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Characteristics of Flakes from Kepok Banana Flour and Black Rice Flour with Variation of Steaming Time

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ABSTRACT

This research has the objective of determining the effect of flour rasio kepok banana and black rice. Black rice flour with variations in steaming time on physicochemical characteristics of flakes. This research used a randomized Complete Design (RCD) factorial pattern with two factors and two replications. The first factor is thr proportion of kepok banana flour: black rice flour (30%: 70%, 40%: 60%, and 50%:50%) and the second factor is the length of steaming time (10 minutes, 15 minutes, 20 minutes). The data obtained was analyzed using ANOVA and followed by the Duncan Multiple Range Test (DMRT) at the 5% level. The results of the research showed that there was interaction. There was a significant difference between the treatments of kepok banana flour: black rice flour on moisture content, starch content, and water absorption. The best treatment is Banana flour: black rice flour on moisture content, starch content, and water absorption. The best treatment is flaked with a proportion of 50% kepok banana flour and 50% black rice flour and a steaming time of 10 minutes produced flakes with characteristics of the value of water content of 4.77%, ash content of 2.12%, fat content of 8.35%, content protein of 5.56%, the starch content of 78.01%, water absorption of 24.96%, hardness of 414.57N and dietary Fiber content of 5.22 %, the calcium content of 169.89mg/100g and the average of favorability scores for taste (3.83), color (4.80), aroma (4.20) and textire (3.37)

1. INTRODUCTION

1.1. Research Background

Flakes represent a viable breakfast option that can be further developed due to their high energy, protein, and nutrient content [1]. Cereals, which are processed grains intended for breakfast, are often available in ready-to-eat formats or may require cooking. Flakes, a common type of cereal, are an example of such processed grains [2].

The basic principle of making flakes is drying starch that has been gelatinized. The gelatinization process carried out in the process of making flakes is by steaming. Steaming time is important because the right steaming time will produce good flakes. Different steaming lengths cause different levels of different gelatinization. Changes that occur during the heating process (steaming) include carbohydrates will experience a slight color change, starch will gelatinize to form a solid network structure proteins will harden due to coagulation, while water content will experience relatively the same changes [3].

Bananas, particularly the kepok variety, offer significant potential for enhancing national food security efforts. Kepok bananas, known for their high carbohydrate content, are frequently utilized in the production of processed food items, including banana flour. Each 100 grams of these bananas contains 26.3 grams of carbohydrates, 109 calories, 0.8 grams of protein, and 71.9 grams of water. Kepok banana flour is advantageous due to its ease of processing into high-value products, its compatibility with other flours and ingredients, and its ability to contribute a distinct aroma to the final product [4] [5]. Furthermore, this flour serves as a viable alternative raw material.

to increase the calcium content of the flakes. Banana flour contains 30-39 mg of calcium [6].

Black rice flour is one type of flour with a high amylose content. The amylose content of black rice ranges from 24.7 to 26.1%, relatively higher than tapioca at 17%, potato at 21%, and cornstarch at 28.70% [7] [8]. Besides being able to help increase amylose levels, the addition of black rice can also increase fiber levels in flakes. Black rice has dietary fiber and hemicellulose content of 7.5 and 5.8% respectively, while white rice is only 5.4 and 2.2% respectively [9]. The protein content of black rice is 8.5% and white rice is 6.8% [10]. [11] has successfully increased protein in breakfast cereal from millet and rice flour enriched with nuts to reduce the incidence of protein malnutrition in children.

The characteristics of flakes are influenced by the cooking process, namely steaming. Steaming of flakes dough can improve the texture of flakes and plays a role in the process of starch gelatinization. Starch gelatinization in flakes occurs in the steaming process [12]. Research [13] showed that

Steaming the flakes dough for 10, 15, and 20 minutes affects the moisture content, starch content, breakability, and rehydration capacity of the flakes produced.

Based on this, this research utilizes kepok banana flour and black rice flour as an effort to develop food fiber-rich flakes and a combination with the length of time the dough is steamed. So the flakes product in this research is expected to have the advantage of high energy content and food fiber. Therefore, this research was conducted to determine the best treatment combination between the proportions of kepok banana flour and black rice flour, as well as the length of steaming time on the resulting flakes product.

1.2. Literature Review

Flakes are a cereal product that is favored by the public as breakfast because it has a good taste, is healthy, and is practical in serving. The main characteristic of flakes is that it has low water content and a crunchy texture. The difference in the composition of amylose and amylopectin in starch affects the level of crunchiness of the flakes produced. The crispness of breakfast food products is one of the important factors, flakes that have amylose content will be hollow, crisp, and crunchy. Another thing that can also affect the crispiness is the baking process with high temperature will affect the quality of texture and crispness produced [13].

