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Physico-Chemical, Organoleptic, and Antioxidant Properties of Black Soybean Flour (*Glycine soja* (L.) Merrit) Flakes with the Addition of Bangle (*Zingiber purpureum* Roxb.)

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ABSTRACT

Flakes are products that are generally made from cereals. In this study, we are interested to use black soybean (*Glycine soja* (L) Merrit) and bangle (*Zingiber purpureum* Roxb.) as flakes ingredients. Black soybeans have high antioxidant components, while bangle contains high antioxidant and fiber components, which enables it to capture free radicals. This study aimed to find the most favorable formula with good physical, chemical, and organoleptic characteristics, which also has the highest antioxidant activity. We used the Completely Randomized Design (CRD) method and the variation of formulation used was the ratio of black soybean flour to bangle as follows: T1 (100%:0%), T2 (95%:5%), T3 (90%:10%), T4 (85%:15%), and T5 (80%:20%). The parameters analyzed included physical properties (color, texture, and water absorption), chemical properties (moisture content, ash content, fat content, protein content, carbohydrate content, crude fiber content, and antioxidant activity, as well as total plate count), and organoleptic properties (color, texture, taste, aroma, and overall acceptance). The research data were analyzed using One-Way Analysis of Variance (ANOVA) at a significance level of 5% and Duncan's multiple range test. The results showed that the best formula for color and texture is T5 L* 54.57, a*-4.22, color b*31.42, hardness 0.74N, and water absorption 30.01%. The best treatment for chemical properties is T5 (moisture: 4.26%, ash: 3.68%, fat: 18.16%, protein: 16.92%, carbohydrate: 56.98%). All formulations meet the total plate count of <2,500. The highest antioxidant activity was in the T5 formulation (49.59 %). The results of the organoleptic properties showed that the most favorable overall organoleptic reception was T1. Flakes based on black soybean flour with the addition of bangle in formulation T5 (80% black soybean flour: 20% bangle) have the potential to be a functional food high in fiber and antioxidants.

Keywords: *flakes; black soybean; bangle; physical; chemical; organoleptic*

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INTRODUCTION

Oxidative stress is a condition where there is an imbalance between oxidants (free radicals) and antioxidants in the body (Nurdyansyah, 2017). This can be prevented by consuming foods that contain high levels of antioxidants. Sources of antioxidants include legumes, such as black soybeans, and spices like bangle.

Black soybeans have a protein content of 40.4 g/100g and contain antioxidants in the form of anthocyanin and isoflavone compounds (Malencic et al., 2012). Soy flour also contains high fiber content (Widaningrum et al., 2005). According to research conducted by Nurrahman (2015), black soybeans also contain higher levels of glutamate, serine, and tyrosine than yellow soybeans, although the difference is not significant.

Bangle (*Zingiber purpureum* Roxb) is a plant that is generally used as herbs, spices, and medicinal plants. Based on research conducted by Astarina et al. (2013), the active ingredients contained in bangle rhizome include saponins, triterpenoids, flavonoids, tannins, glycosides, and essential oils. Flavonoids in the human body function as antioxidants (Neldawati et al., 2013). The benefits of flavonoids include having antioxidant, antibacterial, antiviral, anti-inflammatory, anti-allergic, and anti-cancer activities (Tuarita et al., 2017). Bangle can be developed into innovative food products, such as flakes, cooking spices, and medicines.

Flakes are a type of food made from the main ingredient of cereals (Nurhidayanti et al., 2017). Flakes can be said to be ready-to-eat food, as it is included in fast food and the presentation process is practical, which is only done by adding milk as a mixture (Situmorang et al., 2017). Ready-to-eat food is very suitable for meeting the demands of consumers who want food that is fast and easy to prepare, contains the nutrients needed by the body, and can increase satiety (Menis-Henrique et al., 2020). The development of flake products needs to be carried out due to the increasing demand for ready-to-eat products, especially for breakfast (Febrianty et al., 2015).

