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Research Article

Physical and Chemical Properties of Native and Fully Pregelatinized Cassava Starch (*Manihot esculenta* Crantz)

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ABSTRACT

Starch is widely used as an excipient in pharmaceutical formulations because it is inert and it can be mixed with drugs without any chemical reactions. This study was aimed to develop and to characterize the physical and chemical properties of cassava starch fully pregelatinized (CSFP) and native cassava starch (*Manihot esculenta* Crantz) (NCS). Organoleptic properties, pH, ash content, shrink drying, macroscopic and microscopic analyses, amylose and amylopectin content, bulk and tapped density, the angle of repose and flow rate were physically evaluated for both type of cassava starch. Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), energy-dispersive x-ray spectroscopy (EDS), and differential scanning calorimetry (DSC) were used to characterize and evaluate the chemical properties of the CSFP and NCS. The results of this study indicate that CSFP exhibited different values of those determined parameters compared to that of NCS organoleptic properties i.e, pH, viscosity, ash content, shrink drying, macroscopic and microscopic analyses, amylose and amylopectin content, bulk and tapped density, angle of repose and flow rate. The measurement results with DSC obtained Tg at NCS of 68.18^{o}C while in CSFP there is no Tg because cassava starch (CS) is fully gelatinized. In conclusion, CSFP as a good profile starch contained a higher amount of amylose with larger particle size and good particle density and viscosity than the natural starch and improve its flow properties and compactibility. CSFP had a noticeable effect on fragility, hardness, disintegration time and percentage of drug release from the tablets produced, that can be developed as a pharmaceutical excipient in development of solid dosage forms (sustain release).

Keywords: cassava starch fully pregelatinized, native cassava starch, physical properties, chemical properties, amylose, amylopectin

INTRODUCTION

Cassava is easy to grow in tropical countries, and Indonesia is a cassava producing country. Cassava contains a high amount of starch, about 42.1% (Yusuf *et al*., 2008; Onyango *et al*., 2013). Judging from the process of making amylum (starch), two types of starch are often used in the pharmaceutical industry, namely native starch and modified starch (Bhardwaj *et al*., 2000; Siswanto and Soebagyo, 2006). Native starch is a starch produced from plants that has not been physically or chemically modified.

Starch is an abundant reserve polysaccharide in plants. Generally the starch comprises 20% water soluble portion (amylose) and 80% of air-insoluble part (amylopectin). Amylose is a straight molecule, consisting of 250-300 D-glucose units and a dose by α-1,4-glucoside bond which tends to cause a helix-like molecule. Amylopectin consists of 1,000 or more units of glucose that are also connected with α-1,4 bonds. However, there is also a number of α-1,6 bonds present at the branching points. This bond amount is approximately 4% of all the number of relationships or one for every 25 units of glucose. Amylopectin in the air can form a colloidal solution. When the colloidal content is heated in the past, it is this nature that

becomes the binder. While amylose has the ability to expand in contact with liquids, it is this property that is used as a crushing agent (Juliano, 1971; Gusnimar, 2003).

Native cassava starch (NCS) is a starch produced from plants, and has not undergone physical or chemical processing. NCS is the starch obtained from Manihot esculenta, Crantz root tuber, the powder is smooth and white.

Modification of physical properties of starch is done by pregelatinized. The purpose of physical modification is to improve its flow properties and compactibility so that it can be used as a binder in direct compression tablets and can reduce glidant and antiadherent use (Yusuf *et al*., 2008; Onyango *et al*., 2013). Pregelatinized modification was performed by giving the treatment of an appropriate amount of water and heating at the appropriate temperature (Emami *et al*., 2004; Anwar *et al*., 2006). This method produces starch with larger particle size and higher particle density (Adedokun and Itiola, 2011). In pregelatinized starch gelling process occurs due to the addition of proper water and heating causes the starch granules to absorb water, so that the granules expand to form a thick mass (Patel and Patel, 2006).