Flakes can be made using one type of flour or using composite flour. Composite flour is flour made from two or more food ingredients [14]. The purpose of using composite flour is to obtain suitable material characteristics and obtain certain functional properties and consider other factors such as availability of goods and price [15].

3.1.1 Kepok Banana Flour

Banana kepok flour can be used as an alternative in processing flakes because it will produce flour with white color, in addition to using banana kepok flour. banana will give a banana aroma to the flake product and as a diversification of processed products from bananas. Research conducted [17] showed that the use of 70% banana flour and 30% cassava flour produced banana flakes with a yield of 62.635%, moisture content of 4.307%, starch content of 76.653%, fiber content of 2.323%, fracture strength of 0.272 kg/cm2 and rehydration strength of 71.379%. The average results of the sensory test showed the number of ranks of taste 71, texture 79, and color 80. Another research conducted [18], showed that organoleptic testing of flakes processing with the treatment of 60% banana flour: 40% sago flour is the best treatment, with the value of aroma (70% like), color (64% like), taste (67.33% like), and texture (80.67% very like), while for other treatments the panelists' assessment of the average product in the "like" category. However, banana flour flakes have the disadvantage that they can reduce the level of crispness of the flakes in a relatively fast time due to kepok banana flour having a relatively low amylose content [19]. Therefore, black rice flour was added to increase the amylose content of the flakes.

3.1.2 Black rice flour

Research that has been conducted [8], shows that the black rice tested has the following characteristics: total levels of phenolic compounds 261.7 - 353.0 mg GAE/100 g wk, anthocyanins 52.4 - 126.1 mg/100 g wk, starch 69.8 - 72.8% wk, amylose 22.4 - 26.1% wk, amylopectin 45.3-48.7%, solubility 6.4 - 8.4% and swelling power 6.3 - 7.3%. Research conducted [20] showed that in sensory analysis, the level of acceptance of black rice flour cookies and black soybeans (65%: 35%) was the best cookie formulation most favored by panelists.

Another research conducted by [21], showed that the processing of flakes with a proportion of 40% black rice flour and 60% purple sweet potato flour had a water absorption value of 73.4%, fracturability of 0.313 kg, crispness of 0.923 kg/mm/s, Lightness 38.5 ± 0.6, Hue 355.47 ± 1.22 and

chroma 5.47±0.06.

3.1.3 Gelatinization

The gelatinization process is a change that occurs in starch granules when they swell and cannot return to their original shape. The gelatinization process occurs due to damage to hydrogen bonds that function to maintain the structure and integrity of starch granules [22]. During cooking, it will affect the starch granules. Starch granules occur irreversible swelling in water because the kinetic energy of water molecules is stronger than the attraction of starch molecules so that water can enter the starch granules. The longer the heating, the more starch granules experience development and cannot return to their original condition (gelatinized), so the amount of starch granules and other water-soluble compounds will decrease, on the other hand, the shorter the cooking time, the starch granules are not completely gelatinized.

The addition of bengkuang flour and the length of steaming in the manufacture of the best flakes products in terms of physical and chemical as well as organoleptic obtained in the treatment of the addition of 30% bengkuang flour and the length of steaming time of 5 minutes. the longer the steaming time, the starch content in the flake will decrease, while the faster the steaming time, the starch content will increase. The gelatinization process is a change that occurs in starch granules at the time.

1.3. Research Objective

This research aims to determine the effect of treatment of the proportion of kepok banana flour and black rice flour and the length of steaming time on the physicochemical and organoleptic characteristics of flakes and to determine the best treatment combination of the proportion of kepok banana flour and black rice flour and the length of steaming time in making flakes.

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2. MATERIALS AND METHODS

2.1 Materials and Tools

The materials used were kepok banana from Surabaya Horse Racing Market organic black rice from Asem Market, sugar, salt, margarine, sodium bicarbonate, and water. Materials for analysis were concentrated HCl solution, concentrated HNO3 solution, 25% H2SO4 solution, NaOH solution, Na2SO3 solution, 95% alcohol, 80% ethanol, 4% boric acid solution, 0.1N HCl solution, luff schroll solution, DPPH solution, distilled water.