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Flakes made from black soybean flour with the addition of bangle have high potential as a food diversification product with high antioxidant activity and fiber content. Therefore, it can produce flakes that have more nutritional content than regular flakes and can be used as a health product. Further research is needed on the physico-chemical and organoleptic characteristics of black soybean flour flakes with the addition of bangle. This study aimed to determine the physico-chemical and organoleptic characteristics of black soybean flour flakes with the addition of bangle and its potential as a functional food high in fiber and antioxidants.

METHODS

Materials

The materials used in this study were black soybean seeds. The research material used was black soybeans from the Mekar Mas Producer Cooperative, Kulonprogo, Yogyakarta, Indonesia, and fresh bangle from Gamping Market, Yogyakarta, Indonesia.

Stages of Making Black Soybean Flour

Black soybean flour is made by sorting the seeds first to obtain good quality black soybean seed, then soaking them for 8 hours, then drying them in an oven at 60 ℃ for 48 hours. Dried black soybean seeds are ground into powder and then sifted using an 80mesh sieve (Widiawati & Anjani, 2017a).

Black soybean flour is made by first sorting the seeds to obtain good-quality black soybean seeds, then soaking them for 8 hours, and finally drying them in an oven at 60 ℃ for 48 hours. The dried black soybean seeds are then ground into a powder and sifted using an 80-mesh sieve (Widiawati & Anjani, 2017a).

Stages of Making Bangle Powder

The process of making bangle powder in this study refers to the research conducted by Rifkowaty and Martanto (2016), with several modifications. The bangle rhizomes used were obtained from the Gamping Market, Sleman, Yogyakarta. The process of making bangle powder involves weighing the bangle rhizomes, stripping the bangle skin, then washing the peeled bangle and reweighing it. The washed bangle rhizomes are cut into small pieces, baked in an oven at 60°C for 48 hours, mashed using a blender, and then sifted using an 80-mesh sieve.

Stages of Making Flakes

Flakes are made using a standard formulation by Aulia (2017), with several modifications. The materials used in the formulation were selected with several considerations. The flakes formulation consists of variations of black soybean flour with the addition of bangle, including T1 (100%: 0%), T2 (95%: 5%), T3 (90%: 10%), T4 (85%: 15%), and T5 (80%: 20%). The manufacture of flake products involves mixing ingredients, including the ratio of black soybean flour and bangle, as well as other ingredients. The formulation for making flakes uses 100 grams of flour, according to the percentage ratio of black soybean flour and bangle flour (T1, T2, T3, T4, T5), along with 40 g of cornstarch, 40 g of flour sugar, 30 g of margarine, 200 g of full cream milk powder, 1 g of vanilla, 1 g of baking soda, and 1 g of salt. All ingredients are mixed with a mixer until they are homogeneous. After that, the dough is printed on baking paper with a thickness of ± 1 mm. The printed dough is then placed on a baking sheet and baked in an oven at 100°C for 40 minutes.

Water Absorption

The determination of the durability of the flakes in water or milk was carried out to determine the durability of the flakes when served with water or milk. This analysis was conducted using the gravimetric method. The analysis of water absorption capacity was carried out by weighing the sample, which had a weight of ± 1 gram, and then soaking it in warm water or milk for 5 minutes. After soaking for 5 minutes, the sample was removed, drained, and the weight of the sample was reweighed until it reached a constant weight (Yuwono, 2013). The water absorption capacity formula is (Equation 1):

$$\text{Water absorption capacity} = \frac{B - A}{A} \times 100\% \quad (1)$$

A, sample weight before immersion (g); B = Sample weight after immersion (g)

Texture and Color Analysis

Texture measurements were carried out using the Universal Testing Machine, Lloyd Zwick Z. 05. The first procedure was the preparation of the sample. Then, the Universal Testing Machine program was activated by pressing the ON power button, and we waited until the download process was complete. Standard tests (Compression, Tensile Strength, and penetration) were adjusted. Each sample treatment was adjusted to the parameters to be tested. Then, the sample was placed on the plate by setting the tool in a pre-load condition of 0.02 N, pre-load speed of 50 mm/min, and test speed of 10 mm/min. The data obtained were in the form of a relationship curve between Stress (N) and Crush (%) and Fmax (N). The Fmax (N) value was used to express the hardness level of the sample. The greater the force required, the harder the material was (Nasution et al., 2012).

