Isolation and Characteristics of *Musa troglodytarum* L. Starch at Different Maturity Stage

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**Abstract.** This research was aimed to isolate and to characterize the chemical properties of F’ei banana (*Musa troglodytarum* L.) starch at different maturity stages. Chemical properties observed including moisture, ash, protein, fat, carbohydrate, fibre, and total sugar contents. F’ei banana with different maturity stages, i.e. first, second, and third maturity stages were applied in this research and were collected from the farmers in Naku Village, South Leitimur District. A completely randomized experimental design with three replications was applied. Results showed that the stage of maturity of the banana affected all observed variables. Moisture, fibre, and total sugar contents increased with increasing degree of maturity, whereas other variables were found to be decreased.

**Keywords:** Fe’i banana, isolation, maturity stage, starch

1. **Introduction**

One of the tropical fruits that grow in Indonesia and potentially used as a source of carbohydrates is a banana. Carbohydrates in bananas are medium complex carbohydrates and are available in stages [1]. Apart from being a source of carbohydrates, bananas also contain provitamin A, vitamin B, and vitamin C and minerals (potassium, magnesium, phosphorus, iron, and calcium) are good for the body [2]. Bananas are classified into human uses, ranging from the banana fiber, ornamental banana and edible banana [3]. Banana products represent an important socio-economic and ecological role and have an essential food resource.

One of the local banana varieties in Maluku is known *Musa troglodytarum* L. with local name "pisang tongka langit", also known as name Fe’i banana. Fe’i banana has a distinctive and unique shape because of its upright mark looking up at the sky. In general, Fe’i bananas have an orange to reddish color with brown spots on the skin surface and contain β-carotene compounds reaching 6360 μg/100 g and phenol, hydrocarbon, ester or alcoholic compounds [4]. The results of studies on Fe’i bananas based on the level of maturity showed a significant effect on the rate of respiration and were associated with a decrease in the content of starch as a respiratory substrate [5].

The maturity level of bananas affects the chemical compounds contained therein. Based on the change in color, the level of banana maturity can be determined to start from green which indicates the level of physiological maturity to bright yellow with brown spots leading to aging [6]. Physiological maturity is the level of maturity in which a commodity has passed its developmental stage.

The starch content of each plant is different, depending on each species and varies in different parts of the same plant [7]. The high starch content in fruits is at the level of physiological maturity which is...
a transition from the phase of plant development to the maturity phase. Mature green bananas have a high starch content and will decrease with increasing level of maturity. Starch content decreases during the maturation process with an increase in total dissolved sugar content where the starch content in raw bananas is 21.2% while in ripe bananas by 3.1% [8-9]. Starch content decreases in ripe bananas because more than 80% of starch converted to soluble sugars, namely glucose, fructose, and sucrose. The soluble sugar increases to 19% along with the decrease in starch content during ripening. Kheng [10] reported that the harvest maturity determines the physical and chemical quality of bananas. Research conducted by Musita [11] on plant king plantain, yellow kepok, manok kepok, ambon, muli, cotton, janten, jackfruit, lemongrass king, horn, and batu banana have a starch yield ranging from 0.87-24.12% while information about Fe’i banana starch has not been published yet. This study aims to isolate and characterize the chemical properties of Fe’i banana starch based on the level of maturity.

2. Experimental

2.1 Materials
The primary ingredient in this study is the Fe’i banana obtained from Farmers in Naku Village, Leitimur Selatan District, Ambon City. The chemicals used for the analysis of Fe’i banana starch are NaOH, Na2S2O3, H2SO4, K2SO4, HgO, H2O2, H3BO3, and HCl, all of which are pure analytics from Merck (Germany).

2.2 Description of Maturity level of Fe’i Banana
The maturity level of the Fe’i banana described according to the shape and size of the fruit can be seen in Table 1.

| Appearance               | Maturity level I                         | Maturity level II                           | Maturity level III                           |
|--------------------------|----------------------------------------|--------------------------------------------|---------------------------------------------|
| Fruit size               | Rather big                             | Big                                        | Big                                         |
| Fruit shape              | Rather rounded because there are still corners on the fruit and the angle is rather sharp | Somewhat round because there are still corners on the fruit but the angle is not sharp | Round because most of the corners in the fruit have disappeared |
| Fruit skin surface       | Smooth (no brown patches on the skin surface of the fruit) | Smooth (brown patches have not formed on the surface of the skin) | Rough (there are brown patches on the skin surface of the fruit) |

2.3 Isolation of banana starch
Isolation of banana starch follows the method proposed by Satuhu and Supriyadi [6]. Fe’i banana peeled, weighed, diced (± 1 x 1 cm), then immersed in ± 2500 mL of water for 5 minutes and filtered. After that crushed with a crusher into fruit pulp by adding 1:1 ratio of water (w/v), then filtered with a filter cloth to separate starch and pulp, into the pulp added water with a ratio of 1: 1 (w/v). The screening process is carried out three times until the filter results look clear. The filter results are allowed to stand for about 12 hours to settle. After settling the bright part is discarded. Subsequently the deposited starch was washed with water three times to produce starch. Wet banana starch is dried
in the oven at 40°C for 12 hours. Dried banana starch is mashed with mortar and sieved with a 60-mesh sieve, then stored in a low-density polyethylene plastic-type.

