Functional properties of ripe plantain (Musa spp) flour from different varieties

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Abstract. Ripe plantain has potentially become flour with good sensory and easy to digest. This study was carried out to determine the functional properties of five varieties of ripe plantains flour. This research was conducted using a completely randomized design with a single factor, namely a variety of plantains consisting of five levels: V1 = Kapas (Musa corniculata); V2 = Tanduk (Musa corniculata J.De Leureiro); V3 = Siam (Musa paradisiaca var. Moralis M.); V4 = Kepok (Musa paradisiaca var. Bluggoe); V5 = Raja Bulu (Musa sapientum var. Paradisiaca Baker), and each treatment was repeated 3 times. The result showed that the yield and moisture content of plantain flour from the five varieties ranges from 5.88% - 16.19% and 6.71% - 9.51% and kapok flour has significantly different in moisture content and yield compare with other varieties. The water absorption capacity ranges from 2.87-3.03 g/g, was not significantly different among the treatments. The oil absorption capacity ranges from 2.13-2.30 (g/g) and OAC of ripe kapas was significantly different compared with ripe siam flour and ripe raja bulu flour. The swelling capacity ranges from 3.41-4.19 g/g and SC of ripe tanduk flour was significantly different from ripe kepok flour. The solubility ranges from 8.59-29.67% and solubility of ripe kapas, kepok, raja bulu flour was significantly different with ripe tanduk and siam flour. The peak time (6.84-7.00 minutes) and pasting temperature (94.88-95.03°C) were not significantly different among the treatment. The peak viscosity ranges from 169.00-653.00Cp and ripe kapas and raja buluh flour was significantly different from others, it was higher than others. The breakdown viscosity ranges from 22.00-178.00 Cp and ripe tanduk and raja buluh was significantly different from others, it was higher than others. The setback viscosity ranges from 45.00 -545.67Cp and ripe kapas flour was significantly different among the treatments with the highest value. Based on the result could be concluded that different varieties could have different or the same functional properties. The used of ripe plantain flour for food production could be based on the functional properties of the flour.

1. Introduction

Banana was one of the tropical fruit plants that grows in Indonesia. Banana has become a daily consumption in Indonesia. According to [1], bananas are divided into two major groups, which can be
directly consumed (banana) and some must be processed (plantain). Bananas are nutritious food [2]. Bananas have complete nutrients, including water, carbohydrates, proteins, fats, vitamins, and minerals. According to [3] each banana variety contains several different nutritional values. The main nutrient in 100 grams of banana is 75 g of water content, 1.20 grams of protein, 0.20 grams of total fat, 23.00 grams of carbohydrates, and 0.6 grams of other content. Plantain contains higher carbohydrates, minerals, and vitamins but contains less protein than banana [4], [5], [6].

In Indonesia, plantains have not been utilized optimally. Plantain that is not processed and stored for long periods will rot and be wasted [7]. Plantain can be used as a raw material for making flour. Flour is an alternative form of intermediate products that are recommended because it has a longer shelf life, easy to mix, rich in nutrients (fortified), easily formed, and faster cooked as needed [8]. Some other benefits obtained were easier in packaging and distribution, adding value, and can substitute wheat flour for food diversification, contains good nutrition, and it is easily digested. Plantain flour is one of the local products that have the potential to be developed [9]. Plantain flour was an intermediate product as a raw material for other products, such as baby porridge, bread, biscuits, cookies, and other bakery products.

Bananas that can be used as raw material for making flour have the requirement that it have a starch content of 16.5% to 19.5% [10]. Plantain has higher starch content, which ranges from 20% to 30%, so it was well used for flour manufacturing. Plantain flour was produced from the grinding of dried plantains (dried plantain chips).

