Physicochemical Characteristics and Functional Properties of White Sweet Potato Starch

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ABSTRACT

Sweet potato is an agricultural commodity that is a source of high carbohydrates and can be cultivated in infertile areas. Processing of sweet potatoes as food and industrial raw materials is still limited. One way to process sweet potatoes is to dry the sweet potato into starch so that it can increase the sweet potato storage capacity as well as being beneficial and practical in storage and transportation so that it can be processed into various food products. The purpose of this study was to study and evaluate the physicochemical characteristics and functional properties of white sweet potato starch varieties of AC. Various methods are used to analyze these characteristics and properties, including the kjedahl method, AOAC (Association of Official Analytical Chemistry), SNI (Indonesian national standard) and several methods that have been developed. The results showed that the values of 9.02% moisture content, 0.37% ash content, 0.62% crude fiber, 0.13% fat content, 85.23% starch content, 35.99% amylose content, 88.75% carbohydrate content, 77.14% white degree freeze-thaw stability 95.18 % and clarity of starch paste 44.97%. Characteristics obtained have met the standards, but each variety has advantages and disadvantages so that it can be adjusted to the use of food products that want to use AC sweet potato varieties of white sweet potato.

Keywords— Characteristics, Properties, Sweet Potato Starch

I. INTRODUCTION

Sweet potato (*Ipomoea batatas L.*) is one of the tropical food plants that are widely available in Indonesia. Sweet potato is one type of food that can support community nutrition improvement programs. The caloric value contained in sweet potatoes is quite high, which is 123 calories/100 grams. Judging from its chemical composition, sweet potato has good potential as a food source of carbohydrates, minerals, and vitamins [1]. Sweet potatoes (*Ipomea batatas Linneaus*), also known as yams, are tropical and subtropical annual trees. Sweet potatoes are one of the most important types of roots and root crops of the economy, which can grow in large quantities [2]. Sweet potatoes are widely known as a staple food producing carbohydrates and leaves as vegetables. One form of sweet potato processed which is quite potential in agro-industry activities as an effort to increase added value is starch.

Further utilization of sweet potatoes requires initial characterization of physicochemical properties and functional properties. The difference in varieties of white sweet potatoes causes the physicochemical and functional properties that are obtained differently for each variety. One that can affect the chemical content of white sweet potato starch is the type of soil. Sweet potatoes are a source of pro-vitamin A, this is because sweet potatoes have high levels of carotene and anthocyanin contained in sweet potatoes with colored flesh. The presence of these ingredients makes sweet potatoes widely used as food, raw materials for industrial processes, and animal feed. This study will discuss the physicochemical and functional characteristics of white sweet potato starch with AC varieties cultivated in DI Yogyakarta, Indonesia.

II. METHODOLOGY

Procedure for analyzing the nature and functional properties of starch:

1. ***Water content [3]***

Measurement of water content is done by the oven method. A total of 2-10 grams of the sample were weighed in a cup whose weight was known, then dried in an oven with a temperature of 105°C for 5 hours. The sample is then cooled in a desiccator and weighed until the weight is constant.

$$water\ content\ (\%) = \frac{sample\ initial\ weight\ (g) - sample\ final\ weight\ (g)}{sample\ initial\ weight\ (g)} x100$$
....(1)

2. ***Ash content [4]***

A total of 2 g of the sample is weighed in a porcelain dish whose weight is known (a), then nested using a Bunsen heater until it does not emit smoke. A porcelain dish containing sample (b) which has been prepared and

then put into a furnace at a temperature of 600°C for 2 hours to convert the charcoal to ash (c). A porcelain dish containing ash is cooled in a desiccator and weighed to a fixed weight. The ash content percentage can be calculated using the following formula:

$$Ash\ content\ (w/w\%) = \frac{(c-a)}{(b-a)}\ x\ 100\%$$

....(2)

3. Crude fiber content [5]

2 g was put into a 500 ml erlenmeyer tube and added 100 ml H_2SO_4 0.325 N. The material was then hydrolyzed in an autoclave at 105°C for 15 minutes. Cool the ingredients, then add 50 ml of NaOH 1.25 N. Hydrolysis returns the material in the autoclave to 105°C for 15 minutes. Strain the ingredients using dried filter paper (known weight). After that, wash the filter paper in a row with hot water + 25 ml H_2SO_4 0.325 N and hot water + 25 ml aceton/alcohol. Lift and dry filter paper + ingredients in the oven at 110°C for ± 1-2 hours.

