: Physicochemical Properties of Flakes Made from Different Maturity Levels of Banana (Musa Paradisiaca) CV. Ambon

by Wisnu Cahyadi -

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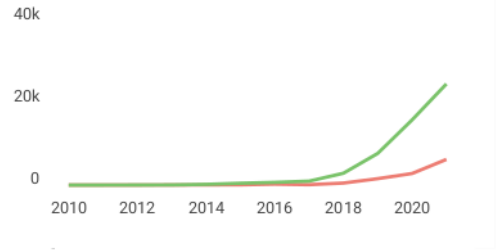

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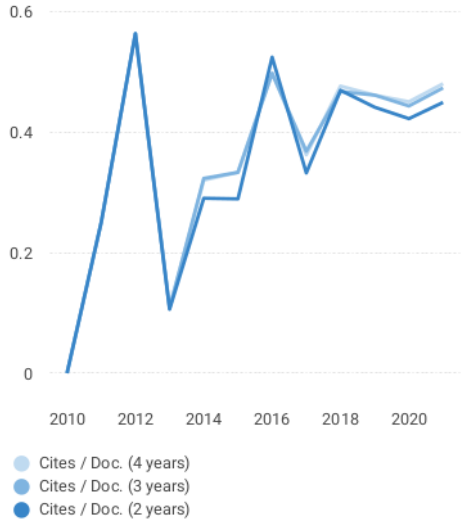

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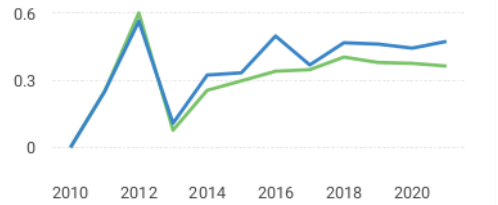

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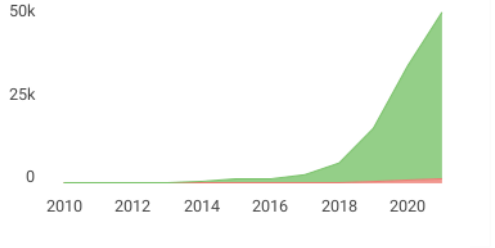

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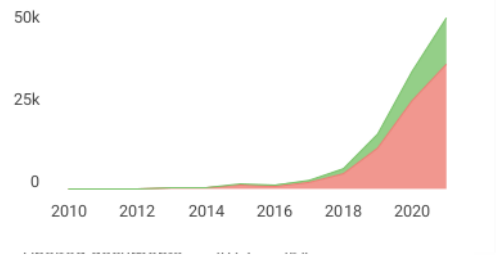

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Abstract. Banana is a fruit that possesses high nutritional contents, especially vitamins and minerals. Banana flour is one of the diversification products in bananas processing that could extend shelf life and add economic benefit, and this product can be further processed into banana flakes. Flakes are ready-to-eat food ingredients that are usually used for breakfast. However, information about the maturity level of bananas on the physicochemical properties of flakes has remained unknown. Therefore, this study aimed to determine the effect of the maturity level of ambon banana flour on the physicochemical properties of banana flakes. The research design used in this study was a randomized block design with the research treatment consisting of 2 factors, namely the maturity level of banana flour (A) and baking time (B) with three replications. The best sample was taken from each group and then the scoring test was carried out until the best sample was obtained. Subsequently, the overall best sample was physicochemically characterized. The results showed that the selected treatment was A1B3 (ripe banana flour, 25 minutes). This study revealed that the flake trials' ripe banana flour from ambon cultivar showed the best physiochemical properties.

1. Introduction

Banana is a fruit that exhibits highly nutritional contents, especially vitamins and minerals. It possesses vitamin B complex (1.10 mg/100 g) and potassium (310 mg/100 g). Another vitamin, for example, vitamin C, and minerals such as phosphorus and iron are also found in banana fruit [1]. According to Winarno (1990), the iron content of bananas can be utilized 100% by the human body. [2]. The total consumption of bananas per capita in Indonesia is relatively stable every year but tends to decline in the last five years with an average decline of 1.80% per year. The consumption level of the other banana cultivars is generally higher than those of *Ambon* and plantain cultivars. In 2011, the banana consumption was increased up to 8.812 kg/capita (29.01%) compared to the previous year. The supply

of bananas used for food ingredients is 93.65%, while the remaining 6.35% is reported underutilized [3].

