Formulation Banana Flakes using Different Type and Concentration of Fillers

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Formulation Banana Flakes using Different Type and Concentration of Fillers

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Abstract. The making banana flakes using ripe banana flour had disadvantages on its physical properties, causing the product to be highly hygroscopic. Therefore the formulation needs the addition of other starch to improve the physical properties of banana flakes. The aim of the research was to determine the type and concentration of the fillers to make the best banana flakes. This research conducted using Randomized Block Design (RAB) with two factor which were type of filler (rice flour (A1), corn flour (A2), modified cassava flour (A3)) and concentration of fillers (5g (B1), 10g (B2), 15g (C)) with three repetition. The responses of the research were physical response and moisture content of the product. Physical responses included hardness test, water absorption index (WAI) and water solubility index (WSI). The best product selecting using de Garmo's index of effectiveness, then the product was analyzed by the chemical characteristic. The best product of Banana flakes was addition with 15% rice flour as fillers. This product has characteristic 3,24% of ash, 3,19% of crude fiber, 7,35% of protein, 2,14% of fats and 83,45% of carbohydrate.

Keywords: Flakes, banana flour, fillers

1. Introduction

According to Mathews [1], skipping breakfast time can cause a negative effect on the body. This is due to low blood sugar levels that are automatically lowing the blood pressure and weaken the nerve impulses to the body would limp and cause the decreased passion for work. Therefore, breakfast is somehow needed as the source of calories to increase the levels of the blood sugar.

Breakfast is very important as an energy source, not only for adults but also for children to support the developments of their brain. For the children having breakfast will help them to be able to concentrate and more active in school, so there is a probability that they will become smarter. The benefit of having breakfast will also reduce the risk of micronutrient deficiency problems, especially vitamins and minerals that supported its developments.

Breakfast contributes about 25% of daily energy that consists of about 450-500 calories and about 8-9 grams worth of proteins [2]. A breakfast that contains 25% of nutritional needs a day is part of the compliance the balance of nutrition and also can affect the thinking process and activated of a person throughout the day, even more so in children of growing age. Sukiniarti argued that about 18,05% Indonesian kids always skipping breakfast [3].

Many factors that make it difficult for kids to eat breakfast such as the difficulty of waking up in the morning and the number of parents who works in the morning cause limited time to prepare breakfast. To compromise with the problems that, it is necessary to make a breakfast menu that

requires an easy and fast to prepare and also attract children for having them. One of the suitable food products is the *flake-shaped* food products. This is due to the changing lifestyle of the society that demands everything in a fast-paced and practical, no exception to the foods, so the demand for fast-served breakfast such as cereals is increasing.

Today most breakfast foods are made from cereals such as wheat, corn, and rice. Breakfast can also be made from fruit as a source of fiber and vitamins. Materials selection for mixed-formulation (composite) is important to produce good product [1]. One type of fruit that can be used as a breakfast meal is a banana. According to Musita, banana is one of the fruits that were riches with nutrition, carbohydrate, vitamins, and mineral sources [4].

In additions for being a source of carbohydrates, bananas also have a good nutritional content of vitamins (pro-vitamin A, B, and C) and minerals (potassium, magnesium, phosphorus, iron, and calcium) are important for the body [5]. Banana is one of the distinguished fruit that found in Indonesia and becomes one of the fruits that the productivities is always increasing every year. However, people's consumption is not so much.

The growth productivity of banana in Indonesia started since 1980-2013 also tend to increase. If the 1980 production of banana in Indonesia amounted 1.98 million tons, then in 2013 has reached 6.28 million tons. The increase of banana production during this period has reached 3.94% per year, where the growth in Java is slightly higher. In 1980-2013 banana production in Java, reached 61.22% of Indonesia's total banana production, while the total production from outside java was 38.78% [6].

Based on the data from the Survei Sosial Ekonomi Nasional (SUSENAS) that conducted by Badan Pusat Statistik (BPS), the consumption of bananas tends to decrease in the last five years, about 1.80% per year. According to the Ministry of Agriculture data, the consumption of Plantain and Ambon's bananas is generally higher than the other bananas. Ambon's banana consumption in Indonesia 2012 is 1.825 kg/capita per year while in 2013 it decreased to 1.251 kg/capita.