Plantain flour was usually made from mature fruit but that are not yet ripe. Based on previous research, plantain types have a significant influence on the characteristics of flour produced. Plantain flour made from unripe kepok produces very good flour because it has white color and attractive [11]. Unripe kepok plantain flour and unripe siam plantain flour have the brightest flour color compared to tanduk plantain, kapas plantain, and raja bulu plantain [12]. Kapas plantain flour was white but not as bright and white as kepok and siam plantain. Whereas tanduk plantain flour produces yellowish flour color and raja bulu plantain flour has a reddish-brown color [9].

Ripe plantain flour was a modification of unripe plantain flour process using ripe plantains. According to [13], plantain flour can be made from unripe plantains and ripe plantains, but characteristics are different. From the sensory test results, the unripe plantain flour has a brown color, tasteless, and odorless. Ripe plantain flour has more advantage than unripe plantain flour, which was easier to digest and better sensory. The ripening stage of plantains could affect the functional properties of flour. Ripe plantain flour has a higher whipping capacity than unripe flour, but a lower swelling capacity, emulsion capacity and viscosity [7].

The purpose of this study was to examine the functional value of ripe plantain flour from five local Indonesian plantain varieties.

2. Materials and methods

2.1. Materials and Tools

The ingredients used to manufacture the flour from five varieties of plantain, i.e.: Musa paradisiaca var. Bluggoe (local name: kepok), Musa corniculata J.De Leureiro (local name: tanduk), Musa paradisiaca var. Moralis M. (local name: siam), Musa sapientum var. Paradisiaca Baker (local name: raja bulu), and Musa corniculata (local name: kapas), sodium metabisulfite. The material used for analysis was aquades, vegetable oil, etc. The tools used to making plantain flour were slicer, infrared cabinet dryer, knife, basin, steamer, grinder, stove, and sealer.

The tools used for analysis include oven vacuum (Mammert), centrifuge (Janetzki T5), Chrome Meter CR-300 (Konica Minolta Co., Osaka, Japan), Rapid Viscosity Analyzer (RVA-TecMaster, Macquarie Park, Australia), waterbath (GFL mbH D-30938 Burgwedel), analytical balance (Mettler Toledo ), Infrared dryer, centrifuse tube, etc.
2.2. Place and Time Research Conduct
This research was conducted in March 2019-June 2019 at the Food Processing Laboratory and Chemical Analysis Laboratory, Research Center for Appropriate Technology LIPI.

2.3. Experiment design
This study was used a completely randomized design with a single factor, namely a variety of plantains consisting of five levels: V1 = Kapas (Musa corniculata); V2 = Tanduk (Musa corniculata J.De Leureiro); V3 = Siam (Musa paradisiaca var. Moralis M.); V4 = Kepok (Musa paradisiaca var. Bluggoe); V5 = Raja Bulu (Musa sapientum var. Paradisiaca Baker), and each treatment was repeated 3 times. The treatment was observed for response parameters which included yield, moisture content, swelling capacity and solubility, water absorption capacity (WAC), oil absorption capacity (OAC), color, and pasting properties. The data were performed using Microsoft Excel 2013 for analysis of variance and Duncan’s test. Data were presented in the form of tables and graphs. The differences between treatments were analyzed using ANOVA. Significant differences between mean values were determined using Duncan’s Multiple Range Test (α=5%).

2.4. Sample preparation
The plantain flour preparation included sorting, washing, peeling, slicing at 1-1.5 cm, soaking in 0.3% sodium metabisulfite solution for 5 min, rinsing, draining, drying using an infrared dryer at 50-55°C for 20-24 h, grinding, and sieving at 40 mesh. Plantain flour was packed using a metalized package.