Bananas are also rich in minerals such as potassium, magnesium, iron, phosphorus, and calcium. Moreover, it exhibits vitamins A, B6 and C and contain serotonin that has a role for neurotransmitter in brain intelligence [4]. The absorption of iron in bananas is almost 100% absorbable by the human body compared to other plant foods. The iron and zinc level per 100 g of bananas reach 2 mg of iron and 0.8 mg of zinc [5]. One of the most common and easy to find banana cultivars in Indonesia is *Ambon*.

To get the nutritional value benefit of bananas, it is necessary to diverse banana processing so that the potential value of bananas can be utilized optimally. One of the diversification products of bananas is banana flour. Banana flour is an alternative for preserving bananas due to its perishable property. Banana flour has several advantages over fresh bananas and other banana preparations (molen, sale, chips, compote, fried banana) which it could extend shelf life, add economic value, and this product could be further processed into various food products (cookies, cakes, bread, biscuits, noodles and complementary foods for breast milk) and easier in handling and distribution [6].

Banana flour has a distinctive taste and smell, so it can be used in the processing of various types of flour based food products. In this case, the banana flour can be an alternative to replace some or all of the other flour. Unripe banana flour is more common than ripe banana flour. The advantages of unripe or green banana flour include a high content of resistant starch and dietary fiber that give beneficial effects for human health [7]. Ambon banana flour can be used as an additional ingredient or the main ingredient in making flakes; this is because the processing of Ambon banana into banana flour increases the starch content. Every 100 grams contains Ambon banana flour possesses 61.3 - 76.5 g and 6.3 - 15.5 grams of fiber [7].

Furthermore, food products from banana flour have high nutritional values, especially vitamins A and Fe. One of the most common and easily found banana cultivars is *Ambon*. This cultivar can be processed as flour and other derivative products, for example flakes.

Flakes are ready-to-eat food ingredients that are usually used for breakfast cereals. There are two groups of breakfast cereals. The first is breakfast cereals that require cooking before eating. The second is breakfast cereals that can be consumed directly with water or milk [8]. The ripeness of bananas used for flake making might give different effects on the physical and chemical properties of flakes. This study, therefore, was conducted to determine the effect of the ripeness level of Ambon banana cultivar on the physical and chemical properties and the nutritional content of flakes produced.

2. Materials and Methods

2.1. Materials

The materials used in this study, including ripe banana flour, unripe banana flour, sugar (®Gulaku), chicken eggs, baking powder (® koepoe – koepoe) and skim milk were purchased commercially. The chemicals including aquadest, luff schoorl solution, KI, $Na_2S_2O_3$, starch, H_2SO_4 6N, concentrated HCl, H_2SO_4 0.3N, $CHCl_3$, NaOH 0.3N, alcohol, n-hexane, kjedahl salt, concentrated H_2SO_4, 30% NaOH, Zn granules, 0.1N HCl, 0.1N NaOH, PP and Na_2SO_3 indicators were obtained from Sigma-Aldrich (Singapore)

2.2. Banana flakes formulation

The processing of ripe and mature banana flours was carried out to provide a raw material in this study. Besides, it was also conducted to verify and modify banana flour production method that has been conducted at the Center for Appropriate Technology Development, Indonesian Institute of Sciences. After that, sugar and starch content analyses were carried out by Luff Schorl method [9] on the Ambon cultivar.

Several trials were conducted to confirm the best formula for flake production by evaluating its physical properties using sensory analysis. The dough stickiness, crispiness, solubility, color, taste and

flavor were evaluated during the change of backing temperature. The formulation matrix in trial production of banana flakes was illustrated in Table 1.

Table 1. Formulation matrix of banana flake trials

Treatments	Ingredients (%)						Baking condition	
	Banana flour	Egg	Skim milk	Sugar	*Baking Powder*	Total	Temperature (°C)	Time (min)
Formula 1	50	15	20	15	-	100	120	t_1 = 15’ t_2 = 10’
Formula 2	48,31	19,32	19,32	12,08	0,97	100	130	t_1 = 10’ t_2 = 10’
Formula 3	48,31	19,32	19,32	12,08	0,97	100	120	t_1 = 10’ t_2 = 10’

2.3. Banana flakes optimation processes

The main research was conducted after the preliminary research. The research design used in this study was a randomized block design (RBD) with a factorial pattern (3 x 3). For detail, as shown in Table 2. The response observed in this study consisted of physical properties (including water absorption index and water-soluble index) and chemical property (including gravimetric method of water content analysis) [9].

