

Partial Characterization of the Physicochemical Properties of Six Indonesia Palma Starches

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ABSTRACT

Palm starches have been used as a staple food in many places throughout South East Asia. The limited information about their properties has limited their application in food and other industrial uses. This study was aimed to characterize the physicochemical properties of different palm starches as potential sources of food and other industrial application. Two sago (*Metroxylon rumphii*, I and II) starch samples and one "sago baru" (*Arenga microcarpa*) starch sample were obtained from several starch processors in Sangihe, North Sulawesi. One sago (*M. sago*), one sugar palm (*A. pinnata* II) and one cassava starch samples were obtained from a small commercial plant in Bogor. One sugar palm (*A. pinnata* I) starch sample was processed following the traditional method from a tree in Tomohon North Sulawesi. Each sample was sun dried after purchase in order to reduce the moisture content. A commercial corn starch (Best Foods Canada Inc, Etobicoke, Canada) sample was purchased from a grocery store in Canada. The chemical analysis showed that the protein and lipid contents of palm starches were similar to cassava, but lower than corn starch. Palm and cassava starches were higher in dietary fiber than corn starch. Palm starch samples were higher in ash content than corn and cassava starch. This difference was almost likely due to the limit processing of these samples when compared to corn. Amylose content was higher in all palm starches than that in corn and cassava starches. Palm starch granules were larger than cassava and corn starch granules. The *Arenga pinnata* starch granules were large (12-70 μ m) and had an elongated shape, whereas, *A. microcarpa* and *Metroxylon* were medium (12-50 μ m) and oval or egg shaped. Some holes were observed for some palm starch samples. Brabender viscosity of *A. pinnata* starch samples were higher than that for cassava and corn starch samples. Variability in viscosity profiles among palm starch samples could be due to the processing which resulted in chemical and physical alteration in the starch granules. The results indicated that palm starches especially starch from *A. pinnata* have several unique properties that could have special applications in food and other industrial uses.

Keywords : Starch, palm, sugar palm, sago, proximate composition, amylase, viscoamylograph.

ABSTRAK

Karakterisasi Beberapa Sifat Fisikokimia dari Enam Pati Palma Indonesia

Pati palma telah digunakan sebagai maknan pokok di banyak tempat di seluruh Asia Tenggara. Keterbatasan informasi tentang sifat sifatnya telah membatasi penggunaan mereka dalam makanan dan industrilainnya. Penelitian ini ditujukan pada sifat sifat fisikokimia dari berbagai pati palma sebagai bahan baku untuk makanan dan industri. Dua jenis sampel pati sago (*Metroxylon rumphii*, I dan II) dan satu sampel pati sago baru (*Arenga microcarpa*) didapat dari beberapa pengolah pati di Sangihe, Sulawesi Utara. Satu sampel pati sago (*M. sago*), satu sampel pati aren (*A. pinnata* II) dan satu sampel pati ubi kayu diperoleh dari satu pabrik pengolahan komersial pati di Bogor. Satu sampel pati aren (*A. pinnata* I) diolah mengikuti cara tradisional dari sebuah pohon di Tomohon, Sulawesi Utara. Masing masing sampel dijemur di panas matahari untuk mengurangi kadar air. Satu sampel pati jagung (Best foods Canada Inc, Etobicoke, Canada) diperoleh dari sebuah toko di Kanada. Analisa kimia menunjukkan bahwa kandungan protein dan lemak dari pati palma adalah sama dengan yang dari ubi kayu, tetapi lebih rendah dari pati jagung. Pati palma dan ubi kayu mengandung serat makanan yang lebih tinggi dari pati jagung. Kandungan abu dari pati palma lebih tinggi dari yang dari jagung dan ubi kayu. Perbedaan perbedaan ini mungkin lebih disebabkan oleh keterbatasan intensitas pengolahan bahan pati palma dibandingkan dengan pada pati jagung. Kandungan amilosa dalam pati palma lebih tinggi dari dalam pati jagung dan ubi kayu. Granula pati palma lebih besar dibandingkan dengan pati jagung maupun ubi kayu. Butiran pati aren berukuran besar (12-70 μ m) dan mempunyai bentuk yang memanjang, sedangkan butiran pati sago baru maupun sago berukuran sedang (12-50 μ m) dan berbentuk oval atau seperti telur. Beberapa lobang terlihat pada butiran pati palma. Viskositas Brabender dari pati aren lebih tinggi dari viskositas pati jagung dan ubi kayu. Variabilitas dalam profil viskositas diantara pati palma kemungkinan berhubungan dengan pengolahan yang menghasilkan perubahan kimia dan fisika dari butiran pati. Hasil hasil penelitian menunjukkan bahwa pati palma, khususnya pati aren memiliki beberapa sifat khusus yang dapat dimanfaatkan untuk penggunaan yang khusus dalam makanan dan industri lainnya.