2.5. Analyses of ripe plantain flour
2.5.1 Yield analysis [14].
Analysis of yields to determine the weight percentage of ripe plantain flour produced based on the initial weight of the raw material. The yield of ripe plantain flour was obtained using the following equation (1):

\[
\text{Yield (\%)} = \frac{\text{initial weight}}{\text{final weight}} \times 100\%
\]  

(1)

2.5.2 Moisture content analysis [15].
Moisture content analysis aims to determine the water content in the material after drying until a constant mass is obtained. The moisture content of the material was calculated by the following equation (2):

\[
\text{M (\%)} = \frac{\text{Wm}}{\text{Wm+Wd}} \times 100\%
\]  

(2)

Explanation =
M : Moisture content
Wm : water content in the material
Wd : weight of dry matter

2.5.3 Swelling power and solubility Analysis [16].
0.2 gram flour sample is put in a centrifuge tube and 10 ml of distilled water is added. The sample was put at 25°C for 5 min and then placed in a water bath at 95°C for 30 min. After that, the flour sample was cooled at 20°C for 1 min, then the sample was centrifuged at 3500 rpm for 15 min to separate the gel and supernatant. The gel formed is weighed to determine the swelling power with the following equation (3):
Meanwhile, the supernatant was placed on a weighed cup and then dried using an oven at 105°C for 4 h to calculate the dissolved starch. Dried supernatant was weighed to calculate the solubility of starch with the following formula (4):

\[
\text{Solubility (\%) = \frac{\text{weight of dried supernatant}}{\text{sample weight}} \times 100}\% \quad (4)
\]

2.5.4 Water absorption capacity [17].
1 gram of plantain flour sample carried out the suspension process in 10 ml of water and put in a 15 ml centrifuge tube. The resulting slurry was homogenized for 1 min at room temperature and centrifuged at 3000 rpm for 10 min. The decantation of the supernatant and the centrifuge weight of the tube and the precipitate were weighed. WAC was calculated by the following equation (5):

\[
\text{Water Absorption Index} = \frac{\text{weight of sediment}}{\text{initial weight flour}} \quad (5)
\]

2.5.5 Oil absorption capacity [17].
1 g of plantain flour sample was suspended in 10 ml of vegetable oil and put in a 15 ml centrifuge tube. The formed slurry was homogenized for 1 min at room temperature and centrifuged at 3000 rpm for 10 min. The supernatant was decanted and the centrifuge and sediment tubes were weighed. OAC was calculated by the following equation (6):

\[
\text{Oil Absorption Index} = \frac{\text{weight of sediment}}{\text{initial weight flour}} \quad (6)
\]

2.5.6 Gelatinization profile analysis [18].
Testing of gelatinization profiles was carried out using the Rapid Visco Analyzer (RVA-TecMaster, Macquarie Park, Australia). Samples of plantain flour were weighed 3.5 g (base 14 g of water content per 100 g of flour) then mixed with 25 g of aquades in aluminum canister. RVA is set at an initial temperature of 50°C maintained for 1 min, then heated to a temperature of 95°C at a speed of 12.2°C/min, then held at 95°C for 2.5 mins and cooled to a temperature of 50°C at 11.8°C/min. Paddle rotation speed of 960 rpm in the first 10 s then drops to 160 rpm which is maintained during the analysis process. Parameters recorded include: pasting temperature, peak viscosity, final viscosity, breakdown viscosity, setback viscosity, peak time, and peak temperature.

2.5.7 Color.
Color measurements will be made on flour samples using a Chrome Meter CR-300 (Konica Minolta Co., Osaka, Japan) with color parameters observed L, a, and b. The analysis will be carried out in three repetitions of the analysis on a spot taken randomly from flour samples. The measurement results are stated in CIE LAB, with the value L (lightness; 0 = black, 100 = white), a (+a = red, -a = green), b (+b = yellow, -b = blue).

3. Results and discussions

3.1. Yield and Moisture Content
Based on table 1 it was known that the yield of plantain flour from the five varieties ranges from 5.88% - 16.19%. The kapas plantain had the largest yield of 16.19%, followed by siam 15.39%, tanduk 15.22%, raja bulu 9.56% and kepok 5.88%. The yield of ripe kapas, siam and tanduk plantain
flour was not significantly different, but it were significantly different from raja bulu and kepok varieties. The kapas, siam and tanduk varieties have the highest yield compared to the others. Each variety of plantain were produced different yield. Ripening stage, moisture, and starch content affect the yield of plantain flour. The plantains that used in this research have the same stage (stage 4-6) but produced different yield, it was presumed each banana has a different starch and moisture content. The tanduk and siam varieties were thought to have higher starch content. Low starch content produces low yield plantain flour [19].