Color testing analysis of flake samples was carried out using a Colorimeter CR-400. The measurements produced values for L, a, and b. The L notation states the brightness parameter, which has a value ranging from 0 (black) to 100 (white). The 'a' notation represents the chromatic mixture of red and green, with a +a (positive) value from 0 to +100 (red) and a-a value (negative) from 0 to -80 (green). The b notation represents the chromatic mixture of blue and yellow, with a+b (positive) value from 0 to +70 (yellow) and -b (negative) values from 0 to -70 (blue) (Hutchings, 1999).

Proximate and Crude Fiber Analysis

The proximate (moisture, fat, ash, protein, carbohydrate) and crude fiber analyses were determined using the standard methods prescribed by the Association of Official Analytical Chemists (AOAC, 2005) with some modifications. The moisture content was analyzed by the drying method. An accurately weighed sample (~2 g) was placed in an aluminum pan and dried in a previously heated vacuum oven at 105°C until a constant weight was achieved (Equation 2).

$$Moisture\ (\%) = \frac{\mathrm{W} - (\mathrm{W1} - \mathrm{W2})}{\mathrm{W1} - \mathrm{W2}} \times 100\% \quad (2)$$

W: the weight of the sample (g); W1: the weight of bottle plus sample (g); W2: the weight of bottle plus sample after drying (g)

The ash content (Equation 3) was determined through the gravimetric method. The ash content of the flour samples was determined by using a muffle furnace at 600°C for 6 hours until a constant weight was achieved.

$$Ash\ (\%) = \frac{\mathrm{W2} - \mathrm{W1}}{\text{sample weight (g)}} \times 100\% \quad (3)$$

W1: the weight of cup (g); W2: the weight of cup plus sample after drying (g)

The protein content was determined through the micro Kjeldahl method using a nitrogen-to-protein conversion factor of 6.25. Approximately 0.2 g of flour was mixed with 0.7 g of catalyst N and 4 mL of H_2SO_4, followed by destruction until the solution turned clear green. After destruction, the sample was distilled and collected in a solution of 5 mL of 4% H_3BO_3 solution and Mr-BCG indicator. Then, 0.02 N HCl was added for titration. The protein content was calculated using the following formula 4.

$$\%N = \frac{(\mathrm{A} - \mathrm{B}) \times \mathrm{N\ HCl} \times 14}{\text{sample weight (mg)}} \times 100\%$$
$$Protein\ (\%) = \%N \times \text{conversion factor} \quad (4)$$

A: sample titration (mL); B: blank titration (mL); Conversion factor: 6.25

The fat content (Equation 5) was analyzed by Soxhlet extraction using hexane as the solvent.

$$Fat\ (\%) = \frac{\mathrm{A} - \mathrm{B}}{\text{sample weight (g)}} \times 100\% \quad (5)$$

A: sample weight + filter paper before soxhletation (g); B : sample weight + filter paper after soxhletation and drying (g)

The total carbohydrate content was determined by difference. The carbohydrate content of the flour samples (Equation 6) was determined by subtracting the total of moisture, ash, protein, and fat from the total dry matter.

$$Carbohydrates\ (\%) = 100 - (\text{moisture} + \text{ash} + \text{protein} + \text{fat content}) \quad (6)$$

Antioxidant Analysis

The antioxidant activity was analyzed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method at a wavelength of 516 nm with a UV-Vis spectrophotometer (Molyneux, 2004). The analysis of antioxidant activity was carried out using the DPPH method. A 50 mL measuring flask was filled with 0.00197 g (1.97 mg) of DPPH powder, which had been dissolved in 50 mL of pro-analysis methanol. The volume was sufficient to reach the limit mark, and then it was covered with aluminum foil (DPPH 0.1 mM).

