Effect of hydrothermal treatment on physicochemical of arenga starch

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Abstract. Native arenga starch has several disadvantages such as easy retrogradation and syneresis and tends to be unstable to acid and heat conditions. Physical modification was carried out on arenga starch which has limitations in the application of food products. Hydrothermal treatment is a physical starch modification technique by combining moisture and heat. This study aimed to modified arenga starch with Heat Moisture Treatment (HMT) and Autoclaving-Cooling (AC) treatment and investigate the properties of modified arenga starch. This study was conducted experimentally using a completely randomized design (CRD) with 7 treatments and 3 replicates. The treatments in this study were native arenga starch (control), HMT heating time (3, 4, and 5 hours) and AC cycle (1, 2, and 3 cycles). The data obtained were statistically analyzed using Analysis of Variance (ANOVA) followed by Duncan's multiple range test (DMRT) at the 5% level. The result shows that hydrothermal modification of starch can improve the physicochemical properties of arenga starch. Modification arenga starch by HMT and AC resulted moisture content ranging from 6.76%-10.24%; amylose content 41.55%-55.79%; amylopectin content 44.86%-58.45%; can increase the value of water holding capacity and oil holding capacity and decrease the swelling power and solubility values. The decrease in peak gelatinization of HMT and AC modified starch which was also followed by a decrease in breakdown showed that the modification was able to increase the stability of starch paste during heating, pressure, and freezing.

1 Introduction

Plantation commodities play an important role in improving the economy in Indonesia. Palm plant (*Arenga pinnata*) is a plantation commodity that has the potential to be developed. The components of the palm plant include sap, leaves, fruits, roots, and stems of economic value. The use of palm plants is still limited, especially in the stem which is rich in starch content. Starch accumulated in the pith of palm plant stems can be obtained through the extraction process. Arenga starch has the potential to be developed in the food industry. The high carbohydrate content in arenga starch can substitute other starch sources in food processing.

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The use of native arenga starch is still limited because it has several disadvantages related to retrogradation, viscosity and low paste resistance. This condition is the reason for the need to modify starch to improve the characteristics of natural arenga starch [1].

Starch modification can be done physically, chemically, and enzymatically. Physical starch modification is generally done because it is simpler and tends to be safer than chemical modifications that leave residues. Physical starch modification can be done by hydrothermal treatment. Hydrothermal treatment combines heating and moisture in the modification process. Physical modification by hydrothermal treatment can improve the physical, chemical, and functional characteristics of starch. Heat Moisture Treatment (HMT) and Autoclaving-Cooling (AC) are physical starch modification methods that utilize the heating and moisture process in starch with a certain moisture content.

The HMT method with temperature treatment and heating duration can improve the physicochemical characteristics of potato starch and improve the starch paste profile to be more stable in lotus starch [2, 3]. The AC method with two-cycle treatment on taro starch modification affects swelling *power,* solubility, resistant starch and starch amylography properties [4]. The three-cycle AC treatment affects canna starch resistant starch levels and can increase the solubility, water-binding capacity, and development rate of jackfruit seed starch [5, 6]. No research has been conducted on the modification of arenga starch by *heat moisture treatment* and *autoclaving-cooling* methods. The purpose of this study was to determine the characteristics of arenga starch modified by Heat Moisture Treatment (HMT) and Autoclaving-Cooling (AC).

2 Materials and methods

2.1 Materials

The material used for starch extraction is the pith of palm stems and water. The materials used for analysis are aquades, amylose standart (Sigma-aldrich), NaOH 1N (merck), acetic acid 1N (merck), ethanol 95% (merck), iodine 0.2% (merck), and olive oil.

Starch extraction used palm stem pith shredding machines, basins, filter cloths, baking sheets, drying ovens, and 100 mesh sieves. The analytical equipment used is an autoclave, refrigerator, HDPE plastic, jar bottle, aluminum foil, rubber, porcelain dish, oven, desiccatator, analytical scale, centrifuge tube, vortex, spatula, waterbath, petri dish, hot plate, test tube, test tube rack, beaker glass, tongs, 100 ml measuring flask, 5 ml volume pipette, UV-Vis spectrophotometer, and cuvette.

