Effect of Ripening Degree on the Quality of Intermediate Product, Banana Flour cv Nangka

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Abstract. There are two types banana such as banana for fresh purposes and cooking banana. Research on bananas mostly were done on table banana, since the value of cooking banana and plantain are consider as lower. In this study the intermediate product banana flour has been studied as affected by degree of ripening such as unripe, half ripe and fully ripe. The quality parameters analysed were proximate content, mineral content, amylose content, glycemic index, amylograph analysis for pasting, and scanning electron microscope. With the increased of ripening the granules was more sticked together, amylose content decreased, peak on the gelatinisation process decreased, calcium decreased, sodium increased, with no change in energy. Glycemic index of banana flour was decreased from unripe, half ripe, to fully ripe; 50.8±29.9, 39.4±27.5, 30.9±13.7 respectively. Thus, the flour from half ripe and fully ripe banana had different characteristics from unripe banana. The new type of flour are potential for preparing various produces for diabetic diet.

1. Introduction

Global demand of banana flour in 2017 was ca. 310 million USD and were being used mostly for food industry, household, beverages, pet food and feed industry. It forecasted by end 2027 to become 735 million USD [1].

National production of banana in Indonesia is the biggest among fruits. It was 7 162 680 metric tonnes in 2017 [2]. Thus it is required an improvement of quality both for fresh and processed products. The reasons because banana produce have to compete with other products overseas, demand of local products also more varies.

Banana comprises many varieties both at collection garden or in the market. Banana can be classified into table or dessert banana (Kepok Kuning, Barangan, Raja Bulu, Cavendish), plantain and cooking banana (Kepok, Uli and Nangka). Cooking banana still needs more research, both for fresh handling and processing. Research on products diversification done are mostly in the field of processing for intermediate products and ready to eat ones.

There are available research works on processing of banana. First is for developing of new products. Banana processing for breakfast meals using composite flour and extrusion [3]; composite flour to replace wheat flour [4]; low calorie biscuits [5], brownies [6], banana instant flour for breakfast [7].

Second is for developing intermediate product i.e. banana flour. Effect of varieties have been explored such as by [8] [9]. However, most of the study were exploring green or mature green banana.
Ripening is the most significant phenomena on fruit including banana has not been explored sufficiently. Ripening in fruit is triggered by ethylene, followed by increase of endogenous ethylene production and respiration rate. At the same time the degradation from starch to sugar, softening, aroma and other catabolism reaction happen. This phenomena can be controlled by anti-ethylene [10]; [11]. Since this process is from unripe to ripe and senescent is an sequential, it is very important to explore the quality of flour produced by banana start from unripe, to ripe. So far it is still limited researcher pay attention to ripe banana flour. Among the researcher studied on the topics are [12]; [13]; [14], [7].

It is still required advance investigation on cooking banana such as CVs. Nangka, Kepok, Muli. Also it is required to explore degree of ripening related to the quality of processed product such as flour. Thus, the aim of the research was to identify characteristics of flour produced from banana cv. Nangka that has various degree of ripening. The hypothesis was various degree of ripening would produce different characteristics of flour product.

2. Materials and methods

2.1 Materials

Materials were banana cv. Nangka from an orchard in Bogor. Banana were harvested in green mature but not ripe yet. After harvest banana were transported to Scale up laboratory of Indonesian Center for Agriculture Research and Development. Equipments used were refractometer (Atago), buret, oven (Memmert), Accu-Check Active (sugar blood tester-mg/DL), Brabender, Atomic Absorption spectroscopy (Shimazu), Scanning Electron Microscope (Carl Zeiss).

2.2 Methods

2.2.1 Preparation of banana

On arrival at ICAPRD laboratory, the banana were dehanded. Immediately samples were processed for flour production of unripe banana flour. The rest of the sampled were stored at 28 °C waiting for samples of further stage of ripening. If the samples were start soften, these would be processed as flour of half ripe. When full ripe, the samples were processed as fully ripe flour. Flour preparation were peeling, cutting, soaking in 1% citric acid for 30 mins, drying in oven dryer at 60 °C for 5 hours.

2.2.2 Analyses

Analyses for fresh banana were total soluble solids (Refractometer, ºBrix), total acid (% titrable acidity), vitamin C (titrable method, mg/100 g). Banana flour were analyzed for water content [15], ash content [15], fat content [15], protein [15], carbohydrate (by difference), energy, starch [15], sugar content [15], dietary fiber [16], amylose [15]. Metal content were Ca, Mg, Na, Zn, Fe (Atomic Absorption method). Visco-amylograph were analysed by using Brabender, SEM gold coating [17], resistant starch type 2 [18]. Glycemic index analyses were performed by using invivo (10 respondents).