All sample formulations were weighed at 10 mg, and dissolved in 10 mL (1000 ppm) of pro-analysis methanol. Then, 5 mL of 0.1 mM DPPH stock solution was taken along with 5 mL of pro-analysis methanol. The UV-vis spectrophotometers were used to measure the absorbance of the blank solutions at a wavelength of 517 nm. The test tubes were filled with the sample solution, and the solution concentrations were obtained at 10 ppm, 40 ppm, 60 ppm, 80 ppm, and 100 ppm. Each concentration was adjusted with methanol pro analysis and made up to 10 mLL. Then, 5 mL of 0.1 mM DPPH solution was added to the sample test solution, which had been pipetted up to 5 mL of each concentration, in a test tube, covered with aluminum foil, and then vortexed until mixed. Next, incubation was carried out for 30 minutes, and then the absorbance was measured at a wavelength of 517 nm using a UV-Vis spectrophotometer. The antioxidant activity was determined by the percentage of radical scavenging activity (% RSA). The free radical scavenging activity was expressed as an inhibition percentage and was calculated using formula 7:

%RSA= (control absorbance – sample absorbance)/ control absorbance × 100% (7)

Organoleptic Test

Organoleptic tests were carried out using hedonic or preference tests, which included parameters such as color, taste, aroma, and texture, with several modifications (Kartika, 1988). A total of 30 untrained panelists were used in the study. The method used was a six-point rating test with a scale where 6 indicated the best trait and 1 indicated the lowest. The six-point hedonic scale was as follows: 5 = really liked, 4 = liked, 3 = somewhat liked, 2 = disliked, and 1 = very much disliked.

Microbiology Analysis

Microbiological analysis was executed using the SNI 01.2332.3-2006 method with some modifications. This analysis was carried out by taking 1 mL of each dilution sample and placing it in a sterile petri dish. Next, 15-20 mL of liquid plate count agar (PCA) media was poured into the petri dish. The mixture in the petri dish was then allowed to solidify. The final stage involved incubation, where all the petri dishes were inserted upside down into the incubator. Incubation was carried out at 37°C for 24-48 hours. The calculation and recording of colony growth were carried out in colony-forming units per gram or milliliter of sample (Maturin, 2001).

Experimental Design

This research utilized a completely randomized experimental design, as detailed in Table 1.

Table 1. Experimental design

Formulation			
Number	**Black soybean flour (%)**	**Bangle (%)**	**Code**
1	100	0	T1
2	95	5	T2
3	90	10	T3
4	85	15	T4
5	80	20	T5

Statistical Analysis

The observed data were analyzed statistically using Microsoft Excel and the One-Way Analysis of Variance (ANOVA) test at a significance level (α) = 0.05 using the Statistical Product and Service Solutions (SPSS) application, version 22. If there were significant differences between treatments, the results were further tested using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Physical Properties of Black Soybean Flour Flakes with Bangle Addition

The physical properties analyzed included color, which comprised the L* value (brightness value), a* value (red-green color tendency, with + indicating reddish and - indicating greenish values), and b* value (yellow-blue color tendency, with - indicating bluish and + indicating yellowish values), as well as texture (hardness) and water-absorbing strength. The results of the physical property analysis of the flakes are shown in Table 2.

Color

The results of the analysis of lightness (L*), redness (a*), and yellowness (b*) are shown in Table 2. The lightness, redness, and yellowness of the flakes increased significantly with the increase in the percentage of bangle flour. According to Buldani et al. (2017), the bangle rhizome has a characteristic yellow color, which is by the analysis carried out for each variation of the sample treatment, namely, the higher the percentage of bangle, the brighter the resulting color. The yellow color of the bangle rhizome has a very significant effect on each sample treatment according to the concentration added. In the process of making flakes in this research, an oven is used, which causes the samples to dry out. Based on research conducted by Winarno (2002), the drying process causes the Maillard reaction to occur between carbohydrates, especially reducing sugars, and amino groups from proteins at high temperatures, resulting in the formation of a brown color in the material, which is usually called the melanoidin compound. The high brightness value of the flake samples can be influenced by several factors, including the use of additional materials and the sample manufacturing process.

Texture (Hardness)

The treatment of black soybean flour with the addition of bangle had a significant effect on the texture test value. The levels of hardness decreased as the percentage of bangle flour added to the flake formulation increased. Based on research conducted by Malencic et al. (2012), it is stated that black soybeans have a protein content of 40.4 g/ 100g, which is higher than that of yellow soybeans. According to Sarabhai et al. (2014), a higher protein content in a cake causes the formation of aggregates, which occurs because the number of hydrophilic groups in the protein increases, binding to starch and preventing water binding. As a result, the texture of the cake becomes harder as the percentage of soy flour added increases. However, in this study, the opposite trend was observed, where the levels of hardness decreased as the percentage of bangle flour added increased. This suggests that the addition of bangle flour may have counteracted the effect of soy flour on texture.