2.2 Arenga starch production

Starch extraction consists of grating, filtration with the addition of water, precipitation, drying and grinding. The pith of the palm stem is grated, the results of the grated stem are then added water until submerged and then filtration is carried out. The filtration results are then precipitated and washed until the precipitated water is white. The precipitate obtained is then dried and ground. The milling results are then sifted using a 100mesh sieve to obtain smooth and homogeneous starch [1].

2.3 Heat moisture treatment modification

Arenga starch with 25% water content, then stored at 5°C for 1 night. Heating is carried out using an oven at a temperature of 110 ° C with a long HMT heating treatment of 3 hours, 4 hours and 5 hours. The starch is then immediately cooled to prevent further gelatinization, and dried at 50°C for 24 hours [7].

2.4 Autoclaving cooling modification

Arenga starch is suspended in 20% water (given a 20% moisture content setting treatment), then the starch is packaged in HDPE plastic and stored in the refrigerator at 4 ° C for 12 hours so that the water distribution on the starch is evenly distributed. Starch that has been regulated water content is then heated using an autoclave at 121 ° C for 15 minutes. The starch is then immediately cooled at room temperature for 1 hour to prevent further gelatinization. Furthermore, the starch was retrograded by cooling at 4°C for 24 hours. For autoclaving-cooling treatment 2 and 3 cycles, the heating process is repeated with an autoclave and cooling temperature of 4 °C one and two more times [4]. Modified Starch is measured water content [8], amylose and amylopectin content [9], water holding capacity [10] and oil holding capacity [11], swelling power and solubility [12].

3 Results and discussion

3.1 Water content

The water content modified arenga starch is lower than the water content of native arenga starch, but there is an increase in water content as the heating time of heat moisture treatment (HMT) and autoclaving cooling (AC) cycles increases (Fig. 1). The moisture content of HMT modified arenga starch ranges from 6.76% - 8.45%, where HMT 3 treatment with 5 hours heating produces the highest water content. This is in line with research on the modification of purple yam starch with HMT treatment, resulting in increased water content with increasing temperature and length of heating time [13]. The decreased water content compared to natural starch is caused because during the modification process there is evaporation of water in the starch due to the heating process. The results of research on the modification of sword koro bean starch, there was a decrease in water content at heating temperatures of 110°C for 13 hours and 16 hours [14].

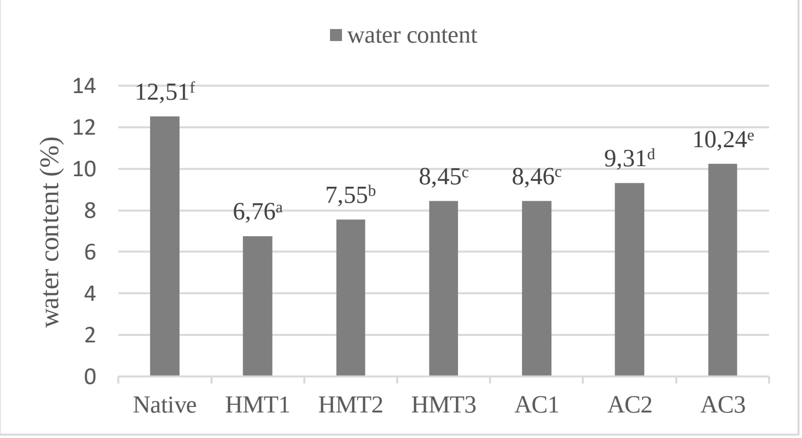

Fig. 1. Water content of native arenga starch, HMT and AC arenga starch.