Obtained data were analysed by ANOVA (Minitab versions 11), then true significance difference to distinguish which one was the best quality.

3 Results and discussion

3.1. Fresh banana

Fresh banana, there was a trend of increase of total soluble solid almost double, but there was not any significant different. This is probably caused by high variation within same maturity (Table 1). Total acidity shows increase with the increase of ripening. And no clear trend on change of vitamin C of all samples.
Table 1. Fresh banana quality of various ripening stages

| Parameters                  | Level of banana ripening | Anova         |
|-----------------------------|--------------------------|---------------|
|                             | Green mature unripe      | Half ripe     | Fully ripe   |
| Total Soluble Solid (°Brix) | 10.00a                   | 19.33a        | 23.40a       | Not significant |
| Total acid (%)              | 0.41a                    | 0.76ab        | 1.16bc       | Significant    |
| Vitamin C (mg/100g)         | 198.79a                  | 166.63a       | 190.47a      | Not significant |

Note: Different letter at different column shows significantly difference at p<0.05

3.2 Banana flour

Banana flour of all ripening stages are presented in Figure 1. From green mature to fully ripe, flour colour was getting darker and darker. The processing step particularly during grinding for fully ripe banana had to be given more effort since it was getting harder. It is recommended to be used hummer mill rather than disc mill for grinding.

Figure 1. Banana flour produced from various stages of ripening

Among chemical characters observed on the flour which were fluctuated are water and protein content. Among parameters increased with the increased of ripening stages are ash, fat, and sugar content. Among parameters decreased are carbohydrate, starch, dietary fibre, and amylose content. All degree of maturity had high energy content since it was above 300 Cal per 100g. The data are in Table 2.

Table 2. Banana flour chemical characteristics from various ripening stages

| Parameters             | Level of banana ripening | Anova         |
|------------------------|--------------------------|---------------|
|                        | Green mature unripe      | Half ripe     | Fully ripe   |
| Water (%)              | 5.58c                    | 2.63a         | 4.93b        | Significant  |
| Ash (%)                | 1.99a                    | 2.05a         | 2.44b        | Significant  |
| Fat (%)                | 0.84a                    | 0.92a         | 1.19b        | Significant  |
| Protein (%)            | 3.20a                    | 5.23c         | 4.63b        | Significant  |
| Carbohydrate (%)       | 88.38b                   | 89.16c        | 86.80a       | Significant  |
| Energy (Cal/100g)      | 373.90a                  | 385.86c       | 376.47b      | Significant  |
| Starch (%)             | 77.21c                   | 72.95b        | 59.48a       | Significant  |
| Soluble sugar (%)      | 1.92a                    | 5.01b         | 19.91c       | Significant  |
| Dietary fiber (%)      | 5.82c                    | 4.93b         | 4.03a        | Significant  |
| Amylose (%)            | 22.09c                   | 17.49b        | 10.42a       | Significant  |

Note: Different letter at different column shows significantly difference at p<0.05
Metal content are presented in Table 3. Metal which were fluctuate are magnesium, Zn and Fe. Sodium increased significantly, but the calcium decreased with the increase of ripening degree.

**Table 3.** Some of banana flour metal content of various ripening stages

| Parameters | Level of banana ripening | Anova |
|------------|--------------------------|-------|
|            | Green mature unripe | Half ripe | Fully ripe |
| Ca (mg/100g) | 16.01c | 6.38b | 5.31a | Significant |
| Mg (mg/100g) | 84.51b | 89.38c | 79.31a | Significant |
| Na (mg/100g) | 4.76a | 6.28b | 9.57c | Significant |
| Zn (mg/100g) | 0.57b | 0.63c | 0.54a | Significant |
| Fe (mg/100g) | 2.19b | 3.53c | 2.07a | Significant |

Note: Different letter at different column shows significantly difference at p<0.05

Viscosity analyses by using brabender are presented in Table 4. Gelatinisation temperature for all stages of ripening were similar which is ca. 79 °C. Viscosity at 93 °C was highest when mature green, getting lower when ripening progress, and reached the lowest when ripening is full. There happened similarly at 93 °C 20 mins and at 50 °C, also at set back. This is probably because with the progression of ripening, there was degradation of starch.