Kata kunci : Pati, palma, aren, sago, komposisi proximat, amilosa, viskoamilograf.

INTRODUCTION

Indonesia is a country rich in natural resources; especially plant producing starches. Traditionally, starch from three species of palm trees, *Arenga pinnata* Merr (sugar palm), *A. microcarpa* Becc. (sago baruk) and *Metroxylon sagu* Roettboell (sago) have been used as a staple food in Indonesia (Efendi, 2010; Lay and Helyanto, 2011; Pontoh, 2004, Bintoro *et al.*, 2007, 2008). There are approximately 4.5 million hectares of sago forest in Indonesia, concentrated mainly in Papua (Bintoro, 2007), whereas sugar palm are approximately 65 thousand ha in all regions of Indonesia (Haryono, 2012). *A. microcarpa* is widely used as staple food in some islands in North Sulawesi (Suryana, 2007).

The chemical composition of sago starch has been reported (Arbakariya *et al.*, 1990; Sim *et al.*, 1991, Zobel, 1992 and Ahmad *et al.*, 1999) and recently has been reviewed by Karim *et al.* (2008). According to those published records the protein, lipid and ash content of sago starch ranges from 0.02 – 0.57%, 0.10 – 0.30% and 0.06 – 0.43%, respectively. On the other hand, the chemical composition of sugar palm (*A. pinnata*) and sago baruk (*A. microcarpa*) starches is not yet reported. This composition is really needed for their various applications in food and other industrial uses.

Physical properties of sago starch have recently been review by Karim *et al.*, (2008) but it has not been determined for sugar palm and sago baruk starch. The granule shape of sago starch is oval or egg shaped, and granules size varies from 20 – 59 μ m.

The viscosity of sago starch has been the focus of several reports with varying results (Mohamed *et al.*, 2008). This variability in results has limited the application of this starch in industry. The reasons which have been proposed for these varied results were differences in molecular weight, ash content, the age of the tree and the different parts of the tree (top, middle or bottom parts of the tree; Mohamed *et al.*, 2008).

The above review shows that there is plentiful information about sago starch properties but there are scarcely information about the sugar palm (*A. pinnata*) and sago baruk (*A. microcarpa*) starch properties. The fact that starch produced from sugar palm has premium over other starches for its application in meat-ball processing (Pontoh, 2004). From the observation, it showed that sugar palm starch has a strong filling and binding capabilities, therefore it can be used in fewer amounts compared to the other starches. Unfortunately, this sugar palm starch properties are not revealed yet.

The purpose of this work was to compare the physicochemical properties of sago, sugar palm and

sago baruk starches with those well known starches of corn and cassava.

MATERIALS AND METHODS

1. Materials

Two sago (*Metroxylon rumphii*, I and II) starch samples and one "sago baruk" (*Arenga microcarpa*) starch sample were obtained from different starch processors in Sangihe, North Sulawesi. One sago (*M. sagu*), one sugar palm (*A. pinnata* II) and one cassava starch samples were obtained from a small commercial plant in Bogor. One sugar palm (*A. pinnata* I) starch sample was processed following the traditional method from a tree in Tomohon. The *M. rumphii* I and II and *A. pinnata* I and II are from the same species, except from different tree and places of the respective species. The starch samples were collected during the period of June to August, 1992. Each sample was sun dried after purchased in order to reduce the moisture content. A commercial corn starch (Best Foods Canada Inc, Etobicoke, Canada) sample was purchased from a grocery store in Canada.

Unless mentioned, all other reagents used were analytical grade. All of the samples were stored in the cold room ($4^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$) until used for analysis.