The tools used were a cabinet dryer, oven, blender, digital scale, basin, spoon, pot, rolling pin, 60 mesh sieve, and processing tools. Tools used for analysis are an oven, analytical balance, tongs, counter cooler, filter paper, water bath, porcelain cup, mortar, glassware, and desiccator.

2.2 Design of Experiment and Analysis

This research used a completely randomized design with 2 factorials, namely the ratio of the proportion of tapioca flour to soybean hull flour (30:70, 40:60, 50:50) and the difference in steaming time, namely 10 minutes, 15 minutes and 20 minutes. Each treatment was repeated 2 times, so there were 18 experimental units.

The data obtained will be processed and analyzed using a Microsoft Excel computer. Data will be analyzed using One-Way ANOVA and Duncan's further test with a significant difference value ($P < 0.05$).

Table 1. Research Experiment Treatments

Comparison of Banana Kepok Flour: Black Rice Flour	Steaming Time (minutes)		
	L1 : 10	L2 : 15	L3 : 20
P1 (30 : 70)	P1L1	P1L2	P1L3
P2 (40 : 60)	P2L1	P2L2	P2L3
P3 (50 : 50)	P3L1	P3L2	P3L3

Data processing and analysis were carried out using *Microsoft Excel* software. Data were entered into a 2-factor completely randomized design. Then the responses used were moisture content, dietary fiber content, starch content, water absorption, *hardness*, and hedonic organoleptic test (taste, color, aroma, texture).

2.3 Observation

2.3.1 Physicochemical Analysis

The parameters analyzed were moisture content, starch content, amylose content, calcium content, water absorption, hardness, and dietary fiber.

2.3.1 Sensory Analysis

Organoleptic testing was performed on samples of flakes. In this organoleptic test, 25 panelists provided an assessment of the taste, aroma, texture, and color.

3. RESULT AND DISCUSSION

3.1 Raw Material Analysis

Analysis of raw materials in this research was carried out on black rice and kepok banana flour. The results of black rice flour analysis can be seen in **Table 2**.

Table 2. Analysis Results of Black Rice Flour

Composition	Black Rice Flour Results	
	Analysis	Literature
Starch Content (%)	63,67	61,35-75,51[23]
Amylose Content (%)	21,73	12,72-21,18[24]

Table 2 shows that black rice flour contains 63.67% starch, these results are by the literature which ranges from 61.35-75.51%. The difference in starch content in each black rice flour can be caused by differences in the type of black rice used. Organic black rice flour has a higher starch content compared to non-organic black rice. Organic planting systems can cause the formation of large amyloplasts with many starch granules in them and can increase amylose content as nitrogen and mineral content (Fe, Mn, and Zn) in the soil increase [25]. Amylose is known to be composed of linear chains and these chains easily form a compact structure that will be difficult to digest by the body [26]. Rice with higher amylose content has a high resistant starch content [27].

Based on the analysis results in Table 2, it is also known that black rice flour contains an amylose content of 21.73%, which is higher than the literature (12.72-21.18%). This difference is due to differences in climatic conditions at the time of plant cultivation. According to Indonesian National Standard 6128 of 2015 concerning rice, it states that the determination of the texture of pera / fluffy is one on the amylose content contained in the material. Criteria for rice texture pera amylose levels > 25%, fluffy texture rice amylose levels 20-25%, very fluffy rice texture amylose levels 15-20%, and rice with sticky texture amylose levels < 15%.

Table 3. Kepok Banana Flour Analysis Results

Composition	Kepok Banana Flour	
	Analysis Result	Literature
Starch Content (%)	75,92	53,36-83,2[28]
Amylose Content (%)	29,94	27,42-48,23[28]
Calcium Content (%)	24,15	23[29]

The results of the analysis of starch and amylose content of kepok banana flour in Table 3 show that it is still within the literature range. Low and high amylose levels can be caused by differences in genotypes, climate, and soil fertility where banana is grown. This statement follows Ref. [30], which states that soil nutrients have a role in starch synthesis in a plant resulting in the degradation of starch components. Lack of C and N elements in the planting even in the early stages will reduce yield. Besides being influenced by the planting location, the starch content of kepok banana flour can also be influenced by various things, including the harvesting age of the

genotype, the growing climate and the analysis process. The starch content of banana fruit increased with increasing shelf life after harvest until the 3rd day, then began to decrease again on the 4th day after harvest. The highest starch content was found in banana fruits with a shelf life of 3 days after harvest. This is thought to be due to the respiration pattern of banana fruits which are climatic. The respiration pattern of climatic fruit has a quadratic pattern. The decrease in carbohydrate content after reaching the highest point means that the ripening process begins to occur [31].