$$Crude\ fiber\ content\ (\%) = \frac{(weight\ of\ filter\ paper+ingredients)-weight\ of\ filter\ paper}{weight\ of\ ingredients}\ x\ 100$$

....(3)

4. Crude protein content (Kjedahl method)

A total of 0.1 g of material was weighed, then a catalyst ($CuSO_4$ and Na_2SO_4) was added with a ratio of 1: 1.2 and 2.5 ml of concentrated H_2SO_4 (producing ammonium sulfate). After that, it is destined to clear (green). Then it is cooled and washed with distilled water to taste. Then it was distilled and 15% NaOH was added. Distillation (distillate) is accommodated with 0.02 N HCl. The distillation process is stopped if the volume of the distillate has reached twice the volume before distillation. The distillation results are then titrated with 0.02 N NaOH and the mensel indicator which is a mixture of methyl red and methyl blue.

$$\%\ Total\ N = \frac{(ml\ titration\ (blanko-sample))\ x\ N\ NaOH\ x\ 14}{weight\ of\ sample\ x\ 1000}\ 100$$

....(4)

% Total protein = % Total N x correction factor (6,25)

.... (5)

5. Fat content [6]

The sample was weighed as much as 5 g wrapped in filter paper coated with cotton and put into soxhlet, then added enough hexan and refluxed for 5-6 hours. then the filter paper containing the extracted fat is heated in an oven

at 105°C, then cooled in a desiccator and weighed in weight. Fat content is calculated by the formula:

$$Fat\ content\ (w/w\%) = \frac{a-b}{c}\ x\ 100\%$$

....(6)

Where :
a : sample weights after extraction (g)
b : sample weights before extraction (g)
c : sample weights (g)

6. Starch content

The starch content can be determined by hydrolyzing starch using a catalyst α-amylase based on the method of [7] modified, so it becomes glucose syrup. A sample of 1 g was dissolved in 8.9 ml of distilled water (1g/10 ml (b/v)), then heated with a water bath until gelatinized. A total of 0.1 ml of the α-amylase enzyme was added to the solution. The solution is reheated at 100°C for 1 hour while stirring. The resulting glucose syrup is cooled to room temperature. After that, the sample was analyzed for total sugar to find out how much starch was successfully hydrolyzed into glucose syrup.

The procedure for measuring total sugar using the [8] method. A sample of 1 ml (containing ≤ 100 μg carbohydrates) was added with 0.5 ml of 5% phenol solution then shaken to be homogeneous. 2.5 ml of H_2SO_4 was added directly to the surface (without touching the test tube wall). The mixing reaction was left uninterrupted for 10 minutes. Readings of absorbance values are carried out at least 30 minutes after shaking at a wavelength of 490 nm. The reading on the spectrophotometer gives a value in the unit of absorbance so that to find out the total amount of sugar in the sample, the standard glucose quva is first made.

The production of glucose standard quva is used for standard glucose (0, 10, 20, 30, 40, 50 and 60 ppm). Each is taken 1 ml according to the procedure for measuring total sugar. The results of the readings on the spectrophotometer were collected and the equations were searched, from this equation can be seen the total amount of sugar contained in the sample. The value of starch can be calculated by the equation:

% starch content = % total sugar x 0.9 ....(7)

Note: the value of 0.9 is a conversion factor for the formation of glucose produced from hydrolysis of starch

7. Amylose and amylopectin content IRRI method [1]

A total of 100 mg of sample was dissolved in 1 ml of 95% ethanol and 9 ml of 1N NaOH. Then the solution is heated at a temperature of 80-100°C for ± 10 minutes until it is gelatinized. The solution is cooled and then tasted on a 100 ml measuring flask with distilled water as a mother

liquor. Then 1 ml of the diluted sample is taken from the mother liquor. The sample was added with 0.1 ml of 0.2% iodine, 0.2 ml of 1N acetic acid, and 3 ml of distilled water. After being left alone for 20 minutes then absorbance values were measured on a spectrophotometer with a wavelength of 620 nm.