2.4 Observation variable

2.4.1 Yield of starch
Yield expressed as a percentage of the weight of starch produced per sample weight [13], can be formulated as follows:

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\% \text{ Yield} = \left( \frac{\text{weight of starch}}{\text{weight of sample}} \right) \times 100\% \]

2.4.2 Proximate analysis
Standard AOAC methods [14] were used for the measurement of moisture, ash, protein, and fat content. The moisture content (%, w/w) was assayed by loss in weight on drying at 105 °C for 5 hr in a hot air oven (Memmert, Germany). The ash (%, w/w) was determined by incineration of a known sample weight in a muffle furnace (Lenton Furnaces, UK). Starch was burnt in a furnace overnight (12 hr) at 550 °C and cooled down in desiccators. The protein content (%) was estimated from the nitrogen content by the Kjeldahl method multiplied by 6.25. Fats were Soxhlet-extracted with petroleum ether (40-60 °C). The crude fiber content (%) was assayed by loss in weight on drying at 105 °C for 2 hr after Soxhlet-extracted.

2.4.3 Carbohydrate by differences [15]
Carbohydrate content is determined by the by difference method, which is a calculation involving water content, ash content, protein content, and fat content.

2.4.4 Total dissolved solids
The sugar sample taken sufficiently, then flattened on the surface of the refractometer. The measurement is done with the help of light to show the color gradient. Numbers showing the color gradient recorded (% Brix).

2.5 Data analysis
The data obtained were then analyzed using variance according to the design used. If there is a different treatment that is very real and real, it will continue with the Tukey test at the level of α = 0.05.

3. RESULTS AND DISCUSSION

3.1 Starch yield
The results of the analysis of the variance showed that the treatment of the maturity level of the Fe’i banana was very significant (P < 0.01) on the yield variable. The yield of Fe’i banana starch based on the level of maturity ranged from 5.54 to 5.93% (Table 2).

The maturity level of bananas is very determining the amount of yield obtained. This is due to hydrolyzing starch to simple sugar which causes the starch yield to decrease in maturity level III. The level of maturity results in a decrease in starch content that is associated with increased activity of the amylase enzyme and other enzymes [16]. Decrease in starch yield at maturity level III due to the process of breaking down starch into simple sugars that is a source of energy for metabolic processes. Li et al. [17] showed that the Increased level of fruit maturity, resulted in a faster change in the starch content of bananas. Khawas et al. [18] also reported that this difference in starch content. The total carbohydrate observed at stage III maturity decreased gradually at a later developmental stage.
Table 2. The influence of the level of maturity on the yield, water content and ash content of Fe'i banana starch

| Maturity Stage | Starch yield (%) | Water content (%) | Ash content (%) |
|----------------|------------------|-------------------|-----------------|
| 1              | 5.93a            | 8.46c             | 0.011a          |
| 2              | 5.73ab           | 9.56b             | 0.010b          |
| 3              | 5.54b            | 10.48a            | 0.007c          |

Means with the same letters in the same column are not significantly different at p < 0.05 level by Tukey’s test.

3.2 Water content
The results of the analysis of variance showed that the treatment of the maturity level of the Fe’i banana was very significant ($P < 0.01$) on the water content variable. The water content of Fe’i banana starch based on the level of maturity ranged from 8.46-10.48% (Table 2). When compared with Kepok banana flour, the water content is higher based on the level of maturity that is equal to 2.42-4.74% [19].

The increasing water content of Fe’i banana starch is in line with the increasing level of banana maturity. These results are the relative same with another researcher for Kepok banana flour [19]. This happens because the process of respiration and water migration from the outside into the flesh. Meanwhile, the increase in water content is caused by the breakdown of starch into sugar and migration of water from the skin to the fruit flesh [18]. Increased water content shows softening of the tissue texture as the level of maturity increases [20]. Softening of fruit tissue shows that carbohydrates are used during the process of respiration and osmotic transfer from the skin to the flesh [21].

Murtadha et al. [22] declare that the higher the level of maturity, the ratio of fruit flesh and skin will increase. The increase in the proportion of fruit flesh and skin is due to an increased water content of pulp (pulp) due to the process of respiration. Respiration can increase the water content due to the breakdown of sugar into CO$_2$ and water and the increase in water content is estimated to be the same as the rate of respiration [15, 23].

3.3 Ash content
The results of the analysis of variance showed that the treatment level of maturity had a very significant effect ($P < 0.01$) on the ash content variable. The amount of ash from the Fe’i banana starch based on the level of maturity ranges from 0.007 to 0.011% (Table 2) lower when compared to the Kepok banana flour based on the maturity level, which is 1.36-2.08% [19].