Table 2. Research design

Type of banana flour (A)	Replication	Baking time (B)		
		15 min (b_1)	20 min (b_2)	25 min (b_3)
Ripe banana flour (a_1)	I	a_1b_1	a_1b_2	a_1b_3
	II	a_1b_1	a_1b_2	a_1b_3
	III	a_1b_1	a_1b_2	a_1b_3
Unripe banana flour (a_2)	I	a_2b_1	a_2b_2	a_2b_3
	II	a_2b_1	a_2b_2	a_2b_3
	III	a_2b_1	a_2b_2	a_2b_3
Mixed banana flour (a_3)	I	a_3b_1	a_3b_2	a_3b_3
	II	a_3b_1	a_3b_2	a_3b_3
	III	a_3b_1	a_3b_2	a_3b_3

2.4. Statistical analysis

The design analysis was carried out to determine the treatment's effect on the observed response using analysis of variance (ANOVA). If Fcount ≥ Ftable at 5% level, then H0 is rejected (H1 is accepted). It means that the type of banana flour and baking time affect the characteristics of banana flakes, so further tests are needed to determine the extent of the differences between each treatment. If Fcount < Ftable, at 5% level, then H0 is accepted (H1 is rejected). It means that the type of banana flour and baking time affect the characteristics of banana flakes.

3. Results and Discussion

3.1. Banana flakes formulation

3.1.1. Banana flour analysis. The total sugar and starch contents of banana flour were illustrated in Table 3.

Table 3. The sugar and starch contents of banana flour

Type of banana flours	Total sugar (%)	Starch content (%)
Ripe banana flour	7.08	64.42
Unripe banana flour	1.26	68.17

Based on the results in Table 3, ripe banana flour has a total sugar content of 7.08% and a starch content of 64.42%. In contrast, banana flour has a total sugar content of 1.26 % and starch content of 68.1663%. The maturity level of bananas affected the starch content of flour produced. Table 1 indicated that the starch content of ripe banana flour was lower than that of unripe banana flour, while the sugar content of ripe banana flour was higher than that of unripe banana flour. The optimal level of fruit maturity might cause this, and starch formation has reached the highest level. At this stage, the sweet and sour tastes have been balanced because most of the tannins have been decomposed [10; 11]. As maturity increases, the number of starch decreases and the sugar content increases [12].

3.1.2. Determination of banana flakes formula. Determination of banana flakes formula carried out by several trials was illustrated in Table 4.

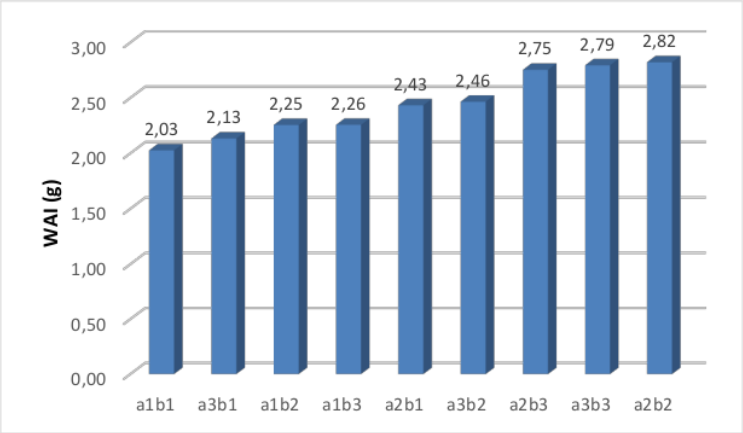
Table 4. The results of banana flake formula trials