Water Absorption Capacity

The treatment of black soybean flour with the addition of bangle has a significant effect on the value of water absorption. The water absorption capacity of the flakes decreased significantly with the increase in the percentage of bangle flour. Black soybean flour has an average starch content of 14.85% (Alamu et al., 2017). This suggests that the higher the amount of soybean flour added, the higher the starch content. The starch content contained in a material affects the structure of the resulting product. Starch binds with water, and then, with high-temperature treatment, the starch gelatinizes, forming cavities in the product structure (Kusnandar, 2010). According to Busono (2013), the more starch that is gelatinized, the more air cavities are formed. The more cavities that form, the more the rehydration process occurs, and the more water is trapped, thereby increasing the rehydration power. This suggests that the high rehydration power of the material is an indication of the amount of water absorbed (Suarni & Subagio, 2013).

Chemical Properties of Black Soybean Flour Flakes with Bangle Addition

Water Content

The results of the analysis (Table 3) showed that the treatment of black soybean flour with the addition of bangle had a significant effect on the water content value. The water content of the flakes decreased significantly with the increase of the bangle flour percentage. According to research conducted by Putri and Triandita (2018), black soybean flour has a water content of 8.33%. Since the food component with the highest percentage in the flakes' dough is black soybean flour, it can be concluded that the high water content obtained in the flakes sample may come from the black soybean flour.

Table 2. Results of the analysis of the physical properties of black soybean flour flakes with the addition of bangle

Formulation	Physical Properties				
	Color			Texture (hardness) (N)	Water Absorption Capacity
	L*value	a*value	b*value		
T1	49.74 ± 0,64^{a}	-4.22 ± 0,31^{a}	15.26 ± 0,25^{a}	1.35 ± 0,02^{d}	42.52 ± 0,97^{d}
T2	51.92 ± 0,61^{b}	-2.56 ± 0,35^{b}	22.73 ± 0,40^{b}	1.24 ± 0,04^{c}	38.19 ± 1,64^{c}
T3	52.18 ± 0,33^{b}	-1.91 ± 0,03^{c}	26.50 ± 0,13^{c}	0.92 ± 0,01^{b}	37.01 ± 1,21^{c}
T4	53.49 ± 0,50^{c}	-1.62 ± 0,09^{cd}	28.87 ± 0,60^{d}	0.78 ± 0,006^{a}	33.72 ± 2,51^{b}
T5	54.57 ± 0,16^{d}	-1.21 ± 0,18^{d}	31.42 ± 0,82^{e}	0.74 ± 0,04^{a}	30.01 ± 1,57^{a}

Different letter notations showed significant differences between formulations (p<0.05) in the same column. T1 = 100% black soybean flour: 0% bangle, T2 = 95% black soybean flour: 5% bangle, T3 = 90% black soybean flour : 10% bangle, T4 = 85% black soybean flour : 15% bangle, T5 = 80% black soybean flour : 20% bangle

Table 3. Results of the analysis of the chemical properties of black soybean flour flakes with the addition of bangle

Formulation	Chemical Properties				
	Water content (%)	Ash content (%)	Fat content (%)	Protein Content (%)	Carbohydrat content (%)
T1	6.06 ± 0.27^{d}	3.92 ± 0.01^{b}	21.14 ± 0.37^{b}	20.31 ± 0.05^{e}	48.54 ± 0.67^{a}
T2	5.08 ± 0.21^{c}	3.76 ± 0.01^{a}	19.35 ± 0.19^{ab}	19.54 ± 0.06^{d}	52.24 ± 0.44^{b}
T3	4.96 ± 0.27^{bc}	3.73 ± 0.17^{a}	19.21 ± 2.11^{ab}	18.75 ± 0.11^{c}	53.32 ± 2.09^{bc}
T4	4.47 ± 0.14^{ab}	3.71 ± 0.02^{a}	19.09 ± 1.44^{ab}	17.83 ± 0.05^{b}	54.88 ± 1.22^{dc}
T5	4.23 ± 0.48^{a}	3.68 ± 0.06^{a}	18.16 ± 0.73^{a}	16.92 ± 0.08^{a}	56.98 ± 0.75^{d}
SNI 01-4270-1996	Max 3	Max 4	Min 7	Min 5	