Pregelatinized starch can be further categorised as partially pregelatinized starch and fully pregelatinized starch (Hadi *et al*., 2016). Modification of starch into its fully pregelatinized form is usually done using an organic solvent (Piyachomkwan *et al*., 2002; Olowosulu *et al*., 2011). Olowosulu (2011) studies on maize starch (MS) and acacia gum (Ac) have been produced using fully and partial pregelatization methods. In this study cassava starch (CSFP) were fully pregelatinized using the method described by the olowosulu (2011). The process of modification was done using organic solvent with the addition of distilled water and then heating above the starch gelatinating temperature to minimise the use of chemical solvents, which is a safer, more efficient and more economical than other methods.

One of the local plants that produce starch that can be modified in this way is cassava starch. In addition to the relatively cheap price, cassava starch is relatively easy to obtain, so potential is used as solid dosage excipients. The high amylopectin content, ie 83%, makes cassava potential used as a binder in the manufacture of pharmaceutical preparations (Juliano, 1971; Gusnimar, 2003).

Starch modification is done by examining if the produced excipients (CSFP) have better physical and chemical properties than NCS. If the physical and chemical properties of the modified starch are sufficient, it can be compressed and used as an excipient in pharmaceutical tablets (Wlodarski *et al*., 2016).

MATERIALS AND METHODS

The study used tubers of cassava (*Manihot esculenta* Crantz) as the basic ingredient to make starch. The cassava was obtained from Banyuning Village in Bali, Indonesia. The starch was prepared using two different methods as follows native starch and fully pregelatinized starch with the addition of distilled water and then heating above the starch gelatinating temperature.

Native starch

The native cassava starch was made by peeling cassava, and then washing it with distilled water until clean. The cassava was then cut into small pieces and crushed using a blender, and then distilled water (2:1 [w/v]) was added to the cassava. The mixture was then squeezed and filtered using a flannelette. The results obtained from filtering were precipitated for 48h. The resulting supernatant fluid was then removed, and the precipitate was washed with distilled water until a cleaner starch precipitate was obtained. Next, the precipitate was dried in an oven at 3°C for 24h, and then crushed and sieved using a 100-mesh sieve (Bhardwaj *et al*., 2000; Siswanto and Soebagyo, 2006).

Fully pregelatinized starch

The fully pregelatinized cassava starch was made with a starch: distilled water ratio of 1:1 (b/v). The mixture was then stirred until a homogenous suspension was formed. The suspension was heated with water vapour at a temperature 80°C in a drum, which was closed for 15min, until gelatinization occurred. The pregelatinized starch was then dried in an oven at 50°C or 48h. Once dried, it was sieved using a 20-mesh sieve (Table I). (Emami *et al*., 2004; Anwar *et al*., 2006; Hastuti, 2009; Mariyani *et al*., 2012; Yusif *et al*., 2016).

Table I. Condition of modification process

Parameter	Process conditions
Fully pregelatinized temperature	80ºC
Heating time	15min
Oven temperature	50ºC
Oven time	48h

Physical and chemical properties of the native and fully pregelatinized cassava starch

Organoleptic properties

A panel of 20 tasters consisting of staff and students from Udayana University were used to evaluate the sensitivity of the NCS and the CSFP. The panellists were selected based on their familiarity with the sensory qualities of starch, and the samples were evaluated at room temperature (30±2°C). A three-point hedonic scale was used to evaluate colour, taste and smell. The panellists were given water to rinse their mouths between evaluations (Kemp *et al*., 2009; Sholihah and Noer, 2014). All of the experiments were performed using protocols approved by the University Ethics Committee (protocol number 2018.03.1.0672).

Bulk density and tapped density

A-10 g quantity of the powder sample was placed in a 50mL clean, dry measuring cylinder and the volume, V_o, occupied by the sample without tapping was determined. After 500 manual taps, the occupied volume was found to be V_{500}. The bulk and tapped densities were calculated as the ratio of the weight and volume of the sample (V_o and V_{500}, respectively) (Carstensen *et al*., 1997; Achor *et al*., 2015).

Determination of iodine and pH tests

Iodine and pH tests were conducted in accordance with the United States Pharmacopeia specifications (United States Pharmacopeial Convention, 2014).

Shrink drying

For shrink drying, some of the starch was incorporated into the moisture balance set at 105°C for an automatic time, and then the weight was accurately weighed until constant (Eckelman, 1998; Piotrowski *et al*., 2014; Krisyanella *et al*., 2017).