The standard curve is made in the same way as the determination of amylose content in the sample. A total of 40 mg of standard amylose was added with 1 ml of 95% ethanol and 9 ml of 1N NaOH then heated at a temperature of 80-100°C for ± 10 minutes until gelatinized. Then the solution is cooled and then put into a 100 ml measuring flask and tasted with distilled water. Furthermore, from the measuring flask are made several concentrations ranging from 50, 100, 150, to 200 ppm. Samples were taken as much as 1 ml of each concentration then added 0.1 ml of iodine 0.2%, 0.2 ml of acetic acid 1N, and 3 ml of distilled water. After leaving it for 20 minutes, the absorbance value was measured on a spectrophotometer with a wavelength of 620 nm. How to determine amylose levels:

1) Data from the reading of the spectrophotometer are y values
2) Determine the value of x using the linear equation of the standard amylose Cure
3) Calculation with :

$$Amylose\ content\ (\%) = \frac{starch\ concentration\ x\ dillution\ factor}{weight\ of\ sample} \ x\ 100\%$$

....(8)

8. *Solubility and swelling power analysis [9]*

A total of 0.5 g of sample was mixed with 50 ml of distilled water in a 250 ml erlenmeyer flask. The sample was placed on a water bath at 70°C for 2 hours with continuous stirring (200 rpm). In the suspension 30 ml of clear solution was taken and then placed on a petri dish whose weight was known. Petri dishes are dried in an oven of 100°C until the weight is fixed, then weighed and the weight increases are calculated.

$$Solubility\ (\%) = \frac{(b-a)\ x\ 50ml}{0,5\ g\ x\ 30\ ml} \ x\ 100\%$$

....(9)

$$SP\ (\%) = \frac{(d-c)}{weight\ of\ sample\ (g)\ x\ (100 - \%solubility)} \ x\ 100\%$$

....(10)

Where :
SP   = Swelling power
a   = initial weight of petri dishes
b   = final weight of petri dishes
c   = initial weight of erlenmeyer

d   = final weight of erlenmeyer

9. *White degree analysis*

The sample is placed in a dish that has been cleaned previously. After that, the cup is placed into the container. The temperature is then balanced by placing the container above the measurement point. The temperature-balanced container is then put into the measuring place, where the whiteness meter displays the white degree value. The white degree value of the sample is measured by comparing the value of the white degree which is read by the value of the white degree of BaSO$_4$ as standard.

$$White\ degree\ value = \frac{white\ degree\ value}{white\ degree\ value\ of\ BaSO4} \ x\ 100\%$$

....(11)

10. Freeze-thaw stability [10]

This method includes freezing treatment (-20°C) 5 ml of 5% (5 g of starch to 100 ml) of starch paste for 18 hours. Then thawed for 6 hours at room temperature. This treatment is called a cycle. At the end of the cycle, the liquid that came out was separated (3000 rpm centrifugation for 10 minutes) then weighed.

$$Sineresis\ (\%) = \frac{separated\ liquid\ (g)}{total\ sample\ weight\ (g)} \ x\ 100\%$$

....(12)

11. Paste clarity

Measurement of paste clarity uses a method developed by [11] in [12]. 1% starch solution (1 g of starch is tasted to 100 ml) is heated in a water bath at 95°C (wait until the temperature of 95°C is then inserted sample) for 30 minutes while stirring, then cooled to reach 25°C for one hour. Paste clarity was measured using a spectrophotometer with the percentage transmittance (% T) at 650 nm and distilled water used as blank.

III.   OUR APPROACH

The following are the results of analysis obtained from physicochemical properties and functional properties of white sweet potato starch natively. Physical analysis includes the value of water content, ash content, crude fiber content, fat and protein content. Chemical analysis includes the values of starch, amylose and carbohydrate levels. Analysis of functional properties included solubility, swelling power, white degree, freeze-thaw stability and clarity of starch paste. The overall values of physicochemical characteristics and functional properties of native white sweet potato starch are presented in Table 1.

Table 1
Physicochemical characteristics and functional properties

Component	Value
Physic	
Water (%)	9.02
Ash (%)	0.37
Crude Fiber (%)	0.62
Fat (%)	0.13
Protein (%)	1.73
Chemical	
Starch (%)	85.23
Amylose (%)	35.99
carbohydrat (%)	88.75
Functional properties	
Solubility (%)	6.90
Swelling Power (%)	16.50
White Degree (%)	77.14
Freeze-thaw Stability (%sineresis)	95.18
Paste Clarity (%T)	44.97

Water content is one of the important parameters in starch products because it is related to the quality and shelf life of a material. In making sweet potato starch the drying process is carried out which aims to reduce the amount of water contained in the raw material. The starch products can be considered good quality if the lower the water content contained because it can reduce the media for microbial growth that can affect or reduce the quality of the product. In general, microbes are easier to grow in materials that have high water content. For flour-like products the requirements for safe water content are less than 14% (<14%) so that it can prevent mold growth [13] The results of the analysis of the water content of white sweet potato starch is ± 10%. In the study of [14] the water content of sago starch was 12.64% while in arrowroot starch it had a moisture content of 7.02% [15]. The moisture content shows that the water content of white sweet potato starch still meets the SNI standard issued by the National Standardization Agency for 2011 for similar products namely tapioca, where the maximum water content for the product is 14%.