2. Proximate Analysis

Standard AOAC methods (Anonymous, 1984) were used for moisture (AOAC method: 14.004), protein ($\text{N} \times 6.25$; AOAC method: 2.057), lipid (AOAC method: 7.062) and ash (AOAC method: 14.006). Dietary fiber was determined by AOAC method 985.29 (Anonymous, 2010).

3. Starch Content

Starch content was determined enzymatically using the method described by Holm *et al.*, 1986. Approximately 30 mg of starch sample was weighted into a 10 mL volumetric flask. To this flask was added 6.0 mL of distilled water and 0.2 mL of NaOH. After mixing and dispersing, the flask was placed in boiling water and kept stirred for 5 minutes. The resulting viscous solution was cooled to room temperature. Two milliliters of 1 N HCl was added and the solution was made up to volume with distilled water. A 1.0 mL aliquot of this solution was transferred to a 16 x 150 mm test tube containing 2.0 mL of acetate buffer (0.1 M; pH 4.7) and 100 μ L of glucoamylase suspension (Boehringer, Germany). The resulting solution was incubated at 60 $^{\circ}\text{C}$ in an agitating water bath (Magni Whril, Blue M Electric Co., Blue Island, USA) for 1 hour. This solution was

quantitatively transferred to a 25 mL volumetric flask and made up to volume with distilled water. A 1.0 mL aliquot of this solution was transferred to a 16 x 150 mm test tube containing 1 mL of distilled water. To this solution was added 1.0 mL of hexokinase reagent (Glucose (HK) 20; Sigma Chemical Co., St Louis, MO, USA), containing NAD, ATP, hexokinase, G-6-PDH, magnesium ions and buffered at a pH of 7.5. The resulting solution was heated in the agitating water bath at 37°C for 30 minutes and the absorbance was measured (Spectronic 1201, Milton Roy, Rochester, NY, USA) at 340 nm. A standard curve was prepared using a series of glucose solution with concentration ranging from 100 to 140 ppm, in 10 ppm increments. The glucose concentration in hydrolyzed sample was determined from standard curve, and the starch content was calculated using the following equation:

$$\frac{\text{mg glucose} \times 0.9 \times \text{dilution factor}}{\text{sample weight} \times 1000} \times 100$$

4. Amylose Content

Amylose content was determined calorimetrically (Williams *et al.*, 1970). A standard curve was prepared using a series of amylose (Amylose Type III: from potato; Sigma Chemical Co., St Louis, MO, USA) solutions which varied from 40 to 100 ppm in 20 ppm increments. Amylopectin (potato amylopectin; Sigma Chemical Co., St. Luis, MO, USA) was added into the standard solutions to maintain the amylose content at 75%.

5. Viscoamylograph

A starch sample (6% w/w) was made up in a 500 mL volumetric flask with distilled water, and the pH of slurry was adjusted to 6.5 with 1 N HCl or 1 N NaOH. The viscosity of each starch slurry sample was determined using a Brabender Viscoamylograph (C.W. Brabender Instruments Inc., South Hackensack, NJ, USA) maintained at 75 rpm. Viscosities were determined using the following viscoamylograph temperature program: constant preheating at 30 °C to 95 °C for 44 minutes; constant heating at 95 °C for 30 minutes; gradient cooling down from 95 °C to 50 °C for 30 minutes; followed by constant heating at 50 °C for 30 minutes.

6. Scanning Electron Microscopy

Morphological characteristics of starch were revealed with a scanning electron microscope (Philips SEM 505; N.V. Philips, Eindhoven, The Netherlands) operated at 10 KV using Sputter Coater S 150 B

(Edward, West Sussex, England) for sample preparation. The sample were sprinkled onto double sided tape attached to aluminum stubs and coated with a 150 Å gold palladium layer.

7. Data Analysis

Four replicates were run for each of the following analysis: proximate analysis, starch content and amylose content. The standard deviation was calculated using StatView 4.01 (Abacus Concepts, Berkeley, CA, USA).

RESULTS AND DISCUSSION

1. Proximate analysis

Proximate analysis results from each sample are presented in Table 1. Lipid content of starch samples analyzed in this study was relatively low ranging from 0.00 to 0.08%. Palm starch samples ranged from 0.00 to 0.03%. This value were lower than those found by Zobel (1992) who reported value for corn, cassava and sago starch of 0.75, 0.20 and 0.15% lipid, respectively. The low lipid concentration levels found in these samples may have been due to the extraction solvent employed which was petroleum ether (AOAC method: 7.062). It has been reported (Morrison, 1988) that complete lipid extraction from starch granules requires either acid hydrolysis prior to petroleum ether extraction or extraction with hot high polarity solvents such as methanol or propanol. Lipid in the starch can be divided into lipid from the outside of granule and lipid from inside of the granule.