Ambon's banana is one of the fruits that contain many nutrients and has a distinctive flavor and aroma, yet also easily damaged, so it needs to be processed into a durable meal, easy to store, and easy to consume. One way to make the Ambon's banana become a durable material is turning it into a banana flour [7].

The flour from Ambon's bananas can be used as a substitution or even as basic ingredient in the manufacture of various foods. For example, making flakes from Ambon's banana is a way to make food diversification and also can be an alternative for breakfast which also can be a source of nutrition for children that answered the problem about the breakfast preparation for children.

One of the most prominent characteristics of flakes is crispness. Therefore, it is necessary to add a fillers material that can improve the characteristics of the flakes according to Triyono, fillers properties dispersed in water rapidly, high solubility, low hygroscopic, able to form *'body,'* low browning but strongly binding with any main materials [8].

One of the characteristics of cereal products that desired by consumers, in general, is its crispiness so that cereals can last long after the addition of milk. This condition can be achieved by the addition of starch in the form of the flour, whether modified or not [9-10]. According to this, it is needed to reformulated banana flakes using varieties of filler such as rice flour, corn flour, and mocaf flour. The research aimed to determine the type and concentration of the fillers to make the best banana flakes.

2. Materials and Methods

2.1. Materials

The materials used for making Banana Flakes are banana flour from Ambon's banana, sugar, eggs, baking soda and high-calcium skim-milk. The materials that used for chemical analysis are aquadest, Kjeldahl salt, H_2SO_4 (p), NaOH, zinc granule, HCl, PP, and n-hexane indicator. The tools that used in making the Banana Flakes are weighing plastic, digital scale, Philips's mixer with speed at 1, oven deck, baking sheet paper, dough sheeter, two spatulas, scissors, and baking sheets. The tools that used for chemical analysis are Kjeldahl flasks, boiling stones, Bunsen, tripod, pumpkin powder, distillation apparatus, titration apparatus, soxhlet, reflux, desiccator, filter paper, cups, oven, furnace, thimble paper and centrifuge.

2.2. Methods

2.2.1. Methods

This research used the Randomized Group Design which was arranged in a factorial way into two factors; each factor consists of three levels of treatment. The first factor is fillers type with rice flour, corn flour, and modified cassava flour. The second factor is the concentrating the fillers with 5g, 10g, and 15g levels of concentrate. From these two factors, nine treatments were obtained, and each treatment was repeated three times, then 27 tests were obtained each. The data were analyzed using ANOVA with significance at $p<0,05$

2.2.2. Formulation of Banana Flake

Formulation of Banana Flake is shown in Table 1.

Table 1. Formulation of Banana Flake all Treatment

Ingredient	Treatment								
	A1B1	A1B2	A1B3	A2B1	A2B2	A2B3	A3B1	A3B2	A3B3
Banana flour (g)	50	50	50	50	50	50	50	50	50
Skim Milk (g)	20	20	20	20	20	20	20	20	20
Egg (g)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Baking powder (g)	1	1	1	1	1	1	1	1	1
Sugar (g)	20	20	20	20	20	20	20	20	20
Rice flour (g)	5	10	15	-	-	-	-	-	-
Corn Flour (g)	-	-	-	5	10	15	-	-	-
Modified cassava flour (g)	-	-	-	-	-	-	5	10	15

2.2.3. Analysis Physical and Chemical of Banana Flakes

Physical response of Banana Flakes including hardness of product, water absorption index, and water solubility index. The hardness of banana flakes was analyzed using Texture Analyser. Water absorption index and water solubility index was analyzed according to Triyono [8]. The best sample was selected by using [11] method. The Best banana flakes analyzed for chemical response for ash, crude fiber, protein, fat, and carbohydrate content of the product. Ash, crude fiber, protein, fat, and carbohydrate content analyzed according to Triyono [8].

3. Results and discussion

3.1. Analysis Physical Response of The Banana Flakes

3.1.1. The hardness of the Product

The hardness of the product might be affected by the ration of amylose and amylopectin to the feedstock. Tjokroadikoesoemo explained that amylopectin in starch has high adhesive properties, so the higher amylopectin level in the raw materials used will cause higher compactness of a product [12].