Measurement of viscosity of the starch

Viscosity determinations for the native cassava starch and cassava starch fully pregelatinized were carried out on a Brookfield digital viscometer using spindle No 4. The viscosity of in situ gelling solutions was measured at different angular velocities at a temperature of 37°C. A typical run comprised changing of the angular velocity from 0.0 to 100 rpm. The averages of two readings were used to calculate the viscosity (Shastri *et al*., 2010; Hareesh *et al*., 2012).

Solubility

With semi micro balances as much as 0.01mg of the starch was added to 1L of cold water, and then stirred. Next, the solubility of the sample was determined. This step was repeated by replacing the water with 95% alcohol (Qazi *et.al*., 2014; Parwiyanti *et al*., 2015).

Microscopic and Macroscopic Properties

The starch granule shapes were observed and photographed using an optical microscope (CX 31, Olympus®) and stratified sieves with the following meshes 20, 40, 60 and 80 (Abdorreza *et al.,* 2012; Bestari *et al.,* 2016).

FT-IR spectra

The infrared spectra of the native and pregelatinized cassava starch samples were recorded with a Fourier transform infrared (FT-IR) spectrophotometer (JASCO FT-IR-4200 type A model) using potassium bromide pellets format mid infrared region of 400 -4000cm^{-1} (Fanani *et al*., 2010).

Ash content

The ash content was evaluated using a furnace method with a temperature of 550ºC (Horwitz and AOAC International, 2006).

Flow rate and angle of repose

The flow time test and the silent angle test were used to determine the flow rate and angle of repose, respectively. The flow time was done using the funnel method (Dreu *et al*., 2016).

Amylose and amylopectin content

The amylose content was determined using the method described by Williams (1958). The starch samples (20 mg) were weighed and placed into a 50mL or 100mL beaker. Furthermore, a-10mL of KOH solution 0.5N (28.055g/L) was added, and the starch was dispersed with a stirring rod or a magnetic stirring bar for 5min, or until fully dispersed. Although most starch samples disperse readily, a "difficult" sample may take as long as 20min to 30min to disperse. The dispersed samples were transferred into 100mL volumetric flasks and diluted to the mark with distilled water with careful rinsing of the beaker. An aliquot of the test starch solution (10mL) was pipetted into a 50 mL volumetric flask, and 5mL of 0.1N HCl (8.17mL conc. HCl/L) was added, followed by 0.5mL of iodine reagent B. The volume was diluted to 50mL, and the absorbance of the blue colour was measured at 625nm after 5min. The colour was found to be stable for several hours. Several of the starch dispersions, together with the amylose control, were analysed at intervals up to 30 day after dispersion. In all cases, the stability of the dispersions was verified, indicating that the dispersions can be stored for several days if necessary, before analysis.

Scanning Electron Microscopy (SEM)

The surface morphology of the native and fully pregelatinized cassava starch was evaluated using SEM (JEOL, JSM-6360, Tokyo, Japan) at X70, X1000 and X2000 magnifications (Gaikwad *et al*., 2010; Octavia *et al*., 2017).

Energy-dispersive X-ray spectroscopy (EDS)

EDS (JEOL, JSM-6360, Tokyo, Japan) was produced from X-ray characteristics, i.e. by firing X-rays at the position we want to know the composition. So after firing at the desired position it will appear certain peaks that represent an element contained. With EDS we can also create elemental mapping (element mapping). EDS can be used to analyze the percentages of each element quantitatively (El-Mallawany *et al*., 2008; Agus Cahyana and Ahmad Marzuki, 2014).

Differential Scanning Calorimetry (DSC)

Thermograms of native and fully pregelatinized cassava starch were performed using DSC-60 (Shimadzu, with software TA-60WS Collection Monitor). The system was purged with nitrogen gas at a flow rate of 30mL/min. Heating was done from 25°C to 300°C at a rate of 10°C/min (El-Mallawany *et al*., 2008; Agus Cahyana and Ahmad Marzuki, 2014).