Treatments	Composition (%)						Baking condition		Description
	Banana flour	Egg	Skim milk	Sugar	*Baking Powder*	Total	Temperature (°C)	Times (min)	
Formula 1	50	15	20	15	-	100	120	$t_1 = 15$ $t_2 = 10$	Sweet, crispy, color and thickness distributed equally
Formula 2	48,31	19,32	19,32	12,08	0,97	100	130	$t_1 = 10$ $t_2 = 10$	Sweet, crispy, color and thickness distributed unequally, solubility was more than four minutes
Formula 3	48,31	19,32	19,32	12,08	0,97	100	120	$t_1 = 10$ $t_2 = 10$	Sweet, crispy, color and thickness distributed equally, solubility was more than four minutes

Based on the trial results for flake formulation in Table 4, formula 1 has a sweet taste, crunchy texture, flat color and uneven thickness. Formulation 2 in description has a sweet taste, slightly hard crispy texture, and slightly charred, somewhat flat color and dissolving time. More than 4 minutes, while formulation 3 is better than formulation 1 and 2 in the description of having a sweet taste, crunchy texture, flat color and dissolving time of more than 4 minutes.

3.2. Main research

3.2.1. Water absorption index. The results of water absorption index analyses on flakes after Duncan's test were shown in Figure 1.

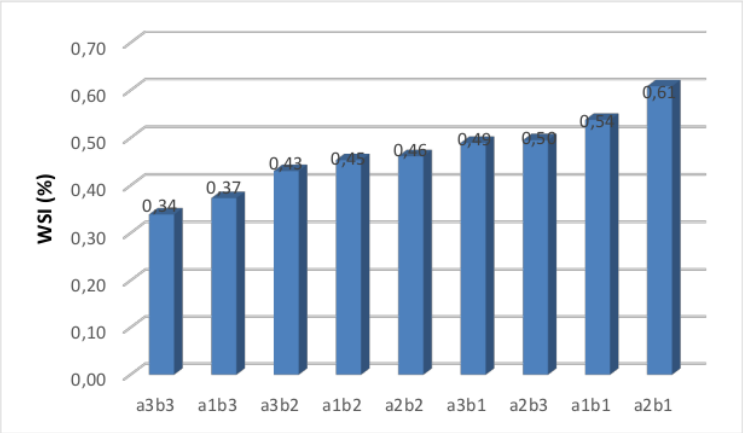


Note: a1b1=ripe banana flour, 15 min; a3b1=mixed banana flour, 15min; a1b2=ripe banana flour, 20 min; a1b3=ripe banana flour, 25 min; a2b1=unripe banana flour, 15 min; a3b2=mixed banana flour, 20 min; a2b3=unripe banana flour, 25 min; a3b3=mixed banana flour, 25 min; a2b2=unripe banana flour, 20 min

Figure 1. Effect of banana flour type and baking time on the water adsorption index of flakes

The treatment of 20 minutes baking time combined with banana flour had the largest average water absorption index, followed by 25 minutes combined with mixed banana flour and 25 minutes of banana flour, while the 15 minutes baking time combined with ripe banana flour had the smallest average value. According to Gujska and Khan [13], the water adsorption index is influenced by protein denaturation, starch gelatinization, and swelling of crude fibers that occur during processing into flour. Furthermore, the water adsorption index is dependent on the availability of hydrophilic groups and the gelling capacity of the macromolecules, namely gelatinized and dextrinized starch. The more gelatinized and dextrinized starch had the greater ability of the product to absorb water [14].

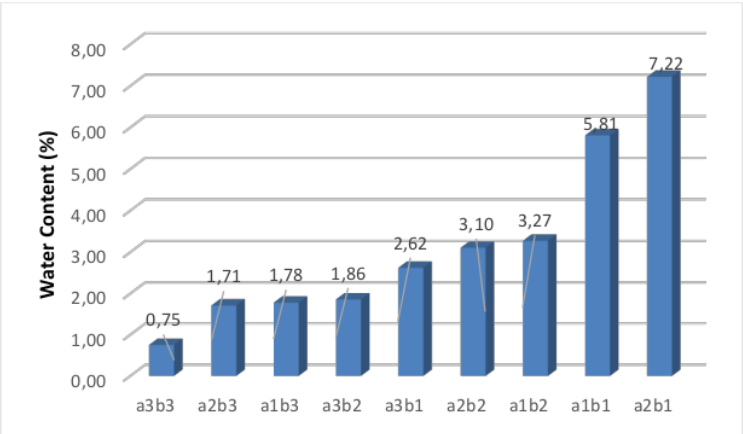
3.2.2. Water-soluble index. The water-soluble index analyses of flakes after Duncan's further test were illustrated in Figure 2. The treatment of 15-minute baking combined with banana flour showed the average value was more significant and significantly different from the other treatments. In contrast, the mixed banana flour treatment had a small average and was significantly different from other treatments. This might be due to the high degradation of amylose and amylopectin. According to Khasanah [15], after the starch undergoes gelatinization, amylose and amylopectin degradation occur to produce smaller molecules. These relatively smaller molecules are easily soluble in water.