Ripe plantain flour has a lower yield compared to unripe plantain flour because during the ripening process, the starch was converted to glucose, thereby reducing the yield of ripe plantain flour. Plantain with a higher ripening stage, have higher water content and lower starch content [19]. This is also in line with [20], that the ripe plantain flour has a sugar content of 12.8% higher than unripe plantain flour 5.53%.

The moisture content of ripe plantain flour from five varieties ranged from 6.71% - 9.51% (Table 1). Plantain varieties have a significant effect on water content (P <0.05). The water content of kepok was the lowest and significantly different (P <0.05) from other varieties.

The average moisture content of ripe plantain flour from this study was still higher compared with ripe plantain flour from [21] (7.00% -7.10%). Different plantain varieties will produce different moisture content of dry products. Supported by research from [22], dried ripe plantain slices from two varieties, namely medium cavendish (Musa acuminata) and Gros Michel (Musa balbisiana) obtained different water content. Ripe plantain flour usually has a higher water content compared to unripe plantain flour (5.10% -6%)[23]. During the ripening process, there is a transfer of water content from the peel to the pulp causing the texture become softer and case hardening occurs during the drying process [24].

Table 1. Yield and water content of ripe plantain flour from different varieties

| Varieties | Yield (%) | Water Content (%) |
|-----------|-----------|-------------------|
| Kapas     | 16.19<sup>a</sup> | 9.41<sup>a</sup> |
| Tanduk    | 15.22<sup>a</sup>  | 8.91<sup>a</sup>  |
| Siam      | 15.39<sup>a</sup>  | 8.48<sup>a</sup>  |
| Kepok     | 5.88<sup>b</sup>  | 6.71<sup>b</sup>  |
| Raja Bulu | 9.56<sup>c</sup>  | 9.51<sup>a</sup>  |

Mean value with different alphabetic in the same column are significantly different (P<0.05)

3.2. Functional Properties

Table 2 describes the functional properties of ripe plantain flour from different varieties. Water absorption capacity (WAC) values of five ripe plantain flour varieties ranged from (2.87-3.03) g/g and were not significantly different (P> 0.05). Raja bulu varieties have the highest WAC value compared to other varieties. WAC flour shows the ability of flour to absorb and bind water in a mixture [25]. WAC ripe plantain flour from the results of this study was higher than the ripe plantain flour of Musa spp., AAB group 0.85 ± 0.06 (g/g) [25], apem variety (Musa sapientum L. var. paradisiaca) 0.71 (g/g) [24] and unripe plantain flour ‘false horn’ varieties (Musa spp. AAB) 2.50 (ml/g) [7]. The high value of WAC flour results in this study indicates that flour was easier to absorb water from the environment during storage. The OAC ripe plantain flour of this study ranged from 2.13-2.30 (g/g) and were significantly different (P <0.05). Siam variety has the highest OAC value and are the most different compared to other varieties. OAC results of this study were lower than the ‘false horn’ variety (Musa spp. AAB) 4.00 (ml / g) for ripe plantain and 5.33 (ml/g) for unripe plantain [7], but higher than the Musa spp., AAB variety 1.02 ± 0.14 (g/g) [25]. Swelling capacity (SC) and solubility of ripe plantain flour in this study ranged from 3.41-4.19 g/g and 8.59-29.67% and both were significantly different between varieties (P <0.05). Kepok variety has the highest SC and most significantly different than other varieties. While the tanduk varieties have the lowest SC. Swelling capacity (SC) shows the
ability of flour to absorb water in hot conditions [24]. SC results of this study were slightly lower than the results of research [7] 2.40 g/g. SC and solubility of flour results of this study were equivalent to the results of the study of [24] 5.237±0.03 g/g and 18.890 ± 0.004%.

