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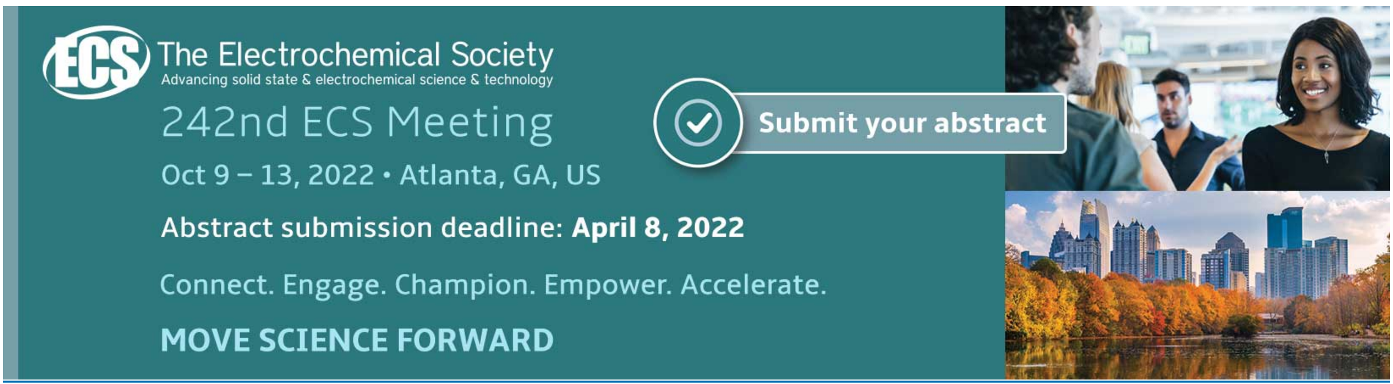

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Physicochemical characterization of starch from seven genotypes banana in West Sumatera

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Abstract. Banana fruit has the potential to be developed as a functional food. For that reason, a detailed characterization of its fruit is necessary. We collected seven banana local genotypes that are widely cultivated in West Sumatra, Indonesia. This study is aimed to determine the physical characteristics and functional properties of banana starch. The analysis was carried out for its starch and proximate variables, XRD, XRF, and RVA. The results showed that the average water content of the starch from the 7 types bananas is ranging from 8.3 to 15.8%, while their ash content is ranging from 0.5 to 2.29%. Protein is in a range between 1.28 to 1.58%, while the fat content is ranging from 0.12 to 0.7%. The crystallinity structure types A involving Pisang Sipuluik, Randah, and Gadang genotypes. Genotype Rotan, Tinalun, and Jantan are classified as type B. While, Pisang Mas is classified as type C. The average starch gelatinization temperature from all 7 genotypes ranges from 70ºC to 75.7ºC.
Keywords: physicochemical, XRD, XRV, RVA

1. Introduction

The biggest cause of death in the world is mostly degenerative diseases such as CVD [cardiovascular disease], cancer, and diabetes. This degenerative disease arises because of the habits of people with poor lifestyles and eating patterns such as low consumption of vegetables and fruit, alcohol consumption, smoking, as well as air pollution from motorized vehicles and factory fumes that cause humans to be exposed to harmful toxins that can disrupt the body's metabolic processes.

Current developments in science and technology do not only assess food in terms of nutrition, sensory, and safety but also consider the effects of food on health and are functional. Food is functional if it contains components [both nutritional and non-nutritional] that are beneficial to the functions of organs in the body relevant to maintaining health or have beneficial physiological effects [1].

Banana starch has been widely studied because of its functional properties that can provide health benefits, including as a component of dietary fiber, preventing colon cancer, being hypoglycemic, hypocholesterolemic, as a prebiotic, reducing gallstone formation, inhibiting gallstone formation, and increasing absorption of micronutrients [2, 3]. Bananas have a high starch content of 28-29%, so they have the potential to be developed as a source of resistant starch. Banana is a climacteric fruit; therefore, it is necessary to process bananas for certain purposes. To increase the utility value of bananas, bananas are processed into starch and flour [4].