The protein content of these starch samples ranged from 0.09 to 0.40%. This range agreed with a previous report (Zobel, 1992) for corn, cassava and sago of 0.35, 0.10 and 0.10%, respectively. *Arenga microcarpa* and *A. pinnata* I had higher protein contents than the other palm starches studied, and this may have been due to less intensive water washing during processing.

Dietary fiber content for these samples ranged from 0.36 to 4.16%. Corn starch had the lowest dietary fiber (0.36%) whereas all other samples had concentration >3.64%. These differences are most likely due to processing. Commercial corn starch is processed by intensive purification employing centrifugation, hydro cyclones and filtration (Watson, 1984). The cassava and palm starch samples used in this study were representative of the processing steps employed in Indonesia which water are washing followed by filtration through cloth or plastic screens. Dietary fiber content of cassava and palm starch could be reduced by improving the purification methods used in traditional starch processing.

Table 1. Proximate analysis (% w/w dry basis¹) of different palm starches compared with the standard corn and cassava starches.

Tabel 1. Analisa proximat (% berat/berat bahan kering) dari berbagai pati palma dibandingkan dengan standard pati jagung dan ubi kayu.

Starch samples Contoh Pati	Moisture Air	Lipid Lipida	Protein Protein	Fiber Serat	Ash Abu
Corn	10.33±0.06 ²	0.03±0.02	0.40±0.01	0.36±0.13	0.22±0.02
Cassava	14.18±0.03	0.08±0.01	0.14±0.02	3.85±0.11	0.20±0.03
M. rumphii I	9.10±0.11	0.00±0.00	0.09±0.04	3.75±0.05	0.42±0.02
M. rumphii II	14.80±0.06	0.01±0.00	0.09±0.01	4.15±0.08	0.60±0.06
M. sagu	15.98±0.06	0.03±0.01	0.06±0.03	3.77±0.06	0.15±0.01
A. microcarpa	13.94±0.02	0.02±0.00	0.28±0.04	4.16±0.07	0.16±0.03
A. pinnata I	14.86±0.00	0.01±0.00	0.26±0.01	4.00±0.12	0.36±0.03
A. Pinnata II	12.14±0.02	0.02±0.00	0.12±0.00	3.64±0.09	0.31±0.01

¹ Mean value and standard deviation are based on four replicates.² Nilai rata-rata dan standar deviasi didasarkan pada empat ulangan.

Ash content of these samples ranged from 0.15 to 0.60%. This range is closed to those previously reported for corn, cassava and sago (*M. sagu*) of 0.1, 0.2 and 0.2%, respectively (Zobel, 1992). *M. rumphii* I and II starch samples had the highest ash content of 0.42 to 0.60%, respectively. This may have been due to the high mineral content of the water used during the processing of these materials.

2. Starch

The starch content of these samples ranged from 95.2 to 99.0% (Table 2). The starch content for cassava and palm was lower than that for corn. This difference in starch content can be directly correlated with the high dietary fiber content of these samples compared to the corn samples.

3. Amylose

Corn and cassava starch were shown to have amylose content of 23.4 and 20.1%, respectively (Table 2). This value agree with those reported in literature for corn and cassava starch of 37.7% and 20.7%, respectively (Williams *et al.*, 1970). Each of the palm starch samples had a higher amylose content than cassava and corn starch. Amylose content for these samples ranged from 26.4 to 28.1%. These values were slightly higher than those reported by Karim (2008). Ahmad *et al.* (1999) reported a wide range (24 to 28%) of amylose content from eleven sago (*Metroxylon* species) starch samples. The wide variability in amylose content could be due to the methodology used by each research or the variability in sample sources. The sources and treatments of raw materials before processing vary time to time and from plant to plant, and so the processing method. For example, Karim *et al.* (2008) and Pei Lang *et al.* (2006)

reported that the amylose content varied from the tree growth stages and the upper part and down part of a tree.

