The Effect of Extrusion Temperature on Changes of Characteristics of Partially Pregelatinized Cassava Starch

Aton Yulianto, Fitri Nur Kayati, Bayu Novariawan, and Arni Supriyanti

***Abstract*—Indonesia has a large potential source of starch, such as cassava starch which can be used for food or pharmaceutical excipients. Weaknesses of cassava starch characteristics such as viscosity, flow characteristic and hard to dissolve in cold water can be improved by physical, chemical and biological modifications.This study was carried out, to modified cassava starch by extrusion system. This process was resulting in the prototype of partially pregelatinized cassava starch (PGCS). The form of PGCS granules has changed from the round shape to flat and widened by heat and pressure of the extrusion process. Likewise, the results of polarizing microscopy observations show that some starch granules have lost their birefringence properties, and some remain intact. The effect of temperature of extrusion on the change of characteristics of partially pregelatinized starch was analyzed using analysis of variance (ANOVA). Based on the p-value regression, the ANOVA analysis showed that the temperature of extrusion has a significant effect on changes in starch viscosity, bulk density, tapped density, and compressibility. But it did not significantly influence the value of moisture content of PGCS.**

***Index Terms*—Characteristics of partial pregelatinized starch, cassava starch, extrusion variable.**

I. Introduction

Starch is the most abundant natural polysaccharide polymer in nature. This is not only an important component of human food but has also been used for more than 100 years as a pharmaceutical excipient. Therefore the food industry and modern pharmaceuticals are inseparable from integrated starch and modified starch.

Pregelatinized starch is one of the modified starches used widely in the industry. Partially pregelatinized starch can be used as a filler, binder and instant material (can be dispersed /dissolved in cold water). The marketing target for this partial pregelatinized starch product from cassava starch is the food and pharmaceutical industry market in Indonesia. The target market segment is food and pharmaceutical industry companies whose products contain partially pregelatinized starch such as pudding producers, baby food, cake mixes, food powder, and salad dressings and for pharmaceuticals such as tablets and capsule layers. This is because pregelatinized starch has a low viscosity so that it will facilitate the distribution of the binder into the tablet period [1].

The technology of making pregelatinized starch is generally by cooking starch in water so that it is gelatinized. And then the starch paste was dried using a spray dryer or drum dryer. The pregelatinized starch product can be formed as fully pregelatinized starch or partially pregelatinized starch. Both types of products have different characteristics. The viscosity, flow rate and compressibility of partially pregelatinized starch are lower than fully pregelatinized starch. Rapid drying technology using a drum dryer will tend to produce fully pregelatinized starch because all starch granules will be broken by heating and friction between the hot drum surface. Therefore in this research of starch modification was carried out using an extruder. So that the gelatination process was easier to control because it occurred base on the dry system (25-30% moisture content). Native starches are heated and pressed during the extrusion process so that part of starch granules will be damaged. Important variables in the extrusion process are the frequency of screw rotation and temperature. The frequency of screw rotation has an effect on the residence time of starch in the extruder. While the temperature of extrusion has an effect on the degree of gelatination of starch. Both of these variables are very influential on the characteristics of partially pregelatinized starch. As far as the search has been carried out, references that discuss in detail about the production of partially pregelatinized cassava starch using extrusion systems have not been found. extrusion systems are usually used in the process of foods such as noodles and artificial rice.

The objective of this research was to obtain partially pregelatinized starch products from cassava starch. The specific purpose in this research was to determine the effect of extrusion temperature on the changes of characteristics of partially pregelatinized cassava starch (PGCS).

II. Materials and Methods

A. Materials

Cassava starch was obtained from Tapioca Mini plant, National Laboratory of Starch Technology, aqua dest as process water.

B. Methods

Cassava starch and process water were mixed, until homogeneous and the water content becomes 25-30%. Then it was steamed for 15-20 minutes until some of the starch granules are gelatinized. Then it was fed to the extruder through the feeder.

Extrusion was proceed using twin-screw extruder with a constant speed of feed and extruder screw, so the retention time of starch in the extruder was constant. The temperature of extrusion was variated in range 40 - 60 ^{o}C. Extrusion products (flakes) was dried using an oven until the moisture

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content reaches 8-14%. Then the product is refined using a disk mill.

C. Evaluation of Characteristics of Partial Pregelatinized Cassava Starch (PGCS)

Evaluation was carried out by observing physical, microscopic, and functional characteristics. The observed parameters include: moisture content, birefringence, SEM, viscosity, bulk density, tap density, compressibility, flow rate, angle of repose and flow properties.

