water and heat and allows starch molecules to bind more water. The presence of water penetration will increase between randomness in the structure of starch. The stronger the bonds between starch molecules, the higher the amount of heat needed to break bonds between molecules so that the higher the gel temperature (Singh-Sodhi and Singh, 2005). The temperature and time of starch gelatinization are influenced by the amylopectin structure, starch composition, granular architecture (Imaningsih, 2012) and amylose content (Murtiningrum et al, 2012). Temperature gelatinization of Banten taro starch higher than sweet potato starch 66,92oC (Irhami et al, 2019); taro flour starch 69oC, corn starch 62-72oC, cassava starch 68-78oC and rice starch 52-64oC (Aryanti et al, 2017).

Besides the gelatinization temperature, other information that can be seen from Figure 2 is maximum viscosity. The maximum viscosity or peak viscosity (PV) value of Beneng Taro Starch is quite small, which is 1075 cP. This result was contrary to the results of research conducted by Fetriyuna et al (2016), that peak viscosity on the taro beneng starch is 3899,5 cP. The high peak viscosity on taro is due to an increase in the viscosity of the paste due to the distillation of starch granules, especially amylose. Amylose content in Beneng Taro Starch is quite high at 28.91% (Nurtiana *et al*, 2019).

Table 1. RVA results of beneng taro starch

RVA parameters	**Replication**		
	L	2	Average
PT: temperature (°C) at 20cp	81.8	82.1	81.9
Pt: time (s) at 20cP	217	218	218
Peak viscosity (cP) PV	1077	1073	1075
Temp. at peak viscosity (°C) PVT	92.1	92.8	92.4
time at peak viscosity (s) PVt	268	272	270
Hot paste Peak viscosity (cP) HPV	858	865	862
Temp HPV (°C) HPVT	86.6	84.9	85.7
Cold paste viscosity (cP) CPV	1257	1264	1261
Cooking ability (s) CA	51	54	52
Viscosity beginning plateau (cP) VBP	1067	1065	1066
Viscosity end plateau (cP) VEP	883	889	886
Breakdown (cP) BD	219	208	214
Setback (cP) SB	180	191	186
Consistency(cP) CS	399	399	399

Maximum viscosity is the viscosity of the paste produced during heating. Increased absorption of starch granules by heat will increase the viscosity of the paste so that at maximum viscosity perfect gelatinization occurs. The greater the ability to expand starch granules, the higher the viscosity of the paste and eventually will decrease again after the rupture of starch granules (Swinkles, 1985). Starches that have high water absorption ability will also experience high swelling which will result in high viscosity of the peak of the paste. Excessive swelling of the starch granules will be followed by the decay of amylose molecules from the granules as a result of its inability to withstand pressure (Wulandari, 2010).

After achieving maximum viscosity, if the heating process in RVA is continued at a higher temperature, the starch granules will be brittle, break apart and cut to form polymers, aggregates and their viscosity decreases due to amylose leaching. The decrease occurred at a heating temperature of 95°C suspension which was maintained for 10 minutes. The value of viscosity reduction that occurs in these conditions is called viscosity breakdown. The score breakdown of Beneng Taro Starch is quite high at 214 cP, it shows the characteristics of starch that is less heat resistant.

Breakdown or decrease in viscosity during heating shows the stability of the starch paste during heating, where the lower breakdown value, the paste formed will be more stable to heat (Rostianti et al, 2018). According to Eliason (2004) breakdown is an important factor that has an influence on the application of starch in food products. When starch granules swell and experience heat and shear, starch undergoes fragmentation and results in a reduction in viscosity which indicates starch breakdown. A high breakdown value is undesirable because it causes low viscosity also results in cohesive properties in a starch paste.

After heating to 95ºC and held for 10 minutes, the starch paste is cooled. When cooled, the viscosity of the starch paste increases again. The setback value of viscosity is obtained by calculating the difference between the viscosity of the starch paste at 50°C and the maximum viscosity that has been reached upon heating. The set back value in this study was also high, 186 cP. This is caused by the tendency of retrogradation in starch paste because of its high amylose content. According to Lehmann et al (2003), the viscosity of paste setback shows a tendency towards retrogradation that occurs in amylose molecules because amylose is more easily exposed to water and recrystallized more easily than amylopectin. A similar result was stated by Fetriyuna (2016) that native Beneng taro starch tends to have a high setback viscosity value. The higher the setback value indicates the higher tendency to form a gel (increase viscosity) during cooling, as well as indicate that the starch paste is fast undergoing retrogradation (Marta, 2011).

CONCLUSION

The microstructure of Beneng taro starch showed polygon and quite uniform shapes. The amylographic profile of the Beneng taro starch respectively for initial gelatinization temperature, maximum viscosity, breakdown viscosity and setback viscosity were 81.9^{o}C, 1075 cP, 214 cP, and 186 cP. These results indicate that Beneng taro starch still has many shortcomings to be applied to food products. So it is necessary to modify native Beneng taro starch.

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