Note: a1b1=ripe banana flour, 15 min; a3b1=mixed banana flour, 15min; a1b2=ripe banana flour, 20 min; a1b3=ripe banana flour, 25 min; a2b1=unripe banana flour, 15 min; a3b2=mixed banana flour, 20 min; a2b3=unripe banana flour, 25 min; a3b3=mixed banana flour, 25 min; a2b2=unripe banana flour, 20 min

Figure 2. Effect of banana flour type and baking time on the water-soluble index of flakes produced

3.2.3. Water content. Water content is a very important component in food because it can affect appearance, texture, and taste. The water content in food determines an ingredient's acceptability, freshness, and shelf life [16]. The results of moisture content analyses of flakes after Duncan's further test were shown in Figure 3.



Note: a1b1=ripe banana flour, 15 min; a3b1=mixed banana flour, 15min; a1b2=ripe banana flour, 20 min; a1b3=ripe banana flour, 25 min; a2b1=unripe banana flour, 15 min; a3b2=mixed banana flour, 20 min; a2b3=unripe banana flour, 25 min; a3b3=mixed banana flour, 25 min; a2b2=unripe banana flour, 20 min

Figure 3. The effect of banana flour type and baking time on the water content of flakes

Based on the results in Figure 3, it can be concluded that the length of baking time, the water content of products decrease. This might be caused at the baking time water was evaporated from the baked material. The baking process, at varying times, causes the evaporation of different moisture content. The longer the baking process is carried out, the more heat is received by the material. The amount of water evaporated in the food material increased, and the measured water content was low [17]. The water content in foodstuffs affects food resistance to microbial attack expressed by Aw, the amount of free water used by microorganisms for their growth. Various microorganisms have a minimum Aw in order to grow well [16].

3.3. Determination selected sample

To determine the selected sample was using the results of the physical and chemical analyses of the flakes then evaluated for scoring from each group. The scoring test was conducted by calculating the range of results from the lowest to the highest. The range of values for the water absorption index was 0.14. The water-soluble index value range was 0.04, and the water-soluble index value range was 1.13, with a score range of 1 - 6. Based on the data obtained from the calculation results of the scoring test, the best sample for each group from this study was shown in Table 5.

Table 5. The best sample based on the scoring test

Treatment	Water content	WAI	WSI	Total
A1B1	2	1	2	5
A1B2	4	2	4	10
A1B3	6	2	6	14
A2B1	1	3	1	5
A2B2	4	6	4	14
A2B3	4	5	3	12
A3B1	5	1	3	9
A3B2	6	3	5	14
A3B3	6	6	6	18

WAI = water absorption index, WSI= water-soluble index

Based on the results of the scoring test in Table 5, the samples selected in each group were A1B3 (ripe Ambon banana flour and 25 minutes), A2B2 (Ambon banana flour and 20 minutes), and A3B2 (Ambon banana flour mixture and time 20 minutes) treatments with a total score of 14. The A1B3 treatment has a water absorption index value of 2.26, while the A2B2 and A3B2 treatments exhibited 2.82 and 2.46. While for water-soluble index analysis, the A1B3, A2B2, and A3B2 treatments showed 0.37, 0.46, and 0.43 values. The A1B3, A2B2, A3B2 treatments possessed water content values of 1.78, 3.10, and 1.86%, respectively.

4. Conclusions

In this study, the effect of flour type from different maturity levels of Ambon banana cultivar and baking times on the physicochemical properties of flake was carried out. We found that banana flour type and baking times affected on water absorption index, water-soluble index, and water content of flakes. Based on a scoring test, the best sample from each group were A1B3 (25 minutes ripe banana flour), A2B2 (20 minutes banana flour mix) and A3B2 (20 minutes mixed banana flour).

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