D. Data Analysis

The test results of the characteristics of partially pregelatinized starch in various extrusion variable according to the test design were calculated by analysis of variance (ANOVA). Differences at p-value <0.05 were considered significant.

III. Result and Discussion

A. The Moisture Content of PGCS

The results of organoleptic observation of PGCS from cassava starch showed as a yellowish fine powder. This is mention in [2] that the PGCS form is a yellowish fine powder.

Observation of the moisture content of PGS showed results in the range of 5.0-11%. The water content of PGS from cassava starch is more influenced by the conditions of the process of drying. Fig. 1 shows fluctuations in changes in water content but still under requirements (maximum 14%) [2].

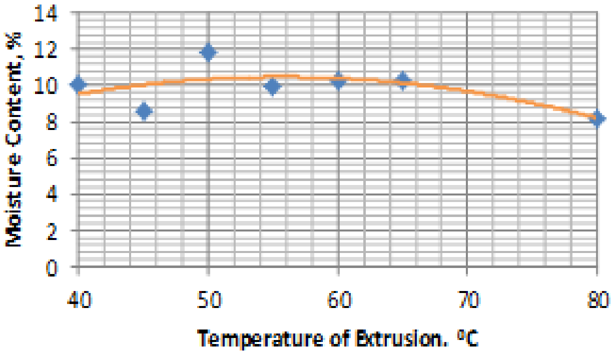
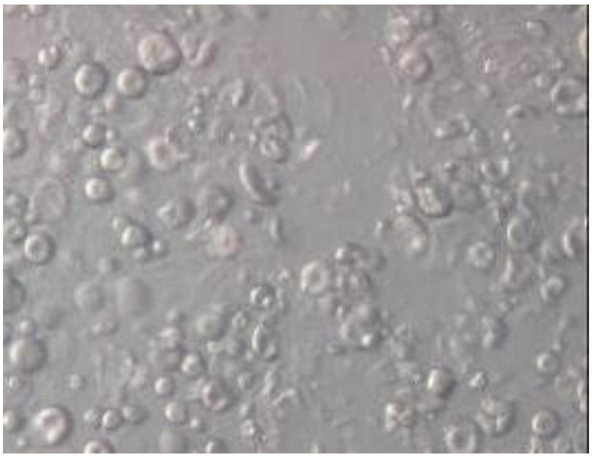
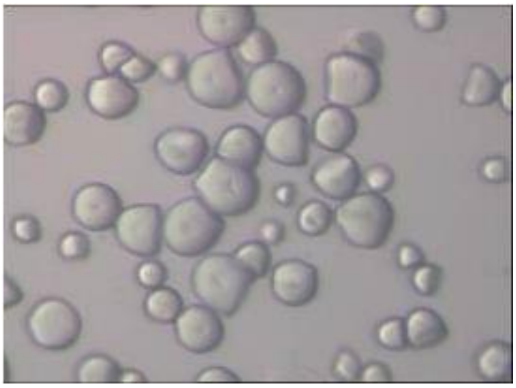


Fig. 1. Graph of moisture content of PGCS.



a. PGCS

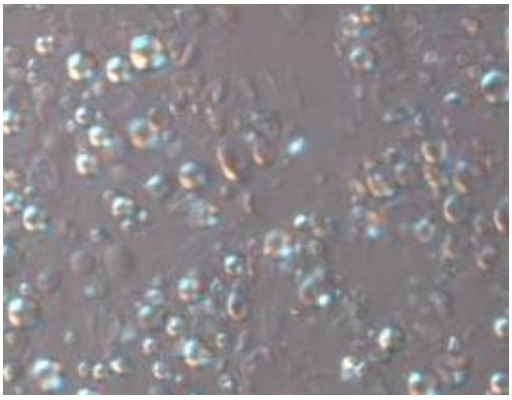


b. Native Cassava Starch

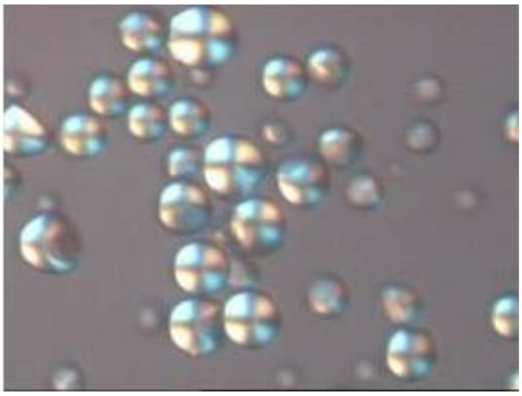
Fig. 2. Microscope image before polarization.

