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Profiles of Modified Sago Starch by Heat Moisture Treatment and Autoclaving-Cooling

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Abstract: *The aim of this research was to examine the effect of starch modification using heat moisture treatment (HMT) combined with autoclaving-cooling on profiles of sago starch. There were 5 types of sago starches to be analyzed. They were native sago starch (A), modified sago starch with 15 minutes of autoclaving and 5 cycles of autoclaving-cooling (B), modified sago starch with 15 minutes of autoclaving and 6 cycles of autoclaving-cooling (C), modified sago starch with 30 minutes of autoclaving and 5 cycles of autoclaving-cooling (D), and modified sago starch with 30 minutes of autoclaving and 6 cycles of autoclaving-cooling (E). The profiles of sago starch included granular morphology (SEM), crystallinity pattern (X-RD), gel strength and whiteness degree. Sago starch profile data were presented in tables and figures. The results showed that modification of sago starch using combination of HMT and autoclaving-cooling methods resulted in a slight change on the starch surface, an increase of gel strength, and a decrease of whiteness. The crystallinity pattern of sago starch changed from C type to A-type.*

Keywords: autoclaving, HMT, profile, sago starch

1. Introduction

Sago starch (*Metroxylon sago*) is a staple food for some people in Indonesia, such as people in eastern Indonesia. Furthermore, sago starch is also used as raw material of traditional foods, such *bagea*, *papeda*, *putu*, *pempek*, *tekwan*, *lapis* cake, and some cookies [1][2][3]. The sago production in Indonesia is found in Maluku, Papua, Kalimantan, Sulawesi, Mentawai Islands, Riau, West Java, Bengkulu, Jambi, Lampung, and Bangka-Belitung [4][5][6]. The use of sago starch for food processing is still limited which is due to unfirmed sago paste. This unfirmed sago paste will affect the characteristics of food product; therefore, modification of sago starch is needed to improve the characteristic of sago starch.

Heat moisture treatment (HMT) and autoclaving-cooling are physical methods of starch modifications. HMT is a heating process at the temperatures 100 to 120 °C for 2 to 18 hours in oven. Moisture content of starch for heat moisture content is limited (≤35%) [7][8][9][10]. Autoclaving-cooling is a combined process consisting of heating and cooling. The temperatures of heating range from 100 to 148 °C for 15 to 60 minutes in autoclave. Autoclaving-cooling could be performed more than a cycle [11][12][13].

Each method of modification had different effects on the starch characteristics, especially on profiles of starch. HMT process could result in changes on granular surface of rice and moonbeam starches [7][10]. Unlike the effects on rice starch, HMT did not have significant changes on granular morphology of some tubers and nuts [9]; however it changed the crystallinity pattern of starch [14][15]. Autoclaving-cooling process resulted in change on granular morphology and relative crystallinity of starch [16][17]. The changes on sago starch by the combination of HMT and autoclaving-cooling was expected to improve its characteristics.

The aim of this study was to determine profiles of modified sago starch by heat moisture treatment (HMT) and autoclaving-cooling, particularly the sago starch granule morphology, crystallinity pattern, gel strength and degree of whiteness.

2. Materials and Methods

2.1 Material

This study used native sago starch from Bangka Belitung Province, Indonesia. There were 5 types of sago starch as samples, namely native sago starch [A], modified sago starch: (15 minutes of autoclaving and 5 cycles of autoclaving-cooling) [B], modified sago starch: 15 minutes of autoclaving and 6 cycles of autoclaving-cooling [C], Modified sago starch: 30 minutes of autoclaving and 5 cycles of autoclaving-cooling [D], and modified sago starch: 30 minutes of autoclaving and 6 cycles of autoclaving-cooling [E].