Increased water content of modified arenga starch *autoclaving cooling* (AC) occurs as the cycle increases. The water content of AC modified arenga starch is lower than the water content of native arenga starch ranging from 8.46%-10.24%, with the highest water content in the three-cycle treatment. This can be due to the high amylose content in modified starch. Amylose has a straight structure so it easily absorbs water and releases it back. Materials with high amylose content will affect water content, where water is easily absorbed and released when given a modified treatment.

3.2 Amylose and amylopectin content

Native arenga starch amylose levels increased after modification with heat moisture treatment (HMT) and autoclaving cooling (AC) (Fig. 2). The amylose content of HMT modified arenga starch increases with the longer the heating is carried out. Increased amylose levels are associated with starch chain interactions in the *amorphous* granule area during the HMT process. Research on HMT modification in starch from 3 rice varieties that have different amylose content ranging from low, medium, to high is also proven to increase the amylose content of starch after HMT modification [15]. Amylose content of AC modified starch increased compared to native starch, increased up to 2 cycles of treatment, but decreased in 3 cycles of treatment. Research on *autoclaving-cooling* modification in cowpea starch with cycle differences, there was a decrease in amylose levels than the 3-cycle treatment, but increased in the 5-cycle treatment [16]. Increased amylose levels also occur in modified taro starch with two cycles of AC treatment [17]. Starch modification with AC can increase starch amylose content through the breakdown of amylopectin. The repeated process of AC modification leads to rearrangement and an increase in the degree of association of starch constituent molecular chains that strengthen starch bonds.

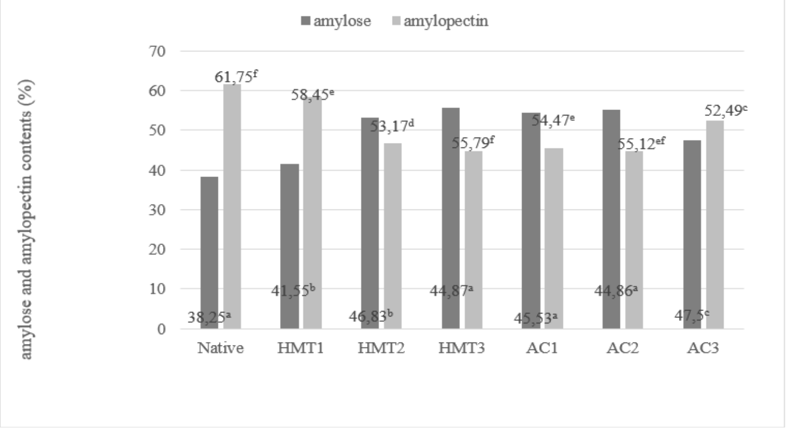

Fig. 2. Amylose and amylopectin contents of native arenga starch, HMT and AC arenga starch.

3.3 Water holding capacity and oil holding capacity

The results showed that the WHC and OHC values of native arenga starch increased after being modified with heat moisture treatment (HMT) and autoclaving cooling (AC) (Fig. 3). The heating process can lead to an increase in the value of the binding capacity of water because the amorphous part undergoes development so that some hydrogen bonds between the amorphous part and the crystalline part will break and then bond with hydrogen from water. Starch that contains high amylose levels will have a high water absorption capacity so that the increase in the WHC value of modified arenga starch in HMT and AC along with the increase in amylose levels it contains. Research on AC-modified cowpea starch resulted in WHC values that increased with increasing AC cycles. The WHC value can be influenced by several factors, including the amount of fiber, amino acid composition, and amylose-amylopectin ratio.

The increase in OHC value of HMT arenga starch and AC along with the longer heating process and AC cycle carried out. The HMT process can break down starch granules causing the granules to stretch and making it easier for oil to enter the granules that are firmly bound by hydrogen bonds. The results of the same study on HMT modified koro bean starch, water absorption capacity increased in natural sword koro bean starch after HMT modification with a temperature of 110 ° C for 10 hours, 13 hours and 16 hours [14].