Based on the results of the research, the average hardness with 9 (nine) banana flakes treatment with 3 (three) repetitions are ranged between 247.48gf - 340.50gf. More data can be seen in Table 2.

Table 2. Mean value of hardness responses

Types of fillers	Concentration of fillers		
	B1 (5%)	B2 (10%)	B3 (15%)
A1 (Rice Flour)	247.48a	257.67a	256.41a
A2 (Corn Flour)	292.8a	317.77a	306.36a
A3 (Modified-Cassava Flour)	340.59a	290.51a	300.94a

*Notation same letters in the same column and line indicate no significant difference at significance level of 5%

The results of the hardness test showed that the type of fillers and the concentration of the fillers, then the interaction between the type of fillers and the concentration were not significantly different.

However, from Table 2 we see that the average of hardness on the treatment shows that the trend is rising at each concentration. This can be attributed to the higher concentration of the starch content on fillers. The higher the starch contents in the material means the amylose and amylopectin levels also higher. Furthermore, it would be faster the water absorbent that causes the product to become crusty.

According to [13] amylopectin will turn the food product into a light, porous, crisp, and crunchy one. Amylose tends to produce the crustiness products, and blooming processes occur in a limited way. According to [14] if the amylose levels are high, then the starch will be dry, less adhesive and tend to absorb water (hygroscopic). According to [15] the water content in food also affects the fracture of the flakes. The presence of water in the intercellular cavities of material can decrease the stiffness of the cell so that it will decrease the hardness of the product.

3.1.2. Water absorption index (WAI)

According to [16] Water Absorption Index (WAI) indicates the ability of the material to be able to interact with water. Based on the results of the research, the average water absorption index has been performed with 9 (nine) banana-flakes treatment with 3 (three) repetitions ranging from 1.92 to 2.18 ml/g. The Water Absorption Index (WAI) test indicates that it is not significantly different, whereas for the interaction between fillers type and fillers concentration gives a real or significant different effect. The interaction effect between factor A and B can be seen in Table 3.

Table 3. The Effect of the types of fillers interaction and fillers concentration response to water absorption index banana flakes

Types of fillers	Concentration of fillers		
	B1 (5%)	B2 (10%)	B3 (15%)
A1 (Rice Flour)	$_{b}2{,}08^{A}$	$_{a}2{,}12^{A}$	$_{b}2{,}18^{A}$
A2 (Corn Flour)	$_{b}2{,}05^{A}$	$_{a}2{,}06^{A}$	$_{a}2{,}03^{A}$
A3 (Modified-Cassava Flour)	$_{a}1{,}92^{A}$	$_{a}2{,}08^{B}$	$_{a}2{,}05^{B}$

*different uppercase in the same line and lowercase in the same column indicate significant difference at a significance level of 5%

Table 3 shows that the type of rice flour fillers is not significantly different in the addition of concentrations of 5%, 10%, and 15%. Likewise, cornstarch fillers were not significantly different at the5%, 10% or 15% concentrate. While the modified cassava flour fillers the addition of 10% and 15% concentrate was not significantly different, but in 5% concentrate was significantly different. This can be attributed to the starch content contained in modified cassava flour is slightly ranged from 67.77% compared to rice flour and corn flour [17].

In the 5% concentrate treatments, the rice flour and the corn flour was not significantly different but on modified cassava flour was significantly different. Same as for the 10% concentrate, the addition of rice flour, corn flour, and modified cassava flour were not significantly different. Also in the concentration of 15% corn flour and modified cassava flour was not significantly different, except for the rice flour. The starch content of rice flour can cause this is slightly higher than modified cassava flour and corn flour ranges from 76% to 82% [18].

If we highlighted the average of each concentration, although only slightly, this happened due to the increasing concentration of the added fillers rising the starch content contained in the material that causes more water absorption, hence the more concentration of starch added and the more water were absorbed then the swelling of the starch is even greater causing the product to be developed (puffed) and facilitate the structure of slabs or pieces of the dough and make the product more crunchy.