Preparation of granules

The wet granulation method of massing and screening was used. 150g batches of formulation mixtures of ranitidine HCl, CSFP/NCS, HPMC K4M, and magnesium stearate were mixed. For small batches the ingredients may be mixed in stainless steel bowls or mortars. They were then moistened with PVP K-30 binder solution to yield 2% w/w, PVP in the final dried granulation. The resulting wet masses were granulated by passing them manually through a 10 mesh sieve, dried oven at 50°C for 7h, and then re-sieved through a 20 mesh sieve. The dried granules were lubricated by using magnesium stearate.

Preparation of tablets

Quantities (150g) of granules from each batch were compressed into tablets with predetermined loads on single tablet press with a 8mm die and flat faced punch assembly. A set of tablets were produced from each pressure. After ejection, the tablets were stored in airtight containers to allow for elastic recovery and hardening, and prevent falsely low yield values before the tablets were subjected to analysis.

RESULTS AND DISCUSSION

The starch is firstly tested to determine its characteristics and to assess whether the starch used is in accordance with those required in the literature (Table II).

Organoleptic test

Odor and taste of the native cassava starch (NCS) and cassava starch fully pregelatinized (CSFP), assessed by panellist equal to value 1 that is odourless and no

taste. While in color, the panelists gave a value of 1 on the cassava starch that is white and the value of 2 for the cassava starch is fully pregelatinized being colored. Organoleptic testing was performed in accordance with the provisions of (Indonesian Pharmacopeia, 2014).

Microscopic and macroscopic analyses

By observing microscopic and macroscopic characteristics, there was a difference between NCS and CSFP. Microscopically native starch has characteristics according to Indonesian Pharmacopeia (2014) in which the starch formed a slightly rounded, single grain and hilar visible in the middle, while the starch is fully pregelatinized has a multifaceted shape, clustered, hilar and lamella is not visible.

The macroscopic test, the test was done by examining the particle size distribution and the mean diameter (dr), using a multilevel crater where the cassava starch was fully pregelatinized has a larger particle size of 0.428 (Table II) than the native starch and classified as coarse powder (Ansel, 2011).

Determination of ash content

Ash contents in NCS and CSFP were 0.053% and 0.073%, respectively (Table II). If these results were compared to the requirements listed on the cassava starch (not more than 0.6%), the ash content contained in the starch have already met the Indonesian Pharmacopoeia (2014) standards. All of the starch contained small amounts of inorganic substances, as determined from the residue left behind after the stabbing. Ash of starch mainly contained sodium, potassium, magnesium, and calcium in the form of metal.

Drying losses

Drying losses are used for the determination of all types of volatile and missing materials under certain conditions (temperature 105ºC). Actually, for substances that are thought to contain water as the only volatile ingredient, the determination of water content alone is sufficient. According to Indonesian Pharmacopoeia (2014), it is required that the drying rate is no more than 15%. The result of this study was dried up 13.43% of NCS and 12.57% for CSFP (Table I).

Solubility test in water.

The results of native starch solubility test and fully pregelatinized (one part of starch plus 10.000 parts of water) after stirring resulted not soluble starch. The starch was present in the form of compact particles and its molecular tissue was bonded through a hydrogen bond. In cold water, the particles will not dissolve and break. But with the heating, the starch particles will bubble and break. Although the starch consists of a series of hydrophilic carbohydrates, but because the starch is present in the form of compact and dense particles, then the water will be difficult to penetrate. Given the rise in temperature and stirring will produce the energy that weakens the hydrogen bond, so that water can be absorbed by the starch grains and become like a gel.

Solubility test in ethanol.

Observation of solubility of NCS and CSFP in ethanol (one part of starch plus 10.000 parts of ethanol) was obtained from the result of insoluble starch. As in the water solubility test, ethanol is also difficult to be absorbed by compacting starch particles, but when the dispersion of the starch is heated and stirred it will become a gel.

Viscosity measurement.

Viscosity determinations for the NCS and CSFP were carried out on a Brookfield digital viscometer. NCS shows the least viscosity (13.15 Pa.s) and CSFP was more (17.6 Pa.s). This says the increase in amylose concentration causes the increase in viscosity of the starch (Table II).