Different letter notations showed significant differences between formulations (p<0.05) in the same column. T1 = 100% black soybean flour: 0% bangle, T2 = 95% black soybean flour: 5% bangle, T3 = 90% black soybean flour: 10% bangle, T4 = 85% black soybean flour: 15% bangle, T5 = 80% black soybean flour: 20% bangle

Ash Content

The treatment of black soybean flour with the addition of bangle had a significant effect on the ash content value. The content of the flakes decreased significantly with the increase of the bangle flour percentage, especially in T1 compared to T2, T3, T4, and T5. There are several factors that can cause high ash content in a food ingredient, such as the type of food ingredient, the method of ashing used, and the temperature and time used for drying. Based on research conducted by Putri and Triandita (2018), black soybean flour has an ash content of 4.33%. Therefore, it is suspected that the high ash content of the flakes sample is caused by several of these factors, since the main component with the highest percentage in the manufacture of flakes is black soybean flour, which can produce a high ash content value. The high mineral content of a food ingredient can also be caused by several factors, such as the concentration of minerals in the soil from which the food is derived (Almatsier, 2010).

Fat Content

The treatment of black soybean flour with the addition of bangle had a significant effect on the fat content value. The water content of the flakes decreased significantly with the increase of the bangle flour percentage. Based on research conducted by Widaningrum et al. (2005), it was found that the fat content contained in black soybean flour was 27.1% (high-fat content). The high-fat content in flakes was also caused by several ingredients added during the manufacturing process. The materials used in the manufacture of flakes that contain high fat are margarine and skim milk. According to Indonesian National Standards (SNI) 3541-2002, margarine has a high fat content of 80%; therefore, the higher the percentage of added margarine, the higher the fat content contained in the food product.

Protein Content

The treatment of black soybean flour with the addition of bangle had a significant effect on the protein content value. The protein content of the flakes decreased significantly with the increase of the bangle flour percentage. Based on the results obtained, there was a decrease in the protein content of these flakes when compared to the protein content contained in black soybean flour. According to Harris and Karmas (1989), the processing of food ingredients using heat has an impact on the nutritional value and causes the nutritional value to decrease when compared to the material before processing. The heating process above 60°C can cause changes in unstable nutrients, including fats, carbohydrates, nucleic acids, and proteins (Hawab, 2004).

Carbohydrate Level

Based on the results of the analysis performed (Table 3), it was found that the treatment of black soybean flour with the addition of bangle had a significant effect on the carbohydrate content value. The water content of the flakes increased significantly with the increase of the bangle flour percentage. The results of the data analysis revealed that the highest results were obtained for water content, ash content, fat content, and protein content in flakes treated with T1, T2, T3, T4, and T5, indicating that the carbohydrate content was inversely proportional. This is consistent with the statement by Kusumawati et al. (2012), which states that as the components of water content, ash content, fat content, and total protein content increase, the carbohydrate content decreases by difference, and vice versa, as the components of water content, ash content, fat content, and total protein content decrease, the carbohydrate content increases by difference in the product.

Table 4. Results of the antioxidant activity of black soybean flour flakes with the addition of bangle

Formulation	Crude FiberContent (%)	AntioxidantActivity (%)
T1	20.60 ± 0.51^{a}	31.38 ± 0.12^{a}
T2	21.39 ± 1.22^{ab}	36.25 ± 0.24^{b}
T3	22.39 ± 0.47^{b}	44.64 ± 0.12^{d}
T4	25.04 ± 0.97^{c}	40.83 ± 0.18^{c}
T5	26.07 ± 0.40^{c}	49.59 ± 0.18^{e}