The higher level of the flakes starch then the water absorption value will increase due to the more gelatinization of starch. The higher the starch content in a product, the water absorption also tends to be higher. This is because the starch granules have a very large water-absorbing capacity because the amount of hydroxyl starch groups is very large [15].

When compared between the three flours (rice flour, corn flour, and modified-cassava flour), the content of starch in the rice is ranging from 76 - 82% [18]. The Amylose content in rice is about 25%, and the amylopectin is about 75%. According to [19] corn flour has a content of 72-73% starch. According to [17] modified-cassava flour has starch of 67.77%. According to [20] maize contains

amylose 25-30% and amylopectin 70-75%, while amylopectin content in modified-cassava flour 75% and amylose of 25%. Based on the average data of starch content, modified-cassava flour starch has the lowest content compared to rice flour and corn flour, as well as its amylopectin content so that the water absorption index value of modified-cassava flour is lower than rice and corn flour.

Amylose-amylopectin ratios, molecular weight distributions, and chain lengths, and the degree of branching and conformations determine the swelling power and solubility [21]. Swelling power is the increase of the volume and the maximum weight of starch during the process in the water. Swelling power shows the ability of starch to expand in water. The higher swelling power means that the ability of starch to expand in water is high as well [22]. Swelling is a trait influenced by amylopectin [23]. A high proportion of the branch chain amylopectin has contributed to an increase in swelling value. Besides, there is a negative correlation between swelling power and amylose levels; swelling power decreases with increasing amylose levels [23].

3.1.3. Water solubility index (WSI)

The Water solubility index shows the ability of material to soluble with water that seen by a large number of particles (g) dissolved in a certain amount of water (ml) [19]. Based on the results of the research, the average water solubility index with 9 (nine) treatments of banana flakes with 3 (three) times of repetitions was ranged from 0.223 g / ml - 0.249 g / ml. Water Solubility Index (WSI) test indicates that the type of fillers, fillers concentrations, and the interaction between the type of fillers and the concentration of fillers not significantly affected WSI product. The average value of each treatment can be seen in Table 4.

Table 4. Mean value of the water solubility index in banana flakes

Types of fillers	Concentration of fillers		
	B1 (5%)	B2 (10%)	B3 (15%)
A1 (Rice Flour)	0.233a	0.238a	0.245a
A2 (Corn Flour)	0.223a	0.249a	0.249a
A3 (Modified-Cassava Flour)	0.228a	0.236a	0.248a

*Notation same letters in the same column and line indicate no significant difference at a significance level of 5%

The average value of each concentration shows that the WSI levels were increased after the 5% addition of flour but has no effect after the 10% or 15% addition. The more addition of the filler's concentration, the level of starch is higher as well as the amylose level. By comparing the type of flours, the rice flour has the level of 76% - 82% of starch [19], it is higher than the starch of wheat, corn or modified-cassava flour. The content of amylose in rice is about 25% and about 75% worth of amylopectin.

According to [19] corn has a content of 72-73% starch with amylose 25-30% and amylopectin 70-75% [19] [20], while modified-cassava flour has 67.77% starch with amylopectin 75% and amylose 25% [20]. The higher the starch content added in the ingredients, the value of WSI is also increasing because of the amylose levels contained in the material. According to [14] if the amylose levels are higher, then the starch will be dry, less adhesive and tend to absorb more water (hygroscopic).

Water solubility is associated with the proneness of the water molecules to interact with the granule molecules in starch and replace the hydrogen interactions between the molecules so that the granules will easily absorb water and have a high development. The existence of such development will suppress the granules from the inside so that the granules will break and the starch molecules, especially amylose will come out [24]. According to [25] when the starch molecule is completely hydrated, its molecules begin to spread to the outer media and the first out is the amylose molecules that have short chains. The higher the temperature the more starch molecules will come out of the starch granules. During the heating process, the starch granules will start to break down, and the starch with the higher amylose content will release more amylose

3.2. Analysis Chemical Response of The Banana Flakes

3.2.1. The moisture content of the Product

Moisture content is very important in determining the durability of the food because it affects physical, chemical, microbiological, and enzymatic changes [26]. Based on the result of the research, the average water content on 9 treatments of the Banana Flakes with 3 times repetitions was ranged from 3.82% – 5.37%. More data can be seen in Table 5 below.