In general, it can be concluded, varieties significantly affect the value of the function of the ripe plantain flour produced. WAC and SC values are high in flour products, have high economic value and are recommended for bakery and pastry products [7]. While the OAC value and high emulsion capacity in flour are very useful for products that require emulsions and creaming properties [7]. The ripe plantain flour results from this study have a high WAC and SC so it can be recommended for bakery and pastry products, but because the OAC value is lower it is not recommended for bakery products that require emulsions and creaming properties, such as cake.

### Table 2. Functional properties of ripe plantain flour from different varieties

| Varieties | WAC (g/g) | OAC (g/g) | Swelling Capacity (g/g) | Solubility (%) |
|-----------|-----------|-----------|-------------------------|----------------|
| Kapas     | 2.87a     | 2.13a     | 4.06ab                  | 8.59a          |
| Tanduk    | 2.91a     | 2.26ab    | 3.41a                   | 29.67b         |
| Siam      | 3.01a     | 2.30b     | 3.56ab                  | 27.75b         |
| Kepok     | 2.95a     | 2.22ab    | 4.19b                   | 17.15b         |
| Raja Bulu | 3.03a     | 2.29b     | 4.11b                   | 12.82a         |

Mean value with different alphabetic in the same column are significantly different (P<0.05)

### 3.3. Pasting Properties

Table 3 describes the pasting properties of ripe plantain flour from different varieties. Peak Viscosity (PV) shows the ability of starch granules to absorb water and expand during cooking [26]. Ripe plantain flour in each plantain variety has a significantly different PV value (p <0.05). Kapas plantain flour and Raja Bulu have the highest PV (653 and 573.33 cP) and ripe siam flour has the lowest PV (169.00 Cp). [18] produce plantain flour with PV 364 cP approaching the value of ripe plantain flour PV from kepok 316.50 Cp. The value of PV of ripe plantain flour is entirely lower than the value of unripe plantain flour [11],[18], [27]. This can be caused by the number of dissolved carbohydrates in ripe plantain flour [28] and a low amount of starch resulting in a decreased ability of granules to absorb water.

### Table 3. Pasting properties of ripe plantain flour from different varieties

| Varieties | Peak Viscosity (Cp) | Breakdown Viscosity(Cp) | Final Viscosity (Cp) | Setback Viscosity (Cp) | Peak Time (menit) | Pasting Temp (°C) |
|-----------|---------------------|-------------------------|---------------------|------------------------|------------------|------------------|
| Kapas     | 653.00d             | 83.67b                  | 1115.00c            | 545.67c                | 7.00a            | 94.88a           |
| Tanduk    | 451.00c             | 178.00c                 | 243.00a             | 45.00a                 | 6.84a            | 94.95d           |
| Siam      | 169.00a             | 27.00a                  | 363.67a             | 124.33a                | 7.00a            | 95.00d           |
| Kepok     | 316.50b             | 22.00a                  | 248.00a             | 110.67a                | 6.96a            | 95.03b           |
| Raja Bulu | 573.33d             | 170.50c                 | 770.33b             | 345.33b                | 6.98d            | 95.00d           |

Mean value with different alphabetic in the same column are significantly different (P<0.05)

Breakdown viscosity (BD) is an easy measure of starch cooked to disintegrate. The higherof breakdown viscosity value, means that the starch more stable in hot conditions. BD of five varieties of ripe plantain flour ranged from 22.00-178.00 Cp and showed a significant difference (p <0.05). The highest BD was produced on tanduk plantain flour and raja bulu (178.00 and 170.50 Cp) and the lowest was produced on siam and kepok plantain flour (27.00 and 22.00 cP). BD siam and kepok plantain flour are lower than ripe plantain flour produced by [18] 35 Cp. This can be caused by
differences in the stage of plantain ripening. The higher the ripening level of plantains, the higher the stability of heat because the available starch content is lower for gelatinization [29].