3.2 Flakes Analysis Results

The results showed that there was a significant interaction between the proportions of kepok banana flour: black rice flour on moisture content, starch content, hardness, water absorption, and dietary fiber content.

3.2.1 Water content

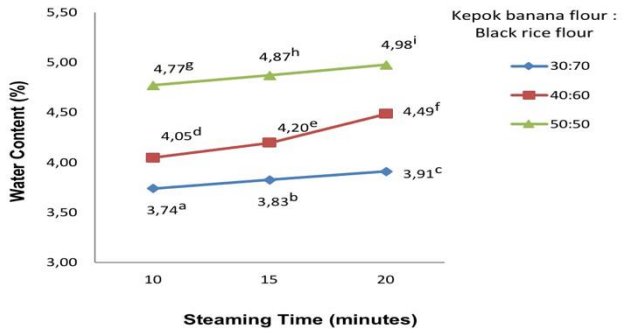

Figure 1. The relationship between the proportion of kepok banana flour: black rice flour and steaming time on the moisture content of flakes.

Based on Figure 1, it is known that the lower the proportion of black rice flour or the higher the kepok banana flour and the longer the steaming time, the moisture content of the flakes will increase. This is due to the higher proportion of kepok banana flour, causing the starch content to decrease. Based on Table 3, kepok banana flour has a higher starch content compared to black rice flour. Starch absorbs water so that the more starch added, the water content of the flakes can increase. The lower the proportion of tapioca as a starch source, the lower the moisture content of flakes because starch absorbs water, and vice versa, the more starch added, the higher the moisture content of flakes [18].

The structure of regularly arranged starch chains in a granule is called the crystalline region, while the disordered region is called the amorphous region. Amorphous regions contain a certain amount of amylose as the main component, while the main constituent of crystalline regions is amylopectin. The crystalline structure of starch will be damaged during gelatinization. The broken crystalline structure causes the starch granule structure to be more tenuous so that the starch granule size is larger, and when flour is mixed it will be higher.

Starch granule development is influenced by the length of time during the steaming process of the flakes. This happens because when the steaming process gets longer, the starch will gelatinize due to the heating process so that water will easily enter the starch granules and be trapped in it. So that the longer the steaming time, the water content of the flakes will increase. This is following the statement [28] which states that the longer the steaming time, the dough traps more water. This is because the longer steaming time will cause the starch to gelatinize perfectly with more water entering the dough due to the breakage of hydrogen bonds between starch molecules.

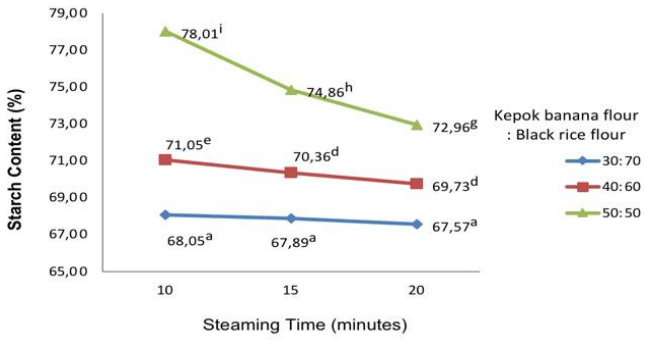

Figure 2. The relationship between the proportion of kepok banana flour: black rice flour and steaming time on the starch content of flakes.

3.2.2 Starch content

Based on Figure 2, it is known that the lower the proportion of black rice flour or the higher the kepok banana flour and the longer the steaming time, the starch content of the flakes will decrease. This is because kepok banana flour has a higher starch content compared to black rice flour. Based on Table 3 and Table 2, it is known that the starch content of 74.79% kepok banana flour is higher than the starch content of 63.16% black rice flour. So the higher the proportion of kepok banana flour added, the starch content of flakes will increase. This statement is supported by [32] that the starch content of flakes is influenced by the starch content components contained in the raw materials used.

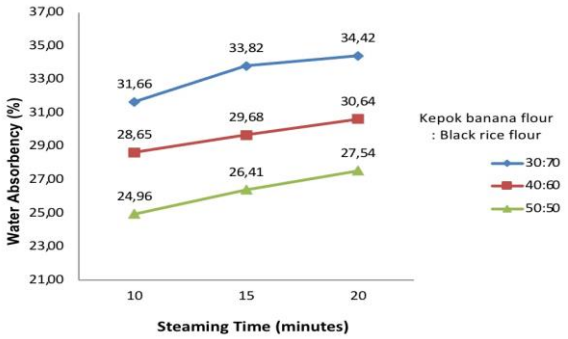

Figure 3. The relationship between the proportion of kepok banana flour: black rice flour and steaming time on the water absorption of flakes.