Amylose and amylopectin contents

Modified starches contained higher amount of amylose than their native form. To make sure there is starch and meets criteria for starch, before and after the modification is done color test with iodine. The characteristic blue-violet color that appears when starch is treated with iodine is due to the formation of the amylose-iodine complex. This color test is sensitive enough to detect even minute amounts of starch in solution

Table II. Physsical characteristic of native CNES and fully pregelatinized starch

Type of Testing	Limit requirements	Native starch	Fully pregelatinized starch
Identification of starch	Blue color with iodine reagent *)	Blue color with iodine reagent	Blue color with iodine reagent
pH	4.5 - 7 **)	6.72	6.84
Microscopic	Oval, single grain, circular hilus *)	Oval, single grain, circular hilus	Rectangular, single, hilus are invisible
Macroscopic	Very fine powder *)	Very fine powder	Coarse powder
Average diameter		0.085	0.428
Ash rate determination (%)	<0.6% *)	0.053%	0.073%
Drying losses (%)	<15% *)	13.43%	12.57%
Solubility test in water	Insoluble *)	Not dissolved	Not dissolved
Solubility test in ethanol	Insoluble *)	Not dissolved	Not dissolved
Measurement of viscosity of the starch		13.15 Pa.s	27.6 Pa.s

* Indonesia pharmacopoeia V (2014) ** USPNF23

Table III. Amylose and Amylopectin content

	Parameter*)	NCS	CSFP
Amylose	17-21%	23.14%	35.02%
Amylopectin	79-83%	76.86%	64.98%

*(Williams, P.C, 1958)

(Figure 6). Native starch has 23.14% amylose content, then it increased to 35.02% (Table III) by temperature heating 80ºC for 15min (Table I). Amylose is present in the amorphous region, and during modification this region is mostly accessible from amylopectin side chains. Therefore, amylose content changed due to modification and structural difference between amylose and amylopectin. With high amylose content, starch will show high volume expansion and a high degree of flakiness.

pH testing

The test results of one-way ANOVA pH-native cassava starch, cassava starch fully pregelatinized. In this study, the level of trust (α) used is 5% (0.05). The significance value of pH measurement gives a value smaller than α so that the decision becomes rejected H_0 i.e. there is a significant difference between native cassava starch, cassava starch fully pregelatinized.

Flow properties

Material flow properties can be illustrated with parameters of flow velocity and angle of repose. Based on the table 5 indicating that the native cassava starch cannot be calculated the value of the flow velocity and the angle of repose because it cannot flow through the funnel while the pregelatinized fully produced starch can flow through the funnel with a flow rate for 100g less than 10s. At the parameters of flow velocity, fully pregelatinized starch has a flow rate of 6.23s, while for the parameters of the angle of repose, and has angle of repose of 32.570. This indicates that the modified material of the starch produced better flow properties compared to the native starch. Based on the theory, a native starch cannot flow in the funnel due to the small particle size and the number of fines contained in the native starch, causing the electrostatic forces that pull each other between the particles so that the movement of particles to be inhibited (Table IV).

150	Elemen number	Elemen symbol	Elemen name	Atomic concentration	Error
NCS	8	O	Oxygen	85,1	0,2
	6	C	Carbon	14,9	0,7

Table IV. Flow properties of starch

Material	Flow velocity (sec/100g)*	Angle of repose (^{0})*	Tapped density (g/mL)*	Bulk density (g/mL)*
NCS	-	-	0.624±0.006	0.463±0.0006
CSFP	6.23±0.15	32.57±1.25	0.793±0.007	0.656±0.002

The sign (-) indicates the material cannot flow; The (*) indicates the result of measurement ± Std Dev with n = 4

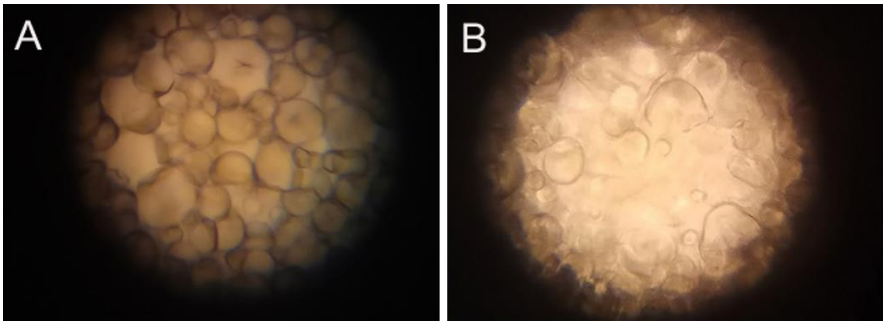

Figure 1. Microscopic starch A. Microscopic NCS with 40X magnification, B Microscopic CSFP with 40X magnification.