The ash content in a material shows the mineral content as a residue from burning organic matter in the form of inorganic minerals which have a high enough resistance to cooking temperature. White sweet potato starch has a percentage of ash that is not too large, which is 0.37% which naturally comes from fresh tubers. Sago starch has an ash content of 0.09% [14]. In cassava starch the ash content was 0.46% [16]. Quality requirements based on SNI issued by the National Standardization Agency in 2011 for tapioca-like products that maximum ash content is 0.50%. The presence of mineral content in ash content in starch products can change the character of starch, especially viscosity after being heated. In general, mineral salts can reduce the ability of starch gel to experience retrogradation. According to [17] mineral salts such as sodium chloride in certain concentrations can slightly increase the viscosity of starch paste.

Crude fiber content is obtained from the residue after the material is washed using strong acids and strong bases. Crude fiber is a part of carbohydrates that cannot be digested, consisting of cellulose with little lignin and a small portion of hemicellulose [18]. In the digestive system, fiber content can have a positive effect but it can also increase product value added. According to [17] cellulose which is part of crude fiber can increase the ability of starch gel to experience retrogradation. The level of crude fiber in white sweet potato starch used in this study was 0.62% while sago starch had a crude fiber content of 0.34% [14]. According to [19] fiber content in tubers is influenced by the moisture content of tubers when harvesting, where low water content in tubers can cause starch content to change to lignin and cellulose.

Fat is one of the parameters that must be considered for the use of starch in its use in food applications. The known fat content in starch can facilitate the formulation stage in the manufacture of products that are very susceptible to the gelatinization process. Product gelatinization is not maximal and evenly distributed due to the binding of water by inhibited (hydrophobic) starch granules due to the fat content so that the resulting product texture is not uniform. In sago starch [14] the fat content obtained is 0.33%, in cassava starch at 0.26% [16]. The fat content obtained from white sweet potato starch is 0.13%, this indicates that white sweet potato starch has a low fat content (<1%). The fat component can form a hydrophobic layer and amylose complex on the surface of starch granules which can increase the gelatinization temperature and reduce solubility, according to [17] this is due to the fat enveloping the granule blocking heat and blocking the interaction of granulla starch and water.

The functional properties of starch can be influenced by non-starch components such as proteins. Proteins can envelop starch granules by forming complexes with amylose so that starch becomes difficult to gelatinize and inhibits development [20]. Protein can reduce starch solubility and extend cooking time because protein can compete with starch in binding water but can increase gel viscosity, because starch particles can fill protein tissue, thus making the gel more rigid [17]. The results of analysis of starch protein content showed that the sweet potato starch product had a protein content of 1.73%. In sago starch and cassava starch the protein levels obtained were 0.18% and 0.29% respectively [14];[16]. In SNI regarding the quality requirements of similar types of tapioca products, protein content is only a marker of nutritional value and does not become a quality specification for sweet potato starch products as well as fat content.

The starch content provides information about the purity of a starch. White sweet potato starch has a fairly good percentage of purity which is 85.23% while starch content is 98.19% [14]. The starch content is the main desired component of starch products both as food and non-food ingredients, this is because starch products themselves are the result of starch extraction from the starch source itself. White sweet potato starch content meets the requirements based on SNI for tapioca-like products with a minimum value of 75%.

The carbohydrate component that forms starch granules consists of amylose and amylopectin. Both of these fractions have different comparisons depending on the type of starch, but generally starch has a greater fraction of amylopectin than amylose. Amylose content plays an important role in hydroxypropylation reactions and film formation. White sweet potato starch used in this study had amylose content of 35.99%. Amylose content of white sweet potato starch has a higher value when compared to sago starch which is equal to 25.15% [14]. According to [18] most natural (without modification) starch contains about 25% amylose. The starch gelatinization profile is strongly influenced by amylose content, the higher the amylose content, the higher the gelatinization temperature and the lower the peak viscosity of the product and the more it tends to retrogradation. Amylopectin levels from white sweet potato starch are ± 64%. The higher the amylopectin level, the higher the clarity of the gel formed from the starch [17].

IV. CONCLUSION

The results of the characterization of white sweet potato starch obtained good results and met the standards for all physical, chemical and functional analyzes. The levels of starch and amylose are quite high with values of 85.23% and 35.99% respectively. In addition, the value of white degrees also has a good value of 77.14%. Some of these things indicate that sweet potato starch can be used for various purposes, one of which is as a raw material for industrial processes.

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