During the steaming process, the longer the steaming time, the starch content of the flakes will decrease. This decrease is due to the gelatinization process that occurs during the steaming process causing swelling of starch granules so that more water is trapped in starch which increases water content while reducing other components including starch. This statement is supported by [33], when starch gelatinization occurs, starch granules experience swelling which

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results in starch granules breaking so that water easily enters the dough.

3.2.3 Water Absorbency

Based on Figure 3, it is known that the higher the proportion of kepok banana flour or the lower the proportion of black rice flour and the faster the steaming time, the lower the water absorption capacity of the flakes. The water absorption of flakes is influenced by the amylose component contained in the flour used, based on Table 3 and Table 2, it is known that kepok banana flour has a higher amylose content compared to black rice flour. So that the more kepok banana flour added can increase the amylose content in the product. Flour with high amylose content has low amylopectin content, where amylopectin is developing the product. The more the product has high expandability, the easier it is to absorb water. Amylose plays a role in product hardness, but amylopectin stimulates the blooming process (puffing), so that the resulting food products are crispy, light, porous, crisp and have the ability to absorb more water [34] The longer the steaming time of the flakes, the water absorption will increase. this is related to the starch gelatinization process that occurs. the steaming process causes starch to gelatinize in the presence of water and high temperatures causing the starch granule structure which was originally arranged regularly to become loose. The crystalline structure (neatly arranged areas) in starch will be damaged during the gelatinization process, which causes the starch granule structure to stretch and results in the size of the starch granules getting bigger so that the water absorption capacity will be higher. degree of gelatinization is the ratio between gelatinized starch and total starch. Higher degree of gelatinization will be followed by greater granule development. The crystalline structure in starch granules is increasingly stretched so that with the addition of the same water, there are differences in water absorption ability. The more stretched the structure in the starch granule, the easier it will be for water to enter and be trapped in it. During the cooking of starch granules, irreversible swelling will occur in water because the kinetic energy of water molecules is stronger than the attraction of starch molecules so that water can enter the starch granules. So that the longer the cooking time causes more granules to develop and cannot return to their original condition (gelatinized), on the other hand, a shorter cooking time allows starch granules to not gelatinize completely.

3.2.4 Hardness

3.2.4

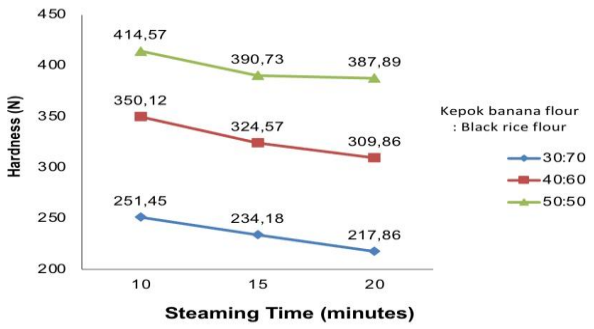

Figure 4. The Relationship between the proportion of kepok banana flour : black rice flour and steaming time on the hardness of flakes.

Based on Figure 4, it is known that the lower the proportion of kepok banana flour or the higher the proportion of black rice flour and the faster the steaming time, the higher the hardness. The hardness value of flakes is influenced by the amylose content of the flour used. Based on Table 3 and Table 2, it is known that kepok banana flour has a higher amylose content than black rice flour. Starch with higher amylose content will produce a product with a harder texture. Products with a high hardness value will reduce the crispness of the resulting product, and vice versa if the hardness value is lower, the crispness obtained will be higher. The main component of starch consisting of amylose and amylopectin has different properties. Amylose is easily soluble in water, has a tendency to retrogradation and produces a hard gel and strong film. Starch with a high amylose content tends to produce a hard product because the expansion process is limited.

Products with high amylopectin content are crispy, light and porous because amylopectin causes the development or expansion process of the product. Conversely, products with high amylose content are hard During the cooking process, the amylose chains will be bound to each other which causes the amylose polymers to be difficult to attract during the development process so that the resulting product is less fluffy [35].