2.2 Modification of Sago Starch

The sago starch was adjusted to achieve 30% of moisture content for HMT process. The sago starch was placed in a jar and closed tight with its lid, then it was covered by flexible plastic bag. Afterwards, it was kept in a refrigerator at 4°C for 24 hours. After that, it was heated into autoclave at 121 °C for 15 and 30 minutes (autoclaving). Then, sago starch was stored at 4 °C for 24 hours (cooling). This process was considered as one cycle of autoclaving-cooling [18][19].

2.3 Starch Granule Morphology

The sago starch was sprinkled on double-sided adhesive tape attached to the aluminum stub. Then it was coated with 20 nm gold under vacuum. Sago starch was observed and photographed using a Scanning Electron Microscope (SEM) at 20 kV acceleration [10].

2.4 Crystallinity Pattern (X-RD)

Sago starch was mixed with pure water. Then it was shaken until the coarse grains separated. The suspension were dropped on the preparation and allowed to dry at room temperature for 24 hours. The specimens were analyzed by XRD (X-ray Diffraction) in the 5 to 80^o (2θ) of scanning area [15].

2.5 Gel Strength and Whiteness Degree

The gel strength of sago starch was measured by texture analyzer [20], whereas the whiteness degree of sago starch was measured by the whiteness meter [21].

3. Results and Discussion

3.1 Starch Granule Morphology

Starch granule morphology of native and modified sago starch was shown in Fig. 1. Analysis granular morphology was to investigate the microstructure of modified sago starch as processed by heat moisture treatment and autoclaving-cooling. The images showed that there was a difference on the granular surface of native sago starch and modified sago starch. The shape of native sago starch granules was oval and some starches were round and smooth on granule surface. Some of the starch granules were truncated side [22].

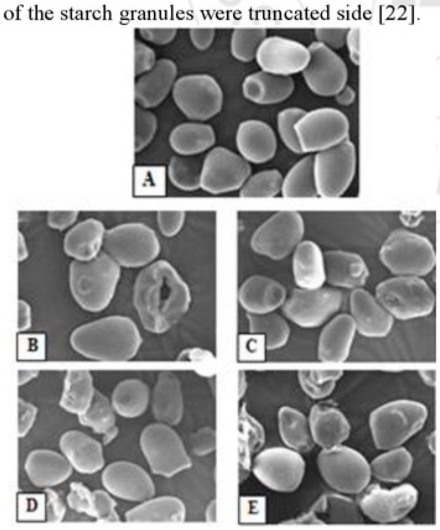

Figure 1: The morphology native (A) and modified sago starch (B, C, D and E) granules

Modified sago starch with a combination of HMT and autoclaving-cooling resulted in a slight change on granular surface and the surface of granules seemed to be rough as shown by the microstructure images. The more cycles applied on sago starch resulted in more changes in the sago starch.

Partial gelatinized starch occurred during HMT due to the limited amount of water in starch; therefore there was only slight damaged on the starch surface. On the hand, more damages on starch surface would appear in higher amount of moisture content in starch [16].

3.2 Crystallinity Pattern

The crystallinity pattern of sago starch was determined by X-ray Diffraction (Fig. 2). The results showed that native sago starch had a strong peak at 5^o to 6^o, 15^o to 20^o, and 23^o to 25^o (2θ). The peaks were 5.88^o, 17.06^o, 18.10^o, 20.10^o, 23.00^o, and 24.72^o (2θ). Native sago starch origins from Bangka-Belitung could be classified as C-type starch granules. Previous studies had shown that sago starch granules were classified as type C starch granules [14][23]. The starch granules of type C were combination of starch granules of A- and B- type.

The modification with combination of HMT and autoclaving-cooling methods changed the crystallinity pattern of sago starch. Sharper peaks were found at 15^o to 20^o (2θ) and 23^o to 25^o (2θ). This indicated that modified sago starch granules were classified as A-type. The change was caused by damage of starch granules structure due to the heating process [17]. Some studies showed that modification with limited moisture content resulted in changes on crystallinity pattern of starch [14][23].