4. Shape and size of sample starch granules

Corn granule size ranged from 5-20 µm with average of 11 µm (Table 3). This granule size distribution for corn starch agreed with previous reports (Watson, 1984) of 5-25 µm with an average of 15 µm. Cassava and starch granules ranged from 6-25 µm with average of 11 µm. This result differed from those previously reported (8, 10) of 5-35 µm with an average of 20 µm. *Metroxylon sagu* and *M. rumphii* had similar granule size, ranging from 12-50 µm with average of 27 µm. This range in size was similar to previous reported (Karim, 2008) for sago (*Metroxylon* sp.) of 10-50 µm.

Table 2. Starch and amylose content (% w/w dry basis¹) of different palm starches compared with the standard corn and cassava starches

Tabel 2. Kandungan pati dan amilosa dari berbagai pati palma dibandingkan dengan pati standard jagung dan ubi kayu

Starch samples Contoh pati	Starch Pati ¹	Amylose Amilosa ²
Corn	99.0±0.20 ³	23.4±0.20
Cassava	97.4±0.20	20.1±0.50
M. rumphii I	96.9±0.20	27.4±0.70
M. rumphii II	95.2±0.80	27.3±0.50
M. sagu	97.8±0.40	28.1±1.10
A. microcarpa	97.6±1.00	27.6±1.10
A. pinnata I	97.6±0.10	26.9±1.70
A. Pinnata II	97.6±0.10	26.4±0.60

Mean value and standard deviation are based on four replicates
Nilai rata-rata dan standar deviasi didasarkan pada empat ulangan.

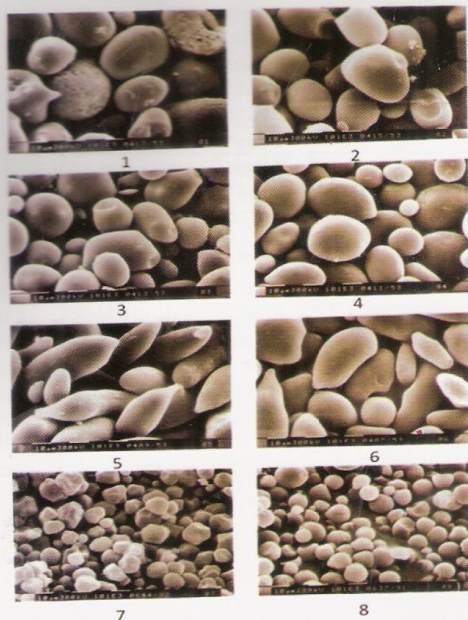


Figure 1. Scanning electron microscopy of various starches 1 and 2. *Metroxylon Rumphii*, 3 and 4. *Metroxylon sagus*, 5. *Arenga pinnata* (Sugar palm), 6. *Arenga microcarpa*, 7. *Zea mayz* (Corn) and 8. *Manihot utilisima* (Cassava).

Gambar 1. Skaning elektron mikroskopi dari berbagai pati. 1 dan 2. *Metroxylon rumphii*, 3 and 4. *Metroxylon sagus*, 5. *Arenga pinnata* (Aren), 6. *Arenga microcarpa*, 7. *Zea mayz* (Jagung) dan 8. *Manihot utilisima* (Ubi kayu).

The granule size of *Arenga* was depend on the species (Figure 1). *Arenga pinnata* granules were elongated and large, up to 70 μm in length. The average granule size of *A. pinnata* I was larger (52 μm) than *A. pinnata* II (35 μm). This difference is most probably due to processing and tree maturity. In traditional processing, shorter precipitation times are used which may result in the loss of small starch granules. The *A. pinnata* I was harvested from mature

tree, whereas the *A. pinnata* II was harvested from immature trees. The granule size for *A. microcarpa* was virtually the same as that found in *Metroxylon* and smaller than that found for *A. pinnata*. The *A. microcarpa* granules had a size range of 15 to 50 μm with an average of 26 μm .

The shape of corn and cassava granules was shown to be a mixture of polyhedral and round for corn and round for cassava. These results agree with a previous report (Jay-Lin *et al.*, 1994). *Metroxylon* and *A. microcarpa* starch had similar granule shapes; oval/egg shape for large and medium granules, and round for small granules. The granules shape of sago starch (*M. sagu*) agree with previous reports (Jay-Lin *et al.*, 1994; Karim *et al.*, 2008).