Hardness is also influenced by the length of steaming. The longer the steaming time, the starch contained in the starch. flakes dough will gelatinize. The baking process after steaming causes the water that has been trapped in the starch granules during the gelatinization process will evaporate and produce air cavities that will produce flakes with a crunchy texture. This statement is following [34], which states that starch gelatinization process affects the breakability of flakes. The starch contained in the flakes will undergo starch gelatinization during steaming which causes the starch granules to swell as the steaming time increases. As a result, the flakes become more porous and easily broken, so the breakability decreases. When drying, the water will be evaporated and produce more pores and the texture of the flakes will be crispy. The high value of breakability, the hardness of the product will also increase so that the flakes become more resistant to pressure, so that the shape of the product can be maintained, not brittle, and not easily destroyed [36].

The crispiness level of a food product is related to the moisture content value. The lower the moisture content of the flakes, the crispier the flakes will be and the greater the crunchiness of the flakes. Starch has a role in the formation of the structure of flakes. Starch contained in white sweet potato flour and mung bean flour will bind with water, then with the cooking treatment at high temperatures, the starch will gelatinize so that cavities will form in the structure of the flakes. The more the starch is gelatinized, the more air cavities will be formed in the flakes. If more cavities are formed, then during rehydration the water that will be trapped in the flakes will be more and more so that the level of rehydration will increase [37].

3.2.5Dietary Fiber Content

Based on Figure 5, it is known that the higher the proportion of black rice flour and the lower the proportion of kepok banana flour and the longer the steaming time, the higher the food fiber content of the flakes produced. the more the proportion of black rice flour added, the higher the food fiber content of the flakes produced. Research conducted [38], black rice has a food fiber content of 8.5% while kepok banana flour has a food fiber content of 7.6% [39], so the more black rice flour in the formulation, the higher the food fiber content of the flakes. This is following Ref. [33] that the fiber component contained in the raw material will affect the fiber content of the resulting flakes product.

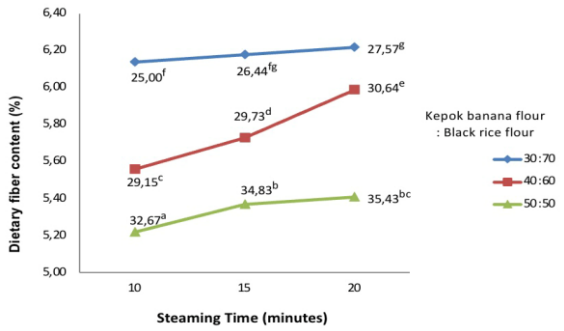

Figure 5. The relationship between the proportion of kepok banana flour: black rice flour and steaming time on the dietary fiber content of flakes.

Food fiber content is also influenced by the cooking process, one of which is heating, the longer the heating, the food fiber content increases. This increase occurs because the heating process causes the formation of indigestible starch which is resistant to hydrolysis by digestive enzymes and cannot be digested in the small intestine. Total dietary fiber is divided into two groups, namely soluble and insoluble dietary fiber. Water insoluble fiber is fiber that cannot dissolve in water and also in the digestive tract. This statement is supported by [40], Cooking with heating causes an increase in insoluble dietary fiber levels due to the formation of undigestible starch. starch or starch degradation products that cannot be digested by the human intestine are called resistant starch. or resistant starch (RS). The formation of resistant starch in food ingredients can be caused by heating. This increase in dietary fiber content is thought to be due to the formation of resistant starch formed during heating that cannot be hydrolyzed and is measured as insoluble dietary fiber.

3.3 Hedonic Organoleptic

Table 4. Hedonic Organoleptic Analysis Results

Chemical Analysis	Treatment								
	A1B1	**A1B1**	**A1B1**	**A1B1**	**A1B1**	**A1B1**	**A1B1**	**A1B1**	**A1B1**
Taste	4.27	4.20	4.23	4.03	4.07	4.00	3.83	3.80	3.90
Aroma	3.77	3.60	3.17	4.37	4.13	3.83	4.80	4.60	4.50
Color	3.53	3.77	3.90	3.97	4.10	4.13	4.20	4.30	4.40
Texture	4.37	4.40	**4.63**	4.03	4.13	4.20	**3.37**	3.47	3.73

3.3.1 Taste

Based on Table 4, the level of panelists' liking for the flavor of flakes ranged from 3.80 - to 4.27 (neutral-like). The lowest liking value is found in the flakes treatment by adding a proportion of 30% kepok banana flour and 70% black rice flour with a steaming time of 15 minutes with an average value of 3.80 while the highest liking value is found in the flakes treatment adding a proportion of 50% kepok banana flour and 50% black rice flour with a steaming time of 10 minutes with an average value of 4.27.