A. Microscopic Characterization of PGS

PGS production by extrusion system is a modified starch which shows that some of the starch granules have ruptured. While some other of starch granules remain intact. Reference [3] shows that PGS still has crystalline granules if it observed using a polarized microscope. The results of the observation using a polarization microscope shown in Fig. 2 (before polarization) and Fig. 3 (after polarization).



a. PGCS



b. Native Cassava Starch

Fig. 3. Microscope image of PGS after polarization.

Polarization results also show the loss of birefringence in some granules that have ruptured during the extrusion process. While some others have a form of granule that is still intact. So that it forms two colors when passed by polarizing light. This color formation due to differences in starch granule refraction index.

Further microscopic observations were performed using SEM. It was seen that the shape of the granules had changed flatter and widened with irregular shapes when compared with native cassava starch. Native cassava starch has a more rounded starch granule form.

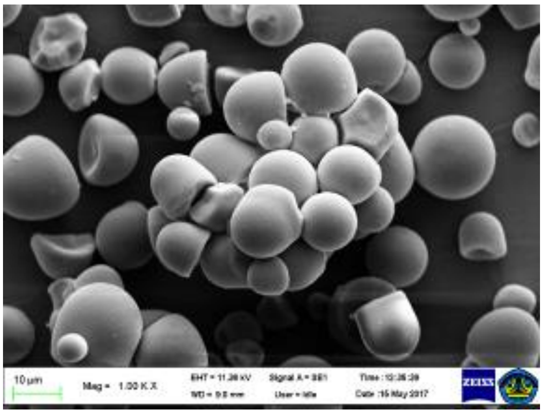


Fig. 4. SEM image of native cassava starch

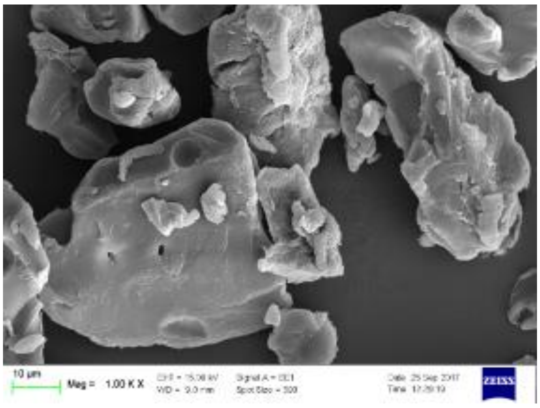


Fig. 5. SEM image of PGCS.

B. Viscosity of PGCS

The extrusion process for the production of PGS uses a double screw extruder with a distance between the threaded shaft smaller than the intermeshing diameter and counter-rotating direction. This screw-type of extruder allows material that slips from the barrel wall to be impossible because intermeshing threads will prevent material from other threads from spinning freely. The material will experience pushing, mixing, heating, suppression, and formation in an extrusion process. This causes the crystalline structure of starch granules was broken and some of the starch granules are gelatinized without swelling due to low moisture content and pressure during the extrusion process. This process will cause changes in the characteristics of cassava starch, especially viscosity in cold water (conc.10%). Increasing viscosity, when dissolved in cold water, is one of the characteristics that was changed.

Based on the p-value regression, results of ANOVA analysis showed that the temperature of extrusion has a significant effect on changes in PGCS viscosity. It can be shown in Fig. 6 that the viscosity pattern of starch tends to rise along with the increase of temperature of extrusion.

Increasing viscosity in cold water showed that extruded flour contain gelatinized starch. The degree of starch gelatinization is related to the tendency between the extrusion moisture and pasting profile or viscosity curve [4]. Gelatinized starch in PGCS allows rapid hydration and can be formulated in different product as instant food for children [5].

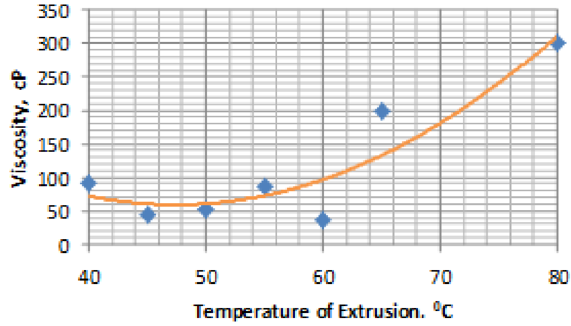


Fig. 6. Graph of viscosity of PGCS.

