Physically modified of sweet potato flour (*Ipomea batatas*) by variation of steaming time and drying method

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Abstract. The major component of sweet potato flour is carbohydrate presented as starch. As other types of native starch that lack of physical and chemical characteristics, the sweet potato flour then is very limited in use. To improve the starch characteristics, it can be made by modifying the starch physically. This study was focused on modification of starch phisically by using *autoclaving-cooling method* with differ in steaming times (15 and 30 minutes) and drying methods (oven and sun drying). The results showed that the modified flour of sweet potato by autoclaving-cooling for one cycle has produce sweet potato flour with a granular structure that can expand and break, lower in starch content, higher in freezing and thawing stability, higher in water absorption index, and lower in hot and cooling viscosities.
Keywords: Sweet Potato, Autoclaving-Cooling, modified starch.

Introduction

Sweet potato (*Ipomoea batatas* L.) is one of crops that grow over Indonesia regions, including Aceh, besides it's easier to plant and maintain, sweet potato can be a source of reliable food. Indonesia is the second largest sweet potato producer after China. The production of sweet potato in Indonesia in 2011 reached 2,192,242 tons (BPS, 2012) and Aceh province in 2011 covering about 1,137 ha with a total production reached 11,844 tons (BPS Aceh Province, 2012).

Native starches such as starch that contained in sweet potato are very limited in use for food industry, because it has higher viscosity, highly cohesive, stable at low temperatures, and unstable when applied in foods with a low pH (Smith, 1999). Modification techniques of sweet potato starch can be made by modifying it physical and chemical from native. A technique that widely used in modifying starch physically is by using autoclaving-cooling method. Modification of starch is conducted to facilitate their use in the food industry, more stable in the process, better texture, have functional properties that are not owned by the unmodified starch, and its consistent so that the process can be controlled.

Physical modifications on the sweet potato flour has been done by Syamsir and Honestin (2009) through a steaming treatment with several drying techniques, but without being followed by a cooling cycle before drying, so it is assumed that has unable to change the physical and chemical properties of flour.

This study aimed to determine differences in characteristics of sweet potato flour with and without modification as well as to determine the effect of steaming time and drying method on the physical and chemical properties of sweet potato flour.

Materials and Methods

The experiment was conducted in Vegetable Processing laboratory, Food Microbiology Laboratory, Food Analysis laboratory and Organoleptic laboratory Department of Agricultural Product Technology University of Syiah Kuala Banda Aceh on October – December 2012.

This research utilized sweet potatoes with purple skin and yellow flesh, could be used in this experiment were obtained from Saree village, District of Aceh Besar, Sodium metabisulfite, water. Analysis materials were aquadest, ethanol, ether alcohol, HCl, NaOH, Anthrone, glucose standard, acetic acid and H_2SO_4. The equipments could be used in bread making: basin, knives, refrigerator, autoclave, slicer, filter, mixer, proofer, oven, 80 mesh sieve, blender, and pan. Analysis equipments were light microscope with camera nicon eclipe, glassware, oven, porcelain dish, furnace, sokhlet, spectrophotometers, hot plate, analytical balance, and centrifuges.

Modification of Sweet Potato Flour

Modification of sweet potato starch was done by the physical modification methode of autoclaving - cooling (Lehman modified method, 2002). The experiment was arranged in a factorial arrangement. The first factor was drying methods consisted of two levels; oven and Sun and the second factor was steaming time consisted of 2 levels; 15 min and 30 minutes. This research was divided into two phases, namely making of sweet potato flour, and modification of sweet potato flour.

In making of sweet potato flour, fresh sweet potato, peeled, washed, soaked in a solution of sodium metabisulphite 0.3 % to prevent sweet potato to be brown and then washed it. Sweet potatoes were shredded then dried in oven with a temperature 60 °C for 13 hours. Dried sweet potato was blended and sieved with 80 mesh, then packed in polypropylene. Next step on modification phases, sweet potato flour 500 g put into glassware of 1000 ml, suspended in water 25 % w/v. The suspention was heated at 70 °C while stirring until homogeneous and thickens . Suspension was autoclaved for 15 and 30 min at 121 °C and cooled at room temperature for 1 hour, then stored at 4 °C for 24 hours . Material was dried in oven at 60 °C for 14 hours, grounded, sieved with a 80 mesh and packaged using a polypropylene plastic.