Final Viscosity (FV) reflects the stability of cooked pasta and the ability to form thick or gel paste after cooling [30]. Ripe plantain flour from kapas varieties and raja bulu have the highest FV (1115.00 and 770 Cp) and siam plantain flour, kepok, and tanduk have a low FV of 363.67; 248.00; 243.00 Cp and did not show a significant difference between the three (p> 0.05). FV of five ripe plantain flour varieties in this study was lower compared to ripe cavendish flour with a ripening level of 5 that is 190.5 RVU (2286 Cp) [28]. This can be caused by differences in the types of varieties and the ripening stage used.

Setback Viscosity (SV) reflects definite syneresis ability during cooling of the starch paste after cooking [31]. The lower SV indicates a lower tendency of retrogradation of starch. Tanduk plantain flour has the lowest SV of 45.00 cP and was significantly different from SV of ripe varieties of kapas plantain flour which was 545.67 cP (p<0.05). The fifth SV of plantain flour in this study was lower than the ripe plantain flour from the study results of 658.8 Cp (54.9 RVU) [28]. SV of ripe plantain flour from the varieties of tanduk, siam and kepok were lower than SV cavendish flour with a ripening stage of 5 [18]. The low SV ripe plantain flour in this study can be caused by a large number of dissolved carbohydrates in plantain flour forming complex compounds with starch causing limitations in the occurrence of hydration and swelling of granules, so that amylose released in the matrix becomes less and decreases retrogradation amylose ability [32].

Peak Time shows the time needed for flour/starch to reach maximum viscosity. The peak time of ripe plantain flour in this study ranged from 6.84-7.00 minutes and did not differ significantly between the five (p> 0.05). This value was higher than the peak time of unripe plantain flour [33].

Pasting Temperature (PT) indicates the minimum temperature needed to cook a sample [34]. The flour of five plantain varieties has a high PT which was 94.88-95.03°C and did not differ significantly between the five (p> 0.05). PT plantain flour in this study was higher than the cavendish variety of ripe plantain flour and unripe plantain flour [27], [28]. The duration of peak time and the high temperature pasting on ripe plantain flour can be due to high sugar content with low starch content [28]. The high content of dissolved carbohydrates (high sugar content) causes the energy needed to gelatinize flour to be higher because dissolved carbohydrates compete with starch in absorbing available water, so it takes longer and higher temperatures to gelatinize the starch.

4. Conclusion
The result showed that the yield and moisture content of plantain flour from the five varieties ranges from 5.88% - 16.19% and 6.71% - 9.51% and kapok flour has significantly different in moisture content and yield compare with other varieties. The water absorption capacity ranges from 2.87-3.03 g/g, was not significantly different among the treatments. The oil absorption capacity ranges from 2.13-2.30 (g/g) and OAC of ripe kapas was significantly different compared with ripe siam flour and ripe raja bulu flour. The swelling capacity ranges from 3.41-4.19 g/g and SC of ripe tanduk flour was significantly different from ripe kepok flour. The solubility ranges from 8.59-29.67% and solubility of ripe kapas, kepok, raja bulu flour was significantly different with ripe tanduk and siam flour. The peak time (6.84-7.00 minutes) and pasting temperature (94.88-95.03°C) were not significantly different among the treatment. The peak viscosity ranges from 169.00-653.00Cp and ripe kapas and raja buluh flour was significantly different from others, it was higher than others. The breakdown viscosity ranges from 22.00-178.00Cp and ripe tanduk and raja buluh was significantly different from others, it was higher than others. The setback viscosity ranges from 45.00-545.67Cp and ripe kapas flour was significantly different among the treatments with the highest value. Based on the result could be concluded that different varieties could have different or the same functional properties. The used of ripe plantain flour for food production could be based on the functional properties of the flour.
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