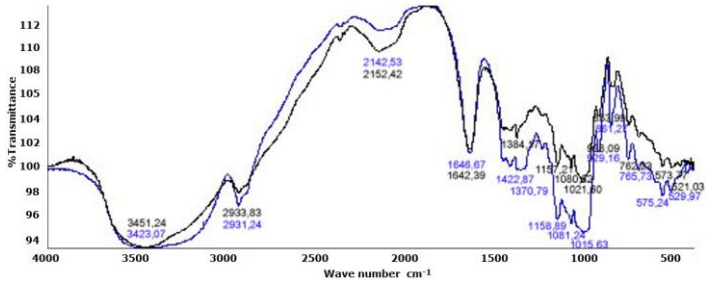

Figure 2 Fourier transform infrared (FT-IR) spectroscopy analysis

According to (Bahram *et al*., 2014), fines have a larger contact area between the larger particles, so the attraction force between the particles increases. This results in the speed of the flow, the more fines the flow rate decreases. In general, the resulting flow velocity and angle of repose have aligned with the difference in its mean diameter. Fully pregelatinized starch with large size has a large flow rate and reduce the density, better angle of repose, and vice versa. This is because the material with large diameter size has small surface area resulting in low cohesiveness and prevents the material to accumulate so that the flow is better, besides the bulk density value of the starch material is fully pregelatinized which is greater than the natural starch. Affect gravity causes the fully pregelatinized starch with a large weight to flow faster than the native starch with smaller weights.

Qualitative testing

Structural changes conformation by SEM

Native starch granules are oval in shape without any hollow area and heterogeneous distribution (Figure 1A). After modification treatment, starch granules were contorted to a folded structure, showed brief ringence and the hollow area inside the starch were observed, which confirmed the presence of a gelatinized granule. From the SEM images, it was observed that the structures of starches were modified.

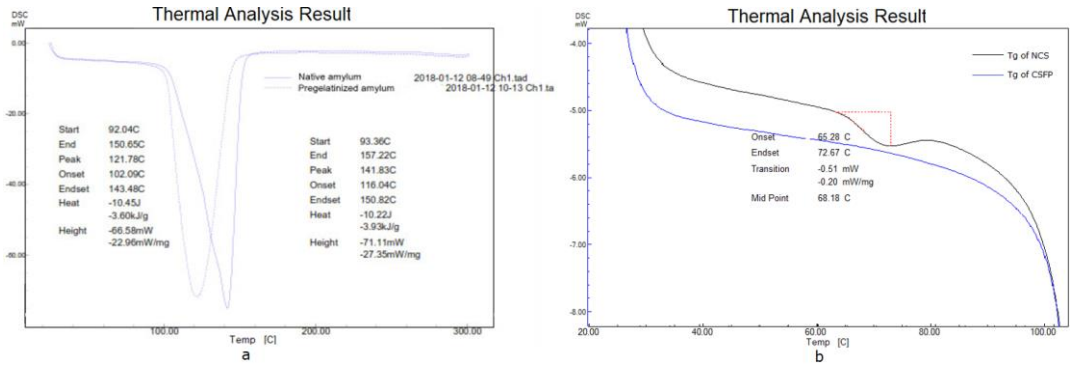

Figure 3a. DSC thermograms of NCS and CSFP b. Tg of NCS and Tg of CSFP

Fourier transform infrared (FT-IR)

Fourier transform infrared (FT-IR) spectra of NCS and CSFP (Figure 2. The infrared spectra of starch examination is used to detect functional groups. Each absorption at a given wavelength represents the presence of a specific functional group. The analysis results in the form of chromatogram signal of IR intensity relation to wavelength. On the NCS spectrum detected there is an O-H function group at wave number 3423.07cm^{-1}, C-H at wave number 2931.24cm^{-1}, C≡C at wave number 2142.53cm^{-1}, C=O at wave number 1646.67cm^{-1}. While in CSFP also detected O-H group at wave number 3451.24cm^{-1}, C-H at wave number 2933.83cm^{-1}, C≡C at wave number 2152.42cm^{-1}, C=O at wave number 1642.39. However, in CSFP this occurs the missing peak of the C-H functional group at the wave number 1422.877cm^{-1}. So from the FT-IR analysis it can be concluded that the process of starch modification does not affect the chemical properties of starch.