The decrease in the ash content of Fe’i banana starch as the level of banana maturity increases. The higher the level of banana maturity, the lower the level of ashes. This caused by differences in mineral absorption capacity at various levels of maturity. Another cause, the ash content of bananas during the ripening process is influenced by the stage of development [24]. The young bananas contain higher ash than mature ones.

3.4 Protein content
The results of the analysis of variance showed that the treatment level of maturity had a very significant effect ($P < 0.01$) on the protein content variable. Protein levels of Fe’i banana starch based on the level of maturity ranged from 3.12 to 4.11% (Table 3).

Decreased protein levels of Fe’i banana starch with increasing levels of banana maturity. The effect in line with the results of the study for Musa ABB [18]. The higher the level of banana maturity, the lower its protein content. This result can be caused by the breakdown of proteins into amino acids used for the process of gluconeogenesis.
Table 3. The influence of the level of maturity on protein, lipid and carbohydrate contents of Fe'i banana starch

| Maturity Stage | Protein content (%) | Lipid content (%) | Carbohydrate content (%) |
|----------------|---------------------|-------------------|--------------------------|
| 1              | 4.11a               | 0.017a            | 87.40a                   |
| 2              | 3.27b               | 0.012b            | 87.15b                   |
| 3              | 3.12b               | 0.018b            | 86.38b                   |

Means with the same letters in the same column are not significantly different at p < 0.05 level by Tukey’s test.

3.5 Lipid content
The results of the analysis of variance showed that the treatment level of maturity had a very significant effect (P < 0.01) on the fat content variable. The lipid content of Fe'i banana starch based on the level of maturity ranged from 0.008 to 0.017% (Table 3).

Decreased fat levels of Fe’i banana starch with increasing levels of banana maturity, in line with the results of the study for Musa ABB [18]. The higher the level of banana maturity, caused the lower the fat content. The fat content in bananas is higher in the early developmental stages and gradually decreases with an increasing level of maturity.

3.6 Carbohydrate content
The results of the analysis of variance showed that the treatment level of maturity had a very significant effect (P < 0.01) on the carbohydrate content variable. Carbohydrate levels of Fe’i bananas starch based on the level of maturity ranged from 86.38 to 87.40% (Table 3).

Decreased carbohydrate levels of Fe’i banana starch with increasing levels of banana maturity and in line with the results for Musa ABB [18]. The higher the level of banana maturity, the lower the carbohydrate content of Fe’i banana starch. This is due to the degradation of starch for sugar synthesis [21].

3.7 Crude fiber content
The results of the analysis of variance showed that the treatment level of maturity had a very significant effect (P < 0.01) on the fiber content variable. The fiber content of Fe’i banana starch based on the level of maturity ranged from 2.42-3.42% (Table 4).

Table 4. The influence of the level of maturity on crude fiber content and total dissolved solid of Fe'i banana starch

| Maturity Stage | Crude fiber content (%) | Total dissolved solid (%) |
|----------------|-------------------------|--------------------------|
| 1              | 2.42b                   | 21.40b                   |
| 2              | 3.18a                   | 21.93a                   |
| 3              | 3.42a                   | 22.20a                   |

Means with the same letters in the same column are not significantly different at p < 0.05 level by Tukey’s test.

The increased of the fiber content of Fe’i banana starch with an increase in the levels of banana maturity, in line with the results of the study for Musa ABB [18]. The higher the level of banana maturity, the more fiber levels increase. This can be caused by an increase in the insoluble food fraction [25].

3.8 Total dissolved solids
The results of the analysis of variance showed that the treatment level of maturity had a significant effect (P < 0.05) on the total dissolved solids variable. Total dissolved solid of the Fe'i starch banana based on the level of maturity ranged from 21.40-22.20% (Table 4).
The increase in total dissolved solid of Fe'i banana starch with increasing levels of banana maturity. This caused by the breakdown of starch into simple sugars. Carbohydrates are available in the form of starch so that the fruit is not sweet, and during the process of fruit ripening, through enzymatic reactions, starch will be broken down into simple sugars such as glucose, fructose, and sucrose so that the fruit becomes sweet [26].

Total sugar is a crucial component in fruit because of the hydrolysis of starch to soluble sugars such as glucose, fructose, and sucrose [27] and is one of the quality parameters that correlate with fruit texture and composition [16, 28]. Changes in total sugar occur because of the inversion of compounds that do not dissolve into a soluble form [29]. The results of this study are in line with what Rahman et al. [30] reported that the highest percentage of total sugar was obtained from fully ripe fruit, followed by 2/3 ripe and the lowest from 1/3 ripe fruit during harvesting and storage periods.

4. Conclusions
The level of maturity of the Fe'i banana influences the yield and chemical properties of starch. The increasing level of banana maturity caused an increase in water content (8.46-10.48%), fiber content (2.42-3.42%) and total sugar (21.40-22.20% Brix), while yield (5.54-5.93%), ash content (0.007-0.011%), protein (3.12-4.11%), fat (0.008-0.017%) and carbohydrate content (86.38-87.40%) decreased.

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