SEM revealed the presence of holes on some of starch granules (Figure 1.1). The most holes occurred on *M. rumphii* I granules followed by *M. rumphii* II and *A. microcarpa*. The *M. sagu* granules had minimal holes. Although the pores on granule surfaces have been reported as a real anatomical feature of the native corn, sorghum and millet granule structure and not artificial of drying specimen preparation or observation techniques (Fannon *et al.*, 1992), the holes on *M. rumphii* I granule were not have the same feature to that on corn starch granules. The holes in this particular starch granules might have been caused by the action of amylase during starch processing storage. The *M. rumphii* I sample had been stored for more than three weeks at a high moisture content (> 30%) before purchase and drying, whereas *M. rumphii* II and *A. microcarpa* samples had been stored only 4 days before drying. In Indonesia, the piths of *M. sagu* are often stored for weeks before processing.

Scanning electron microscopy of *M. rumphii* I and II, *A. microcarpa* and *A. pinnata* I showed the presence of fragments which adhered to the granule surface. The *A. pinnata* I granules were highly contaminated by these fragments, which might have been dextrin or other polysaccharide compounds such as beta glucan or cellulose. These fragments were not observed on the surface of *M. sagu* and *A. pinnata* II. This fact may be explained by the extensive water washing of these two later raw materials.

Table 3. Shape and size of different palm starches compared with the standard corn and cassava starches.
Tabel 3. Bentuk dan ukuran dari berbagai pati palma dibandingkan dengan pati standard jagung dan ubi kayu.

Starch Samples Contoh pati	Size of Starch Granule (μm) Ukuran dari Granula Pati (μm)		Shape of Granule Bentuk dari Granula
	Range	Average	
Corn	5 - 20	11	Polyhedral
Cassava	6 - 25	11	Round
Sago (<i>M. rumphii</i> & <i>M. sagu</i>)	12 - 50	27	Oval/egg shape
Sago Baruk (<i>A. microcarpa</i>)	15 - 50	26	Oval/egg shape
Sugar palm (<i>A. pinnata</i>)	15 - 70	52	Elongated

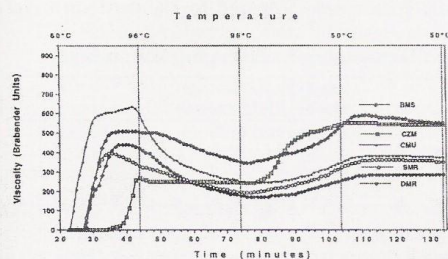


Figure 2. Viscoamylographs of *M. sago* 1 (BMS), Corn (CZM), Cassava (CMU), *M. rumphii* 1 (SMR) and *M. rumphii* 2 (DMR).

Gambar 2. Viscoamilograf dari *M. sago* 1 (BMS), Jagung (CZM), Ubi kayu (CMU), *M. rumphii* 1 (SMR) and *M. rumphii* 2 (DMR).

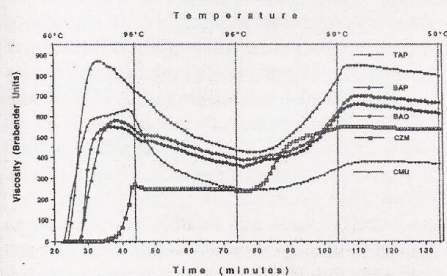


Figure 3. Viscoamylographs of *A. pinnata* 1 (TAP), *A. pinnata* 2 (BAP), *A. microcarpa* (BAO), Corn (CZM) and Cassava (CMU).

Gambar 3. Viscoamilograf dari *A. pinnata* 1 (TAP), *A. pinnata* 2 (BAP), *A. microcarpa* (BAO), Jagung (CZM) dan Ubi kayu (CMU).

5. Viscoamylograph

Table 4 shows the pasting temperature and viscosity of the starch samples used in this study. The initial pasting temperature of corn was the highest (80 °C) observed in these samples, whereas that of cassava was the lowest (60 °C). The initial pasting temperature for cassava agreed with the literature value of 59 °C (Watson, 1984, Jyothi *et al.* 2005). However, the initial pasting temperature of corn which was 80 °C was slightly higher than that previous report (Zobel, 1984) of 73 °C. The initial pasting temperatures of palm starch ranged from 62 to 68 °C. The initial pasting temperature of *M. sago* (66 °C) was close to a previous report of 65–68 °C for sago starch (Mohamed *et al.*, 2008).