**Table 4.** Viscosity analyses by using Brabender of various ripening stages of banana flour

| Levels of banana ripening | Temp gelatinised (°C) | Temp peak (°C) | Viscosity peak (BU) | Viscosity at 93 °C (BU) | Viscosity at 93°C/20’ (BU) | Viscosity at 50°C (BU) | Set Back Visc (BU) |
|---------------------------|----------------------|----------------|---------------------|------------------------|---------------------------|----------------------|------------------|
| Mature green unripe       | 33                   | 79.5           | -                   | -                      | 870                       | 980                  | 1440             +540 |
| Half ripe                 | 32                   | 42             | 78.0                | 93.0                   | 790                       | 790                  | 620              +240 |
| Fully ripe                | 33                   | -              | 79.5                | -                      | 200                       | 240                  | 360              +120 |

Glycemic index (Table 5) are low for all ripening stages. However with the increase of ripening stages, the glycemic index also getting lower, and reach the lowest at fully ripe. This is probably due to the production of fructose rather glucose.

**Table 5.** Glycemic index of various levels of ripening of banana

| Levels of banana ripening | 10 Respondent | Average ±SD | Without outliers sd <20 |
|---------------------------|---------------|-------------|-------------------------|
| Green mature unripe       | 50.8 ±29.9    | 48.4±23.1   | 48.0                    |
| Half ripe                 | 39.4±27.5     | 35.5±18.7   | 36.0                    |
| Fully ripe                | 30.9±13.7     | 29.6±10.7   | 30.0                    |

Resistant starch 3 almost all the same with value from 81.42 to 82.2 percent. Thus, no real effect of ripening on decrease or increase of resistant starch 3.

Microstructure by SEM (Figure 2) show starts some debris at green mature, more debris in starting to ripe and much more debris among the granules. In higher magnification (2000 x), the granules appear to be melted. The shape of granules which is oval is similar to African type of banana muomva-red (non-commercial) [19].
Figure 2. Scanning electron microscope results on various ripening stages of banana flour; 1000 magnification (top), and 2000 magnification (bottom)

Degree of ripening is very important to plant physiologist, so far only paid attention for fresh handling purposes [10], [11]. However, it is phenomena and anti-ethylene treatment also can affect the quality of processed products [20]. Ripening is a gradient process, thus it is necessary to pay attention of the process in order to create a new, unique flour which can be supplied to the food industry. A new unique flour product has been born which is in between green mature to fully ripe i.e. starting to ripe flour products. This product of course has strong aroma of jack fruit, higher sugar content which is sweeter, higher sodium content, and the most important thing is still has low glycemic index even lower compared to mature green Nangka flour. Since there is an evidence of degradation of starch to simple sugar but there is a decrease of glycemic index, it is also possibly biosynthesis of fructose during ripening of banana cv. Nangka. This hypothesis is required to be improved by experiment.

In application point of view, the colour of flour is better than if it is prepared from ripe fruit. It is also easier to process such as slicing, and grinding compared to the fully ripe banana. However, with more diverse the characters of flours, there will more produce can be made. There is a weakness such as colour with can be reduced by maltodextrin [22] however, may affect the original character, or even the price.

Many banana flour uses are for bread [21], ice cream [22], paste blend [24], banana roll [25], yellow noodle [26]. More new products can be made since the results of the research indicate from one banana variety can be made various type of flour such as from mature green flour, from starting to ripe flour, full ripe flour. Nice flavour of jack fruit make the banana cv. Nangka flour is suitable for cake, biscuits. Also other new products such as ready to eat products, ready to use flour for diabetic products, ice cream for diabetics.
The reality that banana cv Nangka has low GI and even lower when ripe, it could be used as direct diet for diabetics. However this still need more research such as 3 meals a day or just one meal before it is be recommended for the diabetic sufferer. It is because GI is related to human metabolism. The new products beside flour could possibly be prepared for direct consumption such as cooked or steamed or canned bananas cv. Nangka. Functional point of view ripe flour can also be used as replacement of sugars (need further research), also can be extracted and prepared to be much better form of simple sugar for diabetics sufferer.

4 Conclusion
The hypothesis has been proven that gradient of ripening produced different characteristics of flour products. Peak of gelatinisation, carbohydrate, starch, amylose, dietary fibre, calcium, GI; decreased with more advance stages of ripening. Whilts, sugar , starch, sodium were increased. All stages of ripening of banana cv. Nangka are good for raw material of food industry and diet for diabetic, since they were low GI.

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