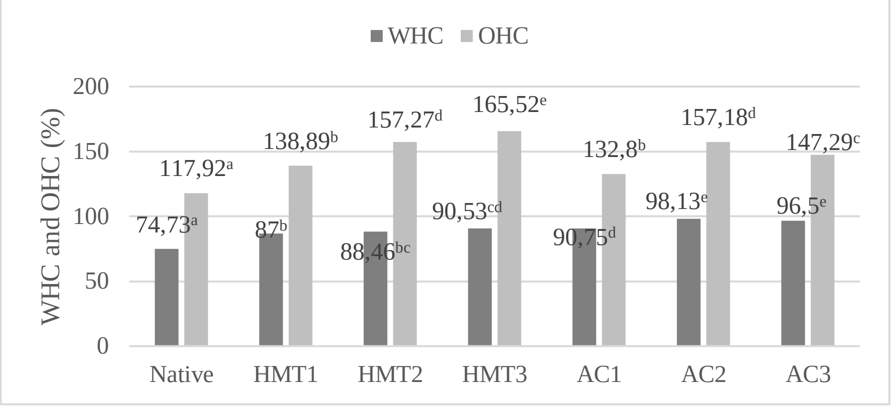

Fig. 3. WHC and OHC values of native arenga starch, HMT and AC arenga starch.

Modification with AC can also increase the ability to hold oil or OHC modified arenga starch. This is in line with research on the modification of white koros word flour with AC treatment has increased the ability of fat binding (OHC) from 106% to 116% [18]. The same thing also happened to AC-modified cowpea starch with cycle difference treatment, there was an increase in starch OHC value along with the increase in autoclaving-cooling cycle [16].

3.4 Swelling power and solubility

The swelling power value produced by modified starch is lower than native arenga starch, both in HMT and AC modified starch. There is a decrease in the value of swelling power along with the increase in the length of time to warm starch in the HMT process (Fig. 4). The decrease in swelling power value in native arenga starch after HMT modification also occurred in lotus starch, where the swelling power value of native lotus starch which was 9,434 dropped to 9,113 after HMT modification [3]. HMT modification of purple yam flour can also reduce the value of swelling power and solubility [19].

The decrease in the swelling power value of AC modified arenga starch occurs along with the increase in the AC cycle. Hidrothermal treatment decreased swelling power of starch due to the rearrangement of starch granules after heat and moisture treatment. A decrease in swelling power value also occurred in AC-modified taro starch in the two-cycle treatment [17]. The solubility value of HMT modification increases with the increase in starch heating time in the HMT process. The same result occurred in HMT modified yellow pumpkin flour which experienced an increase in solubility value after modification with a long modification time treatment [20].

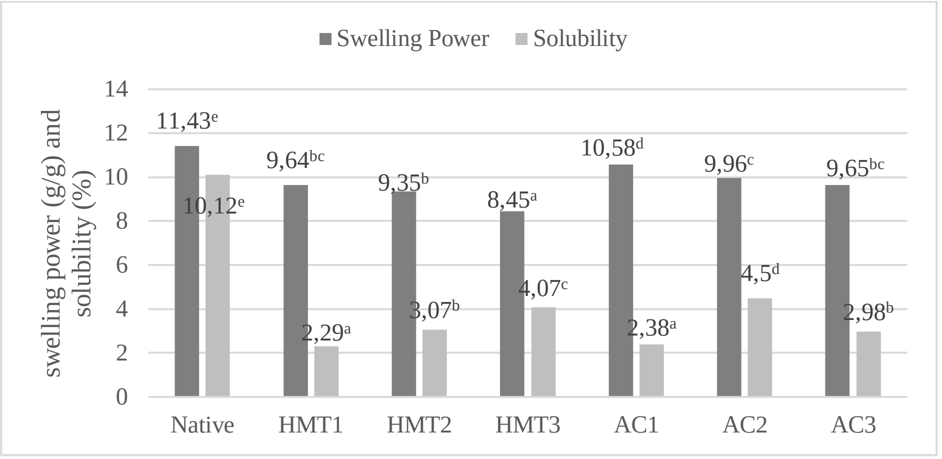

Fig. 4. Swelling power and solubility of native arenga starch, HMT and AC arenga starch.