Table 5. Mean Value of moisture content of the banana flakes

Types of fillers	Concentration of fillers		
	B1 (5%)	B2 (10%)	B3 (15%)
A1 (Rice Flour)	5.37a	4.66a	3.82a
A2 (Corn Flour)	4.82a	4.77a	4.64a
A3 (Modified-Cassava Flour)	5.36a	4.82a	4.75a

*Notation same letters in the same column indicate no significant difference at a significance level of 5%

The result of moisture contents shows that the type of fillers, the interaction between the type of filler and the concentration of the fillers has no significant effect. On the other hand, the concentration of fillers indicates a significant effect on the moisture content of the banana flakes. The further tested of different concentration of filler by Duncan showed in Table 6 below.

Table 6. The Effect of fillers concentration on moisture content of banana flakes

Concentration of Fillers	Average from different Filler for Moisture Content	Significance level 5%
B3 (Con.of 15%)	4,40	a
B2 (Con. of 10%)	4,75	a
B1 (Con. of 5%)	5,18	a

*Notation same letters in the same column and line indicate no significant difference at a significance level of 5%

The higher concentration of the added ingredients will somehow decrease the water content of the water. This may be due to the differences in starch and protein that contain in the fillers. The higher concentration of the added ingredients, the more starch, and protein contained in the material, the water content of the material will be lower. This is due to the more water that is bound in the material and the free water content will be lower.

Water content is related to the protein content, where proteins will bind water through hydrogen bonds. At the time of cooking, the starch molecules will bind with the proteins through hydrogen bonds. Because of the weakening of these hydrogen bonds, water molecules can infiltrate between protein and starch molecules, so that at the cooling time the reinforcement of hydrogen bonds between hydrogen starch molecules involves strongly bonded water molecules is difficult to be released by evaporation or drying. The free water content can easily disappear when evaporation occurs, whereas bound water is difficult to be free in such a way [15].

3.3. Selected The Best Product of Banana Flakes

3.3.1. Selected sample of Banana Flakes

The products were selected based on [11] method. Response variables included in this method are moisture content, crustiness, water absorption index and water solubility index. Based on the effectiveness test using [11] method, there is a rank of treatment from one to nine as shown in Table 7.

Based on the tables above, we can see that the banana flakes with addition 15% of rice flour's is the most selected banana flakes. The best product of banana flakes then continued with the testing of the ash, crude fiber, protein, fat, and carbohydrate content.

Table 7. Ranks of De Garmo effectiveness test

Rank Order	∑Nh	Sample Code	Details
1	0.315	A1B3	15% of Rice Flour
2	0.271	A1B2	10% of Rice Flour
3	0.257	A2B1	5% of Corn Flour
4	0.231	A1B1	5% of Rice Flour
5	0.225	A3B2	10% of Modified Cassava Flour
6	0.153	A3B3	15% of Modified Cassava Flour
7	0.140	A2B3	15% of Corn Flour
8	0.132	A2B2	10% of Corn Flour
9	0.086	A3B1	5% of Modified Cassava Flour

3.3.2. The Result of the proximate test

The selected banana flakes product was continued with the chemical test for seeing the level of ash, the crude fiber, fat, and carbohydrate content. The following Table 8 is the result of the analysis.

Table 8. Banana flakes chemical quality test with the addition of rice flour 15%

Parameter	Value
Ash (%)	3,24
Crude Fiber (%)	3,19
Protein (%)	7,35
Fat (%)	2,14
Carbohydrate (%)	83,45

4. Conclusion

Formulation banana flakes using different type and concentration of filler has been done. The physical response showed that hardness of the product, the water absorption index, and the water solubility index has not significantly affected by the type and the concentration of the filler, and also the interaction between two of them. The result of the moisture content shows that the type of fillers, the interaction between the type of fillers and the concentration of the fillers has no significant effect. Based on De Garmo effectiveness index method, the banana flakes with 15% of rice flour's addition is the most selected banana flakes that have 3,24% ash, 3,19% crude fiber, 7,35% protein, 2.14% fat, and 83,45% carbohydrate content.

5. Acknowledgment

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