PGCS is mostly used as a binder and disintegrant in wet granulation of tablet. Gelatinized starch in PGCS provide effective binding properties. The direct compresssed tablets with 2% of pregelatinized tapioca starch exhibited good disintegration and dissolution [6].

D. Bulk Density, Tapped Density, and Compressibility

Compressibility is determined by bulk density and tapped density. Compressibility value is directly proportional to tapped density and inversely proportional to bulk density. Compressibility value is also related to the the flowability of powder. Compressibility and flow properties are determined based on good flow properties of powder [7], [8], [1]. The compressibility value between 12-16% shows that the powder has a good flow property. While The compressibility value between 5-15% shows that the powder has a very good flow property [8]. So the powder of PGCS will less flowable if the compressibility value is highest. Application of this powder in high speed filler machine of tablet need PGCS with betters flowability. It is needed to ensure that the product of tablet is consistent uniform in weight and active drug content [9].

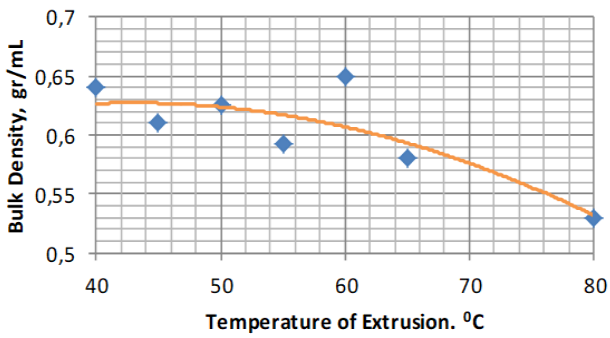


Fig. 7. Graph of bulk density of PGCS.

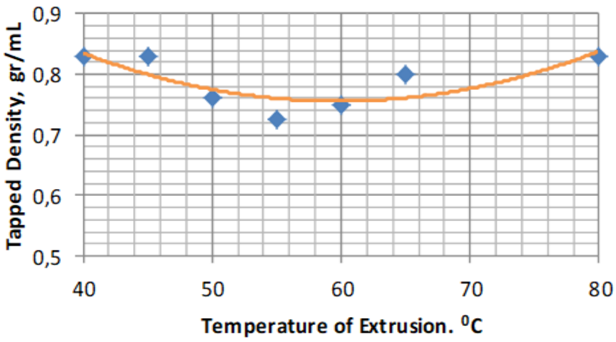


Fig. 8. Graph of tapped density of PGCS.

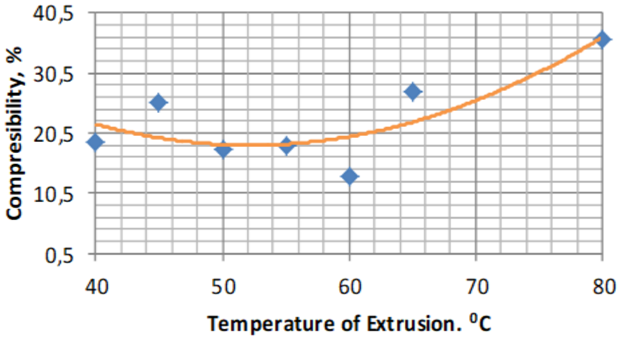


Fig. 9. Graph of compressibility of PGCS.

Based on the p-value regression, results of ANOVA analysis showed that the temperature of extrusion has a significant effect on changes in bulk density, tapped density, and compressibility value. Increasing of the temperature of extrusion will increase the value of tapped density and compressibility value, but decrease the bulk density. The variable interaction process determines the degree of starch gelatination during extrusion. The higher the degree of gelatinization of starch, the starch will expand, so that the value of real density decreases. However, other factors such as material moisture will affect the process temperature the amount of starch which is gelatinized during the extrusion process [10], [11].

IV. Conclusion

In this study, characteristic of partially pregelatinized cassava starch using extrusion system was carried out. From the study, it can be concluded that :

1. The shape of granules of PGCS had changed flatter and widened with irregular shapes when compared with native cassava starch.
2. The temperature of extrusion has a significant effect on changes in PGCS viscosity and PGS compressibility but has no significant effect on the moisture content of PGCS.
3. The flow characteristic of PGCS can be optimized by changing of variables extrusion to obtain partially pregelatinized cassava starch with desired functionality.

Acknowledgment

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