Indonesia is rich in banana species diversity, especially in West Sumatra in the district of Agam, where 20 banana species have been identified [5]. The difference in banana genotype is thought to affect the physicochemical properties of the starch and banana flour produced. The purpose of this study was to study the effect of genotypic differences on the physicochemical properties of banana starch.

2. Materials and Methods

2.1. Material Experimental
Green bananas are obtained from agricultural land in IV Koto District, Agam Regency, West Sumatra, Indonesia. The banana sample used was based on the banana ripeness index 1 based on color [6].

2.2. Isolation of starch.
Unripe banana peeled and cut into small pieces [1 cm3]. Then macerated at low speed using a blender [Philips HR2115, Indonesia] [1: 1 ratio] for 5 minutes. The slurry obtained is sieved using a muslin cloth to remove dirt. The supernatant is removed, then the sediment [starch] is washed several times with distilled water to remove impurities from the starch. The starch is dried in an oven at 50oC overnight. The precipitated white starch is ground with a mortar and pestle to pass mesh 250 U.S. and stored at room temperature in closed containers.

2.3. Proximate Analysis
The proximate composition observed was water, ash, fat, and protein content. Measurements were made using the AOAC standard protocol [7]. About 2 grams of banana pulp is dried at 105°C for six hours to get a constant weight. Estimated water content is calculated from the ratio between dry and wet weights. Determination of ash content is done by burning pulp at 55°C in the furnace. Percentage [%] ratio between ash and sample weight determined from the ash content. Lipid content was measured by the Soxhlet extraction method. Samples were extracted with hexane for six hours. The remaining solution is evaporated and dried to get a constant weight. The resulting dry weight is divided by the weight of the sample to determine its fat content. The measurement of protein content was measured by the Kjeldahl method. Samples were mineralized using concentrated sulfuric acid [H_2SO_4] and distilled before being titrated using 0.02 N HCl. Ammonia levels and protein levels were determined by changing the nitrogen content into protein using a factor of 6.25.

2.4. X-ray diffraction
The crystalline structure of banana starch was studied using an X-ray diffractometer [Xpert Powder PANalytical PW 30/40, Netherlands]. The X-ray diffraction system was operated at 40 kV and 30 mA and the starch diffractogram was recorded from 5°2Ɵ to 50°2Ɵ with a scanning speed of 0.002° / sec and a scanning step of 0.02°. Relative crystallinity was calculated by the ratio of the crystal area to the total diffraction area.

2.5. Paste Properties
Starch viscosity was evaluated using Rapid Visco Analyzer [RVA-Techmaster, 2009, Newport Scientific Pty. Ltd, Australia] and the calculation was performed using Thermocline for Windows v3.0 [TCW3].

3. Results and Discussion

3.1. Sampling
The area is known as 'Kampung Pisang' is in Nagari Koto Panjang, IV Koto District. This area is one of the centers for planting bananas in West Sumatra. About 20 types of bananas are cultivated in this area, and almost every household has a banana garden. In this study, 7 genotypes of banana were used, consisting of Jantan, Rotan, Mas, Sipuluik, Tinalun, Gadang, and Randah. [Figure 1].

Figure 1. Sample of 7 banana genotypes

Banana is a dessert fruit whose edible part is pulpy, firm to tender, free from seeds or pips, and has a characteristic flavor. Plantain is a cooking banana subgroup. Plantain resembles banana but is longer, has a thicker skin, and contains more starch. Most dessert banana cultivars in the world are AA or AAA. Cooking bananas, often named plantains, are mostly AAB, ABB, or BBB [8]. Pisang Mas, Gadang, Randah, and Sipuluik are categorized as banana desserts because they can be consumed immediately after they are cooked. Meanwhile, Pisang Jantan, Rotan, and Tinalun are categorized as cooking bananas because they must be processed before consumption.