Differential Scanning Calorimetry (DSC)

Thermal properties of NCS and CSFP were studied using DSC (Figures 3). Native cassava starch have shown melting endotherms at 141.83°C with normalized heat of fusion 3.93kJ/g. Fully pregelatinized cassava starch showed an interesting change in the thermogram. The melting endotherm for fully pregelatinized cassava starch 121.78°C, whereas diffused endotherm with low enthalpy was observed for fully pregelatinized. The early onset of the fully pregelatinized peak was due to its partial dissolution. Fully pregelatinized of cassava starch significantly affects the thermal properties of a polymer. The measurement of Tg with DSC (Figure 3B). Tg is the main characteristic transformation temperature of the amorphous phase, where at NCS it looks peak Tg 68.18°C, which means NCS does not experience gelatinase and will experience gelatinase at temperature 68.18°C. CSFP is not readable peak Tg means that in CSFP there is a physical change on starch, where starch already experienced full gelatinase.

EDS analysis

After being fired at the desired position, there would appear peaks on the starch representing an element contained. Seen the percentage of each element in the native starch and fully pregelatinized starch. Based on the figure 4 and table VI, analysis of native starch and fully pregelatinized starch using EDS revealed that some of the most abundant elements in percentage form are O with the average percentage of 83.65% and the second most element C at the average of 16.35%.

Correlation between physical properties and flowability indicators for CSFP

The powder physical properties measured included the particle size, shape, density and flowability. Particle size was found to be an accurate predictor of powder flowability, with increasing particle size indicating well in the flow. Particle shape irregularity was found to be the main reason for lower flowability. Irregular particles tended to interlock with each other and resisted powder flow. Wide distributions of particle shapes and sizes were found to have an impact on powder flowability. Although CSFP consisted of a large number of elongated particles, it demonstrated good flowability.

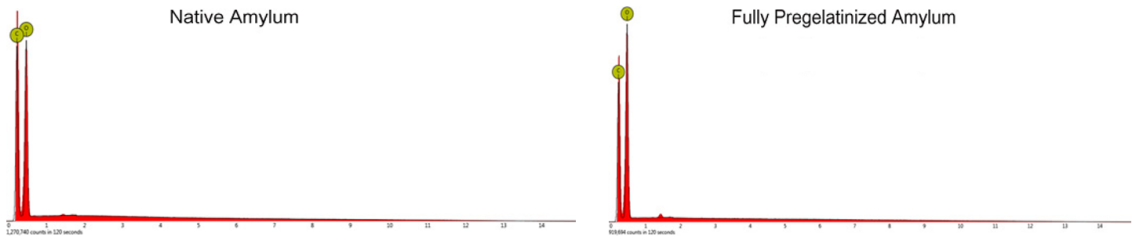

Figure 4. Graphic EDS of NCS and CSFP.

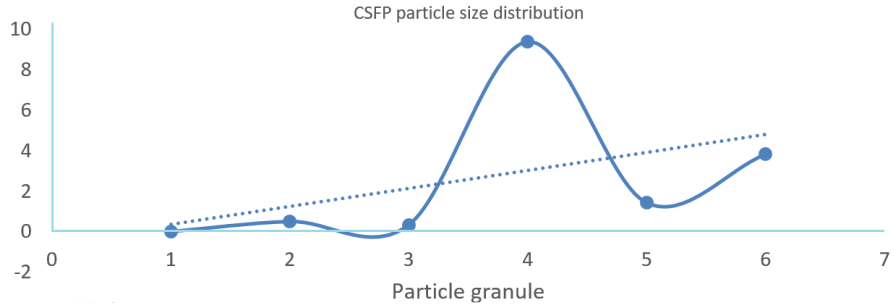

Figure 5. CSFP Particle distribution

Table V. Percentage of starch element

	Elemen number	Elemen symbol	Elemen name	Atomic concentration	Error
NCS	8	O	Oxygen	85.1	0.2
	6	C	Carbon	14.9	0.7
CSFP	8	O	Oxygen	82.2	0.2
	6	C	Carbon	17.8	0.7

This was because of the fact that CSFP bulk consisted of small spherical particles in addition to elongated particles, which appeared to assist powder flow (Figure 5.)