Analysis

Analysis performed on modified and unmodified sweet potato flour includes physical analysis of bulk density (Khalil, 1999), the starch granules (Ropiq et al., 1988), IPA (Water Absorption Index) and IKA (Water Solubility Index) (Anderson centrifugation method, cited by Muchtadi et al., 1988), viscosity (modified Hubeis, 1985) and freezing and thawing stability (Bello-Perez et al., 2002), and chemical analyzes include moisture content, ash, and starch (Apriyantono et al., 1989).

Result and discussion

Yield of sweet potato flour was 22.26 %. According to Alivia (2005) the average yield of sweet potato flour reached 27.4 %.

Physical and chemical properties of yellow sweet potato flour in this study can be seen in Table 1. Value of moisture content and ash content somewhat different from the results of Susilowati and Medikasari (2008) that the water content of 6.77% and 4.71 % ash content. Drying temperature and duration of treatment in the processing of flour will greatly affect the water content of the product.

Modification of sweet potato flour through a process of heating and cooling processes lead to gelatinization and retrogradation. During retrogradation, molecules of amylose with amylose and amylose with amylopectin bind back to each other through hydrogen bonding which causes the starch to be more compact structure, heat resistance, and more difficult to undergo hydrolysis by the enzyme amylase (King and Shindu 2000). This is due to the amylose fraction easier and faster experience than amylopectin retrogradation (Shin et al. 2007).

Yield of sweet potato starch modified after grounding and sieving with 80 mesh was about 32%-38.10%. The yield of modified starch was not very high. It could be caused by a number of solids from the sheets of dried flour that were difficult to refine, modified sweet potato starch was more crystalline form because retrogradation process. At the time of grinding, the product being a bit harsh, and most of them did not pass 80 mesh screening

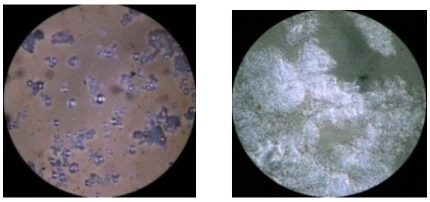
Table 1 . Physical and chemical properties of sweet potato flour

Compounds	Unmodified sweet potato flour	Modified sweet potato flour 1 cycle, 15 minutes, sun drying
Moisture (%)	7,39	7,89
Ash (%)	3,33	2,44
Starch (%)	58,59	47,94
Bulk Density	0,46	0,47
Freeze thawing	78,74	75,63
Water absorption index	2,11	6,13
Water solubility index	0,17	0,17
Hot Viscosity	120	50
Cold Viscosity	319	60

Physical Properties

a. form of granules

Captured using a light microscope at a 40 times of magnification, showed the shape and size of the starch granules microscopically different. Shape of sweet potato starch granules captured in this study were polygonal, round and oval with a variety of granule sizes. The similar results was reported by Siregar and Honestin (2009) which indicated the starch granules were polygonal, round and oval with a variety of granule sizes ranging from 2-10 µm. Influenced The variation starch granule sizes were influenced by deriving of starch. The shape and size of modified sweet potato starch granules and without modification were shown in Figure 1.



a b

Figure 1. Sweet potato starch granules (a) before modification, (b) after 1 cycle of modification with 15 min sun drying.

Based on the analysis, unmodified starch had a granular form intact or round while the modified ones (1 cycle of 15 min) had a broken granules (Figure 1). Heating of starch at above the gelatinization temperature will cause the starch granules swell and then burst. Sunarti et al. (2007) noted that the rupture of starch granules that have been modified due to the heating process at high temperature .

b . Bulk density

Bulk density is an important physical properties of flour which plays a role in the storage, transportation and marketing. A material expressed as a bulk material if the bulk density value is small. Sweet potato flour without modification had bulk density of 0.46 g/ml. This result was in line with Siregar and Honestin (2009) that the sweet potato flour had bulk density between 0.40 to 0.69 g/ml.

The results showed that bulk density of modified sweet potato flour ranged from 0.38 to 0.57 g/ml with an average of 0.48 g/ml. The modifications produced flour with a relatively high density compared to unmodified flour. It assumed that starch gelatinization process that occurs during the heating and the retrogradation process could increase in bulk density. Analysis of variance showed that the interaction between the drying method and heating time and drying methods significantly effects ($P \leq 0.05$) on the bulk density, while the heating time was not significant effect ($P > 0.05$) on the bulk density on modified sweet potato flour .

Based on Figure 2, the value of bulk density tended to decrease with increasing steaming time. This was assumed that the steaming process caused granules starch were gelatinized and swell. Swelling of granules because of gelatinization processcould make starch granules burst and amylose out of the granules. Amylose has gone out will reunite and bind back with amylopectin in the edge of granules such as a nets when cooling so that granule particle size becomes larger due to there are cavity between the granules.
Ade et al. (2009), argued that if the density of the material with a small bulk density value would require more space than the materials with large density for the same weight so it is not efficient in terms of storage and packaging.