3.2. Proximate Analysis

Proximate analysis is a chemical analysis method to identify the nutrient content of a material. The proximate analysis classifies the components present in food ingredients based on their chemical composition and function, namely water, ash, crude protein, crude fat, and extract weight without nitrogen or classified as carbohydrates [9]. The results of the analysis of starch rendement from 7 genotypes ranged from 25.11% - 41.91% **[**Table 1**]**. The Jantan banana had the highest starch yield of 41.91%, while the lowest yield was 25.11% on Rotan. The starch rendement obtained from 7 banana genotypes was still higher than Kadir's study [10] on Kepok, Cavendish, and Mas ranged from 18.91% - 21.4%. This difference can be caused by the extraction method, the level of cleanliness of the removal of the peel, and the technique of separating the residue from the starch sediment.

Table 1. Proximate analysis data of starch [%] from 7 banana genotypes

Types of Banana	Rendement [%]	Moisture [%]	Fat [%]	Ash [%]	Protein [%]
Jantan	41,91	15,76±0,20	0,7±0,62	0,5±0,02	1,4±0,18
Rotan	25,11	8,98±0,19	0,58±0,19	2,29±0,30	1,34±0,30
Mas	32,08	9,67±0,60	0,24±0,03	0,93±0,40	1,28±0,10
Sipuluik	30,29	9,07±0,53	0,12±0,07	0,5±0,01	1,6±0,27
Tinalun	31,56	9,87±0,25	0,69±0,03	0,81±0,60	1,52±0,40
Gadang	28,69	8,31±0,34	0,6±0,050	0,5±0,01	1,4±0,18
Randah	29,57	8,72±0,06	0,25±0,13	1,12±0,20	1,58±0,40

The highest water content of banana starch from the seven banana genotypes was found in Pisang Jantan, namely 15.7%, and the lowest was found in Pisang Gadang, which was 8.31%. Banana starch water content above 12% is not safe for long storage because it is easily overgrown by fungi. This moisture content determines the shelf life of food ingredients. The high and low water content of banana starch is influenced by genetic and environmental factors as well as by factors of media selection and drying time. Besides, Roberfroid [1] suggested that low water content can increase the crystallinity level of starch, while high water content makes starch more easily degraded by enzymes.

Fat content in banana starch ranges from 0,12% - 0,7% with the highest fat content found in Pisang Jantan and the lowest fat content in Pisang Sipuluik. The fat content in banana flour affects the rheological properties of the flour, especially the final product. The ash content in banana starch ranged from 0.5% - 2.29% with the highest ash content found in Pisang Rotan and the lowest ash content in Pisang Gadang. Ash content is a calculation of the remaining inorganic material from the ashing process. This ash content can affect the color and texture of the starch. Besides, often the ash content is also used as a parameter whether or not the processing of a food material is good or the presence of impurities in the food. The protein content in banana starch ranges from 1.28% - 1.6% with the highest protein content found in Pisang Sipuluik and the lowest protein content found in Pisang Mas.