In vitro evaluation of the prepared tablets CSFP and NCS

Tablet weight variation

Twenty tablets were randomly selected and accurately weighed. Results are expressed as mean values ±SD. The average weight of 20 tablets along with standard deviation of entire formulations (Table VII). The percentage of weight variation of individual tablets from the average weight was found to be within ±7.5 % (w/w) which proved that the entire tablets have passed the USP weight variation test.

Hardness test

For each formulation, the hardness of six tablets was determined individually using a hardness tester. The hardness of tablets of entire batches was found 5.21±1.67kg/cm² for NCS and 8.52±0.231kg/cm² for CSFP.

Tablet friability

According to the USPNF23, 10 tablets were randomly selected and placed in the drum of a tablet friability test apparatus. The drum was adjusted to rotate 100 times in 4min then the tablets were removed from the drum, dedusted, and accurately weighed. The percent weight loss was calculated. The friability test of tablets of entire batches (Table VI). depicted that the tablets of entire batches had passed the USP criteria of friability testing (0.5 - 1%, w/w). The results revealed that tablets possess good mechanical strength.

In vitro disintegration test

As the disintegration time for the tablets formulated by using CSFP has increased than

Table VI. Evaluation of physical properties of tablets (150mg) CSFP and NCS

Type of Testing	Limit requirements	NCS	CSFP
Size (mm)	*) 1/3 – 2/3 diameter	3.45±0.09	3.274±0.04
Weight variation test (mg)	**) it can be acceptable if the batch falls within the ±7.5% of Std Dev	151.56±0.03	153.84±0.05
Hardness (kg/cm^2)	*) 4 - 10 kg/cm^2	5.21±1.67	8.52±0.231
Friability (%)	**) loss in weigh less than 0.5 – 1 %	0.541±0.06	0.335±0.09
Invitro disintrgration test (s)	*) No more than 15 minutes for non-coated tablet	38.20±0.34	More than 2h

* Indonesia pharmacopoeia V (2014); ** USPNF23 indicates the result of measurement ±Std Dev with n=5

TableVII. Dissolution Studies

Time (mins)	CSFP (%)	NCS (%)
10	11.5	20.2
20	14.6	36.7
30	23.1	52.5
40	28.8	64.9
50	34.5	75.7
60	41.7	88.3

that of NCS. It is concluded that the binding capacity of CSFP would be many times greater than that of NCS. From the test results of tablet preparations (Table VI.), CSFP is suitable for sustain released tablet because it is able to keep the tablet from being disintegration more than 2h of testing time, while for NCS it is suitable for conventional tablets.

Dissolution test

The dissolution test was carried out by using the USP type II method (paddle method). The beaker is immersed in the water bath of temperature 37°C. It is filled with 900mL of HCl 0.1N and the apparatus was set at 75rpm. The samples were taken in the interval of 10 minutes and estimate the content by spectrophotometer at 320nm. The same procedure was repeated at different time intervals and absorbance was noted and the percentage drug release was calculated (Sulaiman, 2011). From dissolution study of ranitidine HCl tablets formulated by using NCS has increased release than that of CSFP (Table VII).

CONCLUSION

It can be concluded that there are differences of physical and chemical characteristics of native cassava starch and cassava starch fully pregelatinized. CSFP as a method produces a good profile starch contained a higher amount of amylose with larger particle size and greater good the particle density and viscosity than the natural starch and improve its flow properties and compatibility, CSFP has a noticeable effect on fragility, hardness, disintegration time and percentage of drug release from the tablets produced. The percentage of drug release shows that CSFP has a large influence on the binding strength of the tablet. Further studies on this starch as a filler on sustain release tablets will provide further information needed to establish the usefulness of this starch in tablet manufacturing.

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