Panelists preferred flakes with the proportion of kepok banana flour: black rice flour (50: 50). This is because the use of kepok banana flour can increase the sweetness of the flakes. This is supported by the statement of reff [41], that during the ripening process of banana fruit, starch is converted into sugar through an enzymatic process, followed by an increase in the amount of sugar content, especially sucrose. The high sucrose content causes the fruit to taste sweet. Hulu and Handoko's research showed that flakes made from 100% kepok banana flour had a more favorable taste than flakes with sago flour added.

Steaming time does not give significant hedonic organoleptic results of taste, this is because the length of steaming does not affect the taste of the flakes produced because the taste produced by the flakes comes from the ingredients used in its manufacture. This is following reff [42], that the flavor that appears in the product is caused by the ingredients in the product such as banana flour, powdered sugar, margarine, and others.

The level of flavor liking of flakes is also influenced by the addition of additives such as sodium bicarbonate, salt, sugar and margarine. The addition of sodium bicarbonate in flakes acts as a flavor enhancer and savory flavor giver, but the addition of too much sodium bicarbonate causes an unpleasant taste to form.

3.3.2 Aroma

Panelists preferred *flakes* with a higher proportion of banana kepok flour, a lower proportion of black rice flour, and longer steaming time. Page This is because kepok banana flour has a distinctive banana aroma, so the more banana flour is added, the *flakes* produced have a distinctive banana aroma that is favored by panelists. The composition of starch is enough to give a distinctive aroma to the resulting product. Ingredients that contain a lot of starch are enough to bring up a certain aroma in the product, but its presence can be distinguished in the taste of the resulting product.

3.3.3 Color

The more the addition of black rice flour, the more purple the flakes produced, the purple color comes from the anthocyanin content in black rice. This color appears when the ingredients are heated, the gray dough changes color to purplish when cooked. Anthocyanins are water-soluble pigments. Anthocyanins are used as natural colorants in food and beverage products so that they can replace the use of synthetic dyes in food products, anthocyanin pigments can also act as free radical antidotes that function as antioxidants in the body [43].

However, the longer steaming time can reduce the panelists' liking, this is because the purple color produced is faded. The purple

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color is an anthocyanin that is easily damaged at hot temperatures. This is following Reff's research [44] that the processing of materials containing anthocyanins affects the levels of anthocyanins produced. The heating process can damage anthocyanins, so the color will be faded.

3.3.4 Texture

Panelists preferred flakes with a proportion of 30% kepok banana flour and 70% black rice flour with a steaming time of 20 minutes. This is because the flakes have a crunchier texture and are easily broken due to the lower amylose content of black rice flour compared to kepok banana flour. This statement is following reference [34], amylose plays a role in increasing the texture of the flakes. hardness compared to amylopectin so that this is This causes the consistency of the hardness of the sample to increase if the amylose content is higher while the crispness of the sample decreases, where the stick has a crunchy texture. Flour with low amylose content has low amylopectin content. Amylopectin has high amylopectin content, which simulates the puffing process, resulting in crispy, light, porous, and crisp food products. The texture of flakes includes crunchiness, breakability, and consistency at the first bite. Generally, the desired texture of flakes is crispy, and crunchy, not easily broken but not hard. The crunchiness of a product is assessed based on the ease of biting until the product breaks. The texture of a food is influenced by the composition of the raw materials, degree of gelatinization, degree of development, water absorption index, temperature, and baking time [45]. The texture of the material becomes dry and rough because free water on the surface of the material evaporates faster than bound water. Pressure and heat from the oven cause water and volatile components in food ingredients to evaporate. The ratio of amylose and amylopectin content in starch affects the crispness of a product. A high amylopectin content makes the product easy to expand, while a high amylopectin content makes the product crisp.

3.4 Best Treatment Analysis

Based on Table 5, it can be seen that flakes have a fat content of 8.35%, this result has met the standard of flakes according to ref. [45]. The fat content of flakes is influenced by the fat content of the raw materials used. According to Reff [46], black rice flour has a fat content of 3.42%. Thus, the higher the proportion of black rice flour added, the higher the fat content of the flakes. In addition, the fat content will increase during the processing process due to the addition of other additives such as margarine which can increase the fat content of the flakes. This statement is supported by reff [47] which states that margarine contains several lipids and some of the lipids are in bound form as lipoproteins. If margarine is added to the dough, the dough will have a high-fat content as well.