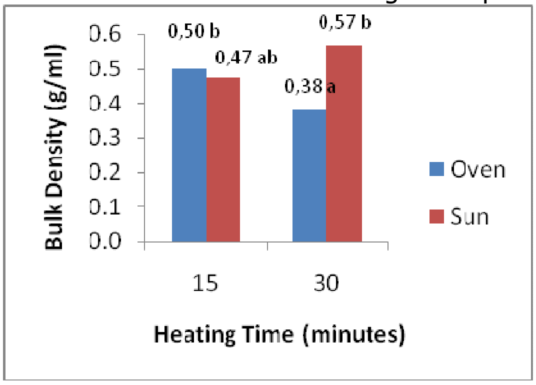


Figure 2. The bulk density values of modified sweet potato flour

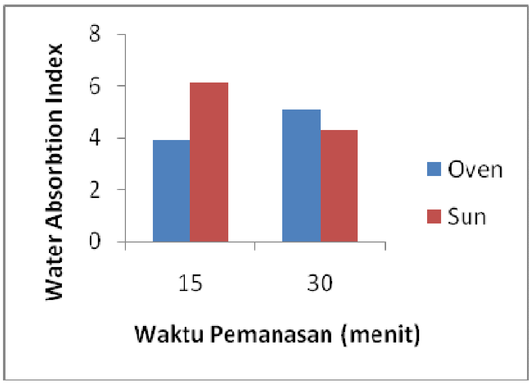


Figure 3. Water Absorption Index of modified sweet potato flour.

c. Freezing and Thawing Stability

Analysis of the freezing and thawing stability of modified sweet potato starch were ranged from 72.91 to 77.17% with an average of 75.62%. This result is lower than the stability of sweet potato flour without modification 78.74%. Analysis of variance showed that the steaming time, drying methods and the interaction between them were not significantly effect ($P>0.05$) on the viscosity of hot and cold modified sweet potato starch.

d. Water Absorption Index and water solubility index

Results of water absorption index ranged from 3.91 to 6.13 with an average value of 4.85 while the water solubility index values ranged from 0.14 to 0.19 with an average value of 0.17. Analysis of variance showed that the interaction between the steaming time and drying methods had significantly effect ($P<0.05$) on water absorption index of modified sweet potato flour, while the steaming time and the drying method were not significant effect ($P>0.05$) on water absorption index of modified sweet potato flour.

According Khasanah (2003), after having starch gelatinization there would be a degradation of amylose and amylopectin to produce smaller molecules. Relatively smaller molecules will be soluble in water.

e . Viscosity

Hot viscosity was measured at a temperature of 70-80 °C, while the cold viscosity was measured at a temperature of 26-27 °C. The highest hot and cold viscosities of sweet potato flour without modification was 120 cP and 319 cP. From these results was shown clearly that in cold conditions starch has a higher viscosity than in hot conditions. The viscosity of modified sweet potato flour was much lower than the sweet potato flour without modification. The results of hot viscosity ranged between 40-80 cP with an average value of 55 cP, while the cold viscosity ranged between 40-120 cP with an average value of 80 cP. Steaming process causes damage to the starch granules and reduce its viscosity. Sunarti et al. (2007), also noted the similar results that the viscosity or gel strength of the flour decreased due to the release of amylose from the broken starch granules due to heating. Rupture of starch granules that have been modified affect its ability to form a gel.

Analysis of variance showed that the steaming time, drying methods and the interaction between them did not affect significantly (P>0.05) on the viscosity of hot and cold modified sweet potato flour.

Chemical Properties

Chemical properties of sweet potato starch modified analyzed include moisture content and ash content . Water content of sweet potato modified starch ranged between 7.89% - 9.09 % with an average value of 8.50 % general . Ash content ranged from 2.44% - 2.88% with an average value of 2.59% general . Results from the second analysis of variance showed that the chemical nature of the heating , drying methods and the interaction between them does not affect significantly (P > 0.05) on moisture content and ash content of sweet potato starch modified .

Conclusions

Modification of sweet potato flour by autoclaving-cooling with 1 cycle produced sweet potato flour with the granular structure that expands and breaks, lower starch content, higher freezing and thawing stability, higher water absorption index, and had lower hot and cold viscosity. Drying method significantly affected the bulk density. Interaction between steaming time and drying method affected on the bulk density and water absorption index modified flour.

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