Different letter notations showed significant differences between formulations ($p<0.05$) in the same column. T1 = 100% black soybean flour: 0% bangle, T2 = 95% black soybean flour: 5% bangle, T3 = 90% black soybean flour: 10% bangle, T4 = 85% black soybean flour: 15% bangle, T5 = 80% black soybean flour: 20% bangle

Crude Fiber Content

The treatment of black soybean flour with the addition of bangle had a significant effect on the crude fiber content value (Table 4). The crude fiber content of the flakes increased significantly with the increase of the bangle flour percentage. Bangle rhizome has a crude fiber content of 8.52% (Suparto et al., 2000). According to research conducted by Putri and Triandita (2018), black soybean flour has a crude fiber content of 8.45%, while research by Widaningrum et al. (2005) found that black soybean flour has a crude fiber content of 3.2%. The differences in crude fiber content values can be attributed to differences in varieties and growing locations of black soybeans. The high amount of crude fiber contained in these flakes is the result of a combination of the ingredients mixed in, mainly from bangle and black soybean flour.

Antioxidant Activity

The DPPH test results shows that the antioxidant activity of the flakes increased significantly antioxidant activity of the flakes increased significantly with the increase of the bangle flour percentage (Table 4). Based on the analysis, it showed that the higher the percentage of bangle addition, the higher the antioxidant activity value. This is due to bangle having a high content of flavonoids and phenolics. Flavonoids and phenolics are secondary metabolites found in plants and play a role as antioxidants. If the content of phenolic compounds is higher in a material, the antioxidant activity of that material will be greater (Konaté et al., 2010). Phenolic components or flavonoids are the main compounds that play a role in antioxidants (Al-Farsi et al., 2007). The antioxidant activity value of these flakes can also be influenced by other ingredients added during the dough-making process, such as the main ingredient component with the highest percentage, namely black soybean flour.

Microbiological Properties of Black Soybean Flour Flakes With The Addition of Bangle

Based on the total plate count analysis data from Table 5, the flakes samples had a total plate count of less than 2,500 colonies/g in all treatments.

According to SNI, the microbiological limit requirement for cereal quality is a maximum of 5 x 10^5 colonies/g. The total plate count of black soy flour flakes with the addition of bangle in the T1, T2, T3, T4, and T5 treatments was less than 2,500 colonies/g, so it can be concluded that the flakes met the SNI requirements for cereal quality. The results of the analysis of treatments T1, T2, T3, T4, and T5 showed that treatment T5 had the lowest total plate count, indicating that the addition of bangle to the flakes sample had a significant role in inhibiting microbial growth. This is because the bangle rhizome contains secondary metabolites.

Table 5. Microbiological properties of black soybean flour flakes with the addition of bangle

Formulation	Total Plate Count (colonies/g)
T1	< 2.500
T2	< 2.500
T3	< 2.500
T4	< 2.500
T5	< 2.500
SNI 01-2973-1992	Max 5x10^5

T1 = 100% black soybean flour: 0% bangle, T2 = 95% black soybean flour: 5% bangle, T3 = 90% black soybean flour: 10% bangle, T4 = 85% black soybean flour: 15% bangle, T5 = 80% black soybean flour: 20% bangle

Table 6. Organoleptic test results of black soybean flour with the addition of bangle

Formulation	Organoleptic Parameters				
	Colour	Taste	Aroma	Texture	Overall
T1	2.60 ± 1.10^a	3.63 ± 0.92^b	3.30 ± 0.83^a	3.66 ± 0.80^a	3.73 ± 1.01^c
T2	2.93 ± 0.82^a	3.36 ± 0.88^b	3.33 ± 0.80^a	3.46 ± 1.00^a	3.43 ± 0.93^{bc}
T3	3.50 ± 0.82^b	2.80 ± 0.80^a	3.36 ± 0.80^a	3.43 ± 0.97^a	3.13 ± 0.81^{ab}
T4	3.60 ± 0.85^b	2.53 ± 0.86^a	3.43 ± 0.89^a	3.36 ± 0.99^a	2.83 ± 0.87^a
T5	4.06 ± 0.78^c	2.40 ± 1.10^a	3.50 ± 0.86^a	3.16 ± 0.74^a	2.66 ± 0.95^a