The higher the temperature, the more amylose comes out of the starch granules so that the solubility value or solubility of yellow pumpkin flour is also higher [20]. The solubility value of starch increased in the two-cycle treatment, but there was a decrease in the three-cycle treatment. Similar research results on modified taro starch resulted in increased solubility values after being treated with two cycles of AC [17] This is closely related to the levels of amylose that modified starch produces.

3.5 Pasting properties

The gelatinization profile of starch can be measured using a rapid visco analyzer, which presents data on peak time, gelatinization temperature, peak, trough, breakdown, setback, and final viscosity. The application of starch depends on the viscosity properties of the starch. Starch modification can change the characteristics of starch. This is seen in Table 1 and Fig. 5.

Table 1. Rapid-visco parameters of native and modified arenga starch.

Sample	Peak Time (min)	Pasting Temp. (°C)	Peak	Trough	Breakdown	Setback	Final Viscosity
			(Cp)				
Native	6,87	76,85	6167,00	2153,00	4014,00	1504,00	3657,00
HMT 1	7,40	79,45	3594,00	1952,00	1642,00	1960,00	3912,00
HMT 2	7,67	79,45	3076,00	1648,00	1428,00	1519,00	3167,00
HMT 3	7,73	79,90	2582,00	1401,00	1181,00	1147,00	2548,00
AC 1	6,93	77,60	4758,00	2538,00	2220,00	2301,00	4839,00
AC 2	7,40	79,90	3765,00	2104,00	1661,00	2193,00	4297,00
AC 3	7,07	78,65	4515,00	2169,00	2346,00	2627,00	4796,00

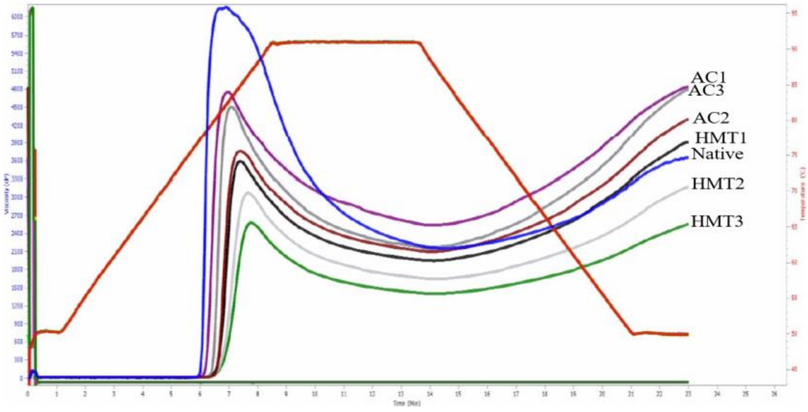

Fig. 5. Pasting profile of native arenga starch, HMT and AC arenga starch.

The increased gelatinization temperature in HMT and AC modified starch compared to native starch, indicates changes in the structure of amylose and amylopectin in starch. The peak gelatinization and breakdown of natural starch decreases with starch modification. This shows the stability of native starch on heating and lower pressure than HMT and AC-modified starch. The decrease in peak gelatinization of HMT and AC modified starch which was also followed by a decrease in breakdown showed that the modification was able to increase the stability of starch paste during heating, pressure, and freezing. AC and HMT can change the profile of starch paste during the heating process [17].

4 Conclusion

Modification of arenga starch by HMT and AC can improve the physicochemical characteristics of native arenga starch. The longer HMT heating time causes changes in the characteristics of arenga starch including an increase in water content, amylose content, WHC, OHC, and solubility, but decreases swelling power. Modification with HMT and AC produces arenga starch paste that is more stable than native arenga starch. AC modification can improve the physicochemical characteristics of arenga starch in one and two cycle treatments, but there is a decrease in amylose levels, solubility values, WHC and OHC values in three-cycle treatments.

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