The maximum peak pasting temperature for these samples varied from 74 to 96 °C. Corn had the

highest maximum peak pasting temperature (96 °C). Palm starch samples had low maximum peak pasting temperatures (initial and maximum) can be explained by their crystalline structure. Corn which had the highest initial and maximum pasting temperatures has an A-crystal pattern, while cassava and *M. sago* are Ca-crystal pattern (Kawabata *et al.*, 1984). Starch granules with an A-pattern contain a lower concentration of water molecules (Imberty, 1991), and the lower the starch crystal water content the more energy which is required to achieve gelatinization.

Representative viscoamylographs for the eight starch samples used in this study are shown in Figure 2 and 3. Each of the palm and cassava starch samples had a higher maximum viscosity during heating than corn starch. Only *M. sago* had a viscosity similar to that of corn during the low temperature holding period. *Metroxylon rumphii* (I and II) samples had viscosities lower than corn during the low temperature holding period, while *A. microcarpa* and *A. pinnata* had higher viscosity profiles. The higher viscosity observed for *M. sago* when compare to *M. rumphii* during both high and low holding temperatures was most likely due to the extensively damage granules of *M. rumphii* rather than starch origin (see results from SEM; Figure 1). Three palm (*A. pinnata* I, *A. pinnata* II and *A. microcarpa*) samples had viscosities higher than corn and cassava starch during the low temperature holding period. The higher viscosity observed for *A. pinnata* I when compared to *A. pinnata* II might be due to the manner of processing and/or tree maturity. In addition, the *A. pinnata* I sample had the largest average size granules which are surface contaminated as reveal by SEM.

This higher viscosity of the sugar palm starch during the low temperature explain the advantage of the sugar palm starch over the other starch for using fewer starch content in the processing of meat ball. This property can be used also in other application both in food and other industrial uses (Purwani *et al.*, 2006). Fewer starch content means less energy content which concerned for food intake and also less cost for production.

The disadvantages of the palm starch compared to corn starch are the quality of the starches. The results show the high content of protein, dietary fiber and ash and related to the less intensive purification during processing. The other quality problem is related to the present of starch granule damage. Therefore, the improvement of palm starch processing is very important to improve the quality of the starch. By improving the palm starch quality, their properties advantages can be better for new application in food and other industry.

Table 4. Pasting temperature and viscosity of diferent palm starch samples compared to standard corn and cassava starch samples.

Tabel 4. Suhu pasting dan viskositas dari contoh pati palma dibandingkan dengan pati standard jagung dan ubi kayu.

Starch Sample Contoh Pati	Pasting Temperature Suhu Pasting		Maximum Pasting Pasting Maksimum	Viscosity (Brabender Units) Viskositas (Unit Brabender)	
	Initial Awal	Maximun Maximum		After Holding 30 Minutes at 96°C Setelah ditahan 30 Menit pada 96°C	After Holding 30 Minutes at 50°C Setelah ditahan 30 Menit pada 50°C
Corn	80	96	270	240	540
Cassava	60	87	635	245	370
Sago (<i>M. rumphii</i> & <i>M. sago</i>)	66	82	440	345	550
Sago Baruk (<i>A. microcarpa</i>)	68	78	550	360	615
Aren (<i>A. pinnata</i>)	66	81	870	425	800

CONCLUSION

Results from chemical composition analysis among the palm starch samples showed a great deal of similarity. The amylose content of the six palm starch samples studied was higher than that found in cassava and corn starch. All palm starch samples were high in dietary fiber which was likely due to the manner of processing. Therefore, improve traditional palm starch processing could result in higher palm starch quality. Poor starch processing and poor raw material and product handling were most likely responsible for damage granules and the presence of chemical fragments on granule surfaces. Variability in granule size and shape was found among the palm species. *Arenga pinnata* had the largest and *A. microcarpa* had the smallest granule size. The variability in granule size and shape, damage granules and the presence of chemical fragments appear to be responsible for the variability in the viscosity profiles observed among the palm starch samples. High pasting viscosity of sugar palm starch had advantages over other starches that can be some specific application in food and other industrial uses.

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