3.3. XRD

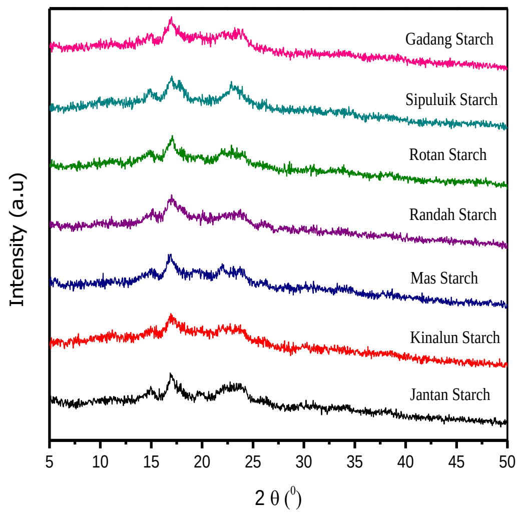

Figure 2. Starch XRD graph of 7 banana genotypes

The crystallinity of starch granules can be seen using the X-ray diffraction pattern method. It can be determined by integrating the curve under the peaks of the amorphous and crystalline regions. The X-ray diffraction peak intensity produced on the curve corresponds to the crystalline area in the starch granule [11]. Starch types classified based on the XRD analysis peaks and the degree of crystallinity obtained [12]. It can be seen in Figure 2 that the main difference between type-A and type-B starch is that type-A has a strong peak at an angle of sin 2Ɵ 18° but does not have a substantial rise at an angle of sin 2Ɵ 5° and 22° whereas in type-A -B has a strong peak at the tip of sin 2Ɵ 5° and 22° but does not have a substantial rise at the angle of sin 2Ɵ 18°. There are other crystal types in starch, namely type-C, type-C, of mixed starch between type-A and type-B starches. It is called mixed type starch because it has a strong peak at a sin angle of 2Ɵ 5°, which is a characteristic of B-type starch but does not have a substantial rise at an angle of 2Ɵ 22° sin, which is characteristic of A-type starch.

The type of starch in the seven banana genotypes has the same class for each genotype. Type A starch is found in Pisang Sipuluik, Randah, Gadang. Type B starch is found in Pisang Jantan, Rotan, Tinalun, Meanwhile, type C is found in Pisang Mas. According to Kim et al. [13], type-A starch has a higher resistance than type B starch. This is probably due to type A starch having a denser crystal structure [14]. According to Jyothi et al. [15], type-A starch has higher water retention than B starch because it has a more compact structure. Generally, type A starch is more comfortable to digest than type B [16]. Starch grains' crystallization is influenced by other starch components, including protein, lipids, and cellulose [17]. Crystallinity is also influenced by external factors such as variation and the environment in which each variety is cultivated [18].

3.4. Pasting Properties

The gelatinization profile data of processed banana starch from the RVA curve in Figure 2 can be seen in Table 2. The pasting temperature of bananas ranged from 70ºC - 75.7ºC The Jantan has a higher temperature than other banana varieties. Banana peak viscosity varies from 4475-6177cP. Tinalun has the highest peak viscosity compared to different types of bananas. This shows that Tinalun can form pasta when cooked. Rotan has the highest breakdown value compared to other varieties at 1910 cP. At the same time, Sipuluik has the highest setback value of 2525 cP compared to different types.

According to Cahyana et al. [19], the viscosity breakdown can describe starch stability during the stirring and heating processes. This is because an increase in the breakdown viscosity is associated with an increase in amylose leaching solubility. The amount of amylose in water will affect the consistency. He also stated that the protein matrix could cause a high pasting temperature in aggregates surrounding the starch, which inhibited the water absorption process, increasing temperature.

This is in line with Li and Zhu [20] research results, which states that the amylose-lipid complex will increase granule integrity and gelatinization temperature and reduce retrogradation. This amylose-lipid complex will interfere with amylose molecules' mobility and reduce amylose solubility in water to reduce the setback viscosity [21].

In general, the setback viscosity value of each variety is high. This indicates that the starch content of each banana variety is more susceptible to retrogradation. According to Roberfroid [1]; Saguilan et al. [22], Tovar et al. [23], This phenomenon is advantageous because it will facilitate forming type III resistant starch.

Table 2. Analysis of RVA Starch 7 banana genotypes

Types of banana	Peak [Cp]	Trough [Cp]	Breakdown [Cp]	Final Viscosity [Cp]	Setback [Cp]	Peak Time [Min]	Pasting Temperature [ºC]
Jantan	5016	3767	1249	5903	2136	8.67	75.7
Rotan	4914	3004	1910	5214	2210	7.40	70
Mas	4475	3428	1047	4881	1453	9.27	71.7
Sipuluik	5078	3727	1351	6252	2525	7.87	74.15
Tinalun	6177	4423	1754	6042	1619	8.73	74.1
Gadang	5280	3533	1747	5272	1739	8.80	72
Randah	5185	3914	1271	5888	1974	8.13	73.7

4. Conclusion

The seven banana genotypes have the potential to be developed as functional foods. Jantan Banana has a high yield, good for food processing, but it cannot be stored for a long time. Based on the type of crystallinity, Rotan, Jantan, and Tinalun bananas are more digestible than Sipuluik, Randah, Gadang, and Mas bananas. Sipuluik, Rotan, Gadang, and Randah starches can be applied to the manufacture of ice cream and yogurt products, Tinalun starch is suitable for making pasta, while Mas starch is not suitable as a thickener.

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