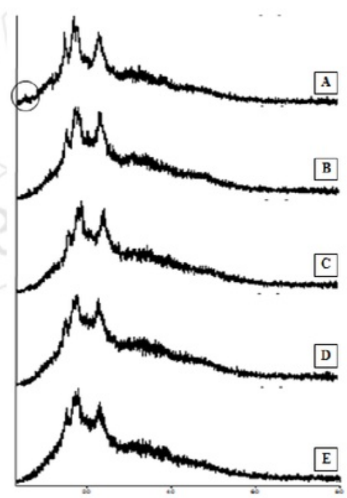

Figure 2: The crystallinity pattern of native (A) and modified sago starch (B, C, D and E)

3.3 Gel Strength

The results showed that the gel strength of native sago starch increased after modification (Fig. 3). The gel strength of native sago starch was 70.92 cP, while the gel strength of modified sago starch was124.70 to 184 cP.

The previous studies showed that gel strength of modified cassava, pinhao and corn starch were higher than native cassava, pinhao and corn starch after modified with limited moisture content [15][12]. Autoclaving-cooling cycles resulted in increasing of gel strength of sago starch. The gel strength was influenced by starch retrogradation. Increasing of gel strength of modified was also influenced by swelling power and solubility index. Decreasing of swelling power and solubility index would cause increasing of gel strength of starch [15].

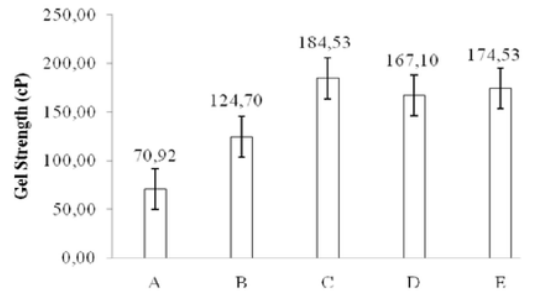

Figure 3: The gel strength of native (A) and modified sago starch (B, C, D and E)

3.4 Whiteness Degree

The whiteness degree of native sago starch was 91.23%, while the whiteness degree of modified sago starch was 84.64 to 87.18% (Fig. 4). The whiteness degree of sago starch decreased after modification. The previous studies showed that the whiteness degree and brightness of sweet potato and jicama starch were lower than native sweet potato and jicama starch.

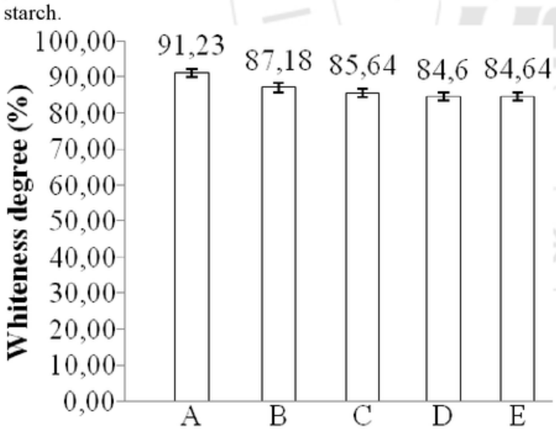

Figure 4: The whiteness of native (A) and modified sago starch (B, C, D and E)

The heating process caused gelatinization. It resulted in formation a starch paste. The paste color of modified starch was darker than native starch. The limited moisture content resulted in partial gelatinization on starch, so the decreasing of whiteness degree was not too large. The whiteness of modified sago starch was decreased due to non-enzymatic browning reactions (Maillard reaction) during heating. The Maillard reaction resulted in a decrease of brightness of sago starch, therefore the value of whiteness degree of sago starch decreased.

4. Conclusion

Modified of sago starch by HMT and autoclaving-cooling resulted in a slight change on the surface of starch granule, an increase of gel strength and a decrease of whiteness. The crystallinity pattern of modified sago starch which was initially C- type changed to A- type.

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