Table 5 shows that the protein content of flakes is 5.54%, this result indicates that flakes with a proportion of 50% kepok banana flour: 50% black rice flour with a steaming time of 10 minutes have met the SNI Cereal standard. The protein content of flakes is influenced by the protein content of black rice flour. According to reference research [50], black rice flour contains 9.97% protein. Thus, the higher the proportion of black rice flour added, the protein content of the flakes will increase.

The ash content of the flakes amounted to 2.12%, this result shows that the flakes with the proportion of 50% kepok banana flour: 50% black rice flour with a steaming time of 10 minutes have met the Cereal SNI standard. The ash content of a food material shows the residue of inorganic materials that remain after a material is burned. Ash content is closely related to the mineral composition of the material used. According to Ref. [50], black rice flour has a mineral composition in the form of 0.257 mg calcium (Ca), 0.335 mg Iron (Fe), 0.821 mg Potassium (K), 3.11 mg Magnesium (Mg), 0.042 mg/ml Zenk (Zn). So when the proportion of black rice flour added is higher, it will increase the ash content of the flakes. This statement is supported by reff [1], that ash content is related to the mineral content of a material. The higher the ash content, the higher the mineral content in the food. Mineral elements are organic substances or known as ash content. In addition, minerals are quite stable during heating so they tend not to break down. changes during the baking process. In addition, the increase in the ash content of flakes can also be influenced by the addition of ash content from supporting materials [51]. The supporting materials used in making flakes are water, sodium bicarbonate, margarine, and salt which contain minerals that will also increase the ash content of the product. According to Ref. [52], ash content has a relationship with the minerals of a material, which can be organic or inorganic salts or minerals in the form of organic compounds such as sodium bicarbonate.

Table 5 shows that flakes with a proportion of 50% kepok banana flour: and 50% black rice flour with a steaming time of 10 minutes have a calcium content of 171.182 mg/100 g. This result is lower than the literature (267.957 mg/100 g). This difference can be caused by the difference in calcium content of the raw materials used in making flakes. The higher the calcium content of the raw materials, the higher the calcium content of the flakes. Based on Table 1, it can be seen that kepok banana flour has a calcium content of 169.98 mg/100 g. The decrease in calcium content in flakes can be caused by calcium loss during the processing of flakes, especially during the baking process. This statement follows Ref. [53], stating that cooking and drying processes can reduce calcium levels by up to 25% compared to raw materials.

Table 5. Best Treatment Analysis Results

Parameters	Analysis Result	Literature
Fat content (%)	8.35 ± 0.04	*Min 7%[48]*
Protein content (%)	5.54 ± 0.04	Min 5%[48]
Ash content (%)	2.12 ± 0.01	Max 4%[48]
Calcium content (mg/100 g)	169.98 ± 0.18	267.957[49]
Carbohydrate content (%)	*79.23 ± 0.01*	*Min 60.7%[48]*

Based on Table 5, it can be seen that the flakes have a carbohydrate content of 79.23%. meet the standard of flakes according to SNI Cereal. The carbohydrate content of flakes is calculated using the by-difference method so this calculation is influenced by several other nutritional components contained in the flakes such as moisture content, fat content, ash content, and protein content. The higher the other nutrients in the flakes, the lower the carbohydrate value, conversely, the lower the other nutrients, the higher the carbohydrate value [53]. The carbohydrate of a food product is influenced by the carbohydrate content contained in the raw materials. According to Ref. [54], black rice flour has a carbohydrate content of 83.8%. This causes the high carbohydrate content in flakes. In addition, according to reff [54], the increase in carbohydrate content of an ingredient is also due to the drying process of dried foodstuffs that will lose water and this causes the concentration of the remaining ingredients such as carbohydrates, fats and proteins so that they will be present in a larger amount of dry weight unity when compared to their fresh form.

4 CONCLUSION

A notable interaction was observed between the ratios of kepok banana flour and black rice flour and the duration of steaming concerning various attributes of the flakes, including moisture, starch content, water absorption, hardness, and dietary fiber. The optimal combination was found to be equal proportions of 50% kepok banana flour and 50% black rice flour, steamed for 15 minutes. This mix resulted in flakes with 4.77% moisture, 78.01% starch, 24.96% water absorption capacity, 414.57 N hardness, and 5.22% dietary fiber. Sensory evaluation scored the flakes with a taste rating of 3.83, color rating of 4.80, aroma rating of 4.20, and texture rating of 3.37. Additionally, the analysis revealed that these flakes contained 8.35% fat, 5.56% protein, 2.12% ash, 169.98 mg/100 g calcium, and 79.23% carbohydrates.

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