Note: Different letters in the same line indicated a significant difference with a level of 5%, T1=100% black soybean flour:0% bangle, T2 =95% black soybean flour:5% bangle, T3=90% black soybean flour:10% bangle, T4=85% black soybean flour:15% bangle, T5=80% black soybean flour:20% bangle

The bangle rhizome contains several secondary metabolite compounds, including alkaloids, flavonoids, essential oils, saponins, tannins, and triterpenoids, which have antibacterial activity (Nahak et al., 2014). The content of secondary metabolites in bangle is capable of inhibiting the growth of pathogenic bacteria detrimental to human life, such as *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, *Neurospora* sp, *Rhizopus* sp, and *Penicillium* sp (Nursal et al., 2006). Therefore, it can be concluded that the low total plate count value of black soybean flour flakes with the addition of bangle was due to the addition of bangle, which was proven to inhibit microbial growth.

Organoleptic Properties

Analyzing organoleptic properties is crucial to determine the acceptance and preferences of the formulated product. The organoleptic test results are presented in Table 6.

a. Color

The results of the analysis reveal that treatments T1, T3, and T5 are significantly different, while treatments T1 and T2, and treatments T3 and T4 are not significantly different. Therefore, it can be concluded that the treatment of black soybean flour with the addition of bangle has a significant effect on the organoleptic test values of the color parameters. The organoleptic test values for the color parameter with formulation variations in each sample between black soybean flour and bangle range from 2.60 to 4.06.

The organoleptic test for color parameters showed that the average panelist preferred the T5 treatment flakes sample. This is because the color of the T5 treatment flakes sample had a brighter or more yellow color, which led the panelists to be more interested in this sample compared to other treatments. The higher the percentage of bangle used, the higher the panelist's preference value for the flakes sample. Therefore, it can be concluded that the percentage of bangle usage has a significant effect.

b. Taste

Flakes made from black soybean flour with the addition of bangle tend to have a predominant taste of bangle. The taste that arises from black soybean flour is masked by the strong taste of bangle, so the higher the percentage of bangle used, the more distinct the bangle flavor that appears. The use of spices in a product can have an effect on the aroma, taste, color, and sometimes can cover up unwanted odors, such as the unpleasant odor found in soybean flour. Volatile compounds can provide aroma and oleoresin, thereby affecting the taste of food or drink (Fitri, 2018).

c. Aroma

All treatments have no significant effect to aroma. The organoleptic test values for the aroma parameter with formulation variations in each sample between black soybean flour and bangle range from 3.30 to 3.50. The roasting process used to make flakes can cause the starch in the material to undergo extensive changes, eliminating water molecules and fragmenting sugar molecules. This leads to the breaking of carbon bonds, producing carbonyl and volatile compounds, which give rise to a distinctive aroma in the product (Arifin, 2011). According to Hastuti (2012), the components in the dough can cause a distinctive odor, such as when mixing margarine and eggs, which can provide an aroma that consumers like. The use of margarine as a fat in the manufacture of flakes is an important component, as it adds aroma that can cover up the unpleasant odor contained in soy flour.

The dominant aroma that appears comes from the aroma of bangle, which is due to the volatile compound content in bangle, giving it a real aroma and oleoresin (Fitri, 2018). This is supported by Tahir's statement (2013), which notes that the bangle rhizome contains chemical compounds in the form of essential oils and oleoresin.

d. Texture

The results of the analysis showed that all treatments had no significant effect. Therefore, it can be concluded that the treatment of black soybean flour with the addition of bangle has a significant effect on the organoleptic test values of texture parameters. The organoleptic test values for texture parameters with various treatments for each flake of black soybean flour with the addition of bangle range from 3.16 to 3.66. Based on research conducted by Martinez and Pilosof (2014), the protein content in a food product can affect the texture by acting as an emulsifier, allowing it to form a gel in food. The higher the protein content, the harder and rougher the texture of a food ingredient, while the lower the protein content, the more brittle the texture of a food ingredient. According to Widiawati and Anjani (2017), the texture can be affected by the fat content. This is because the fat lubricates the internal structure of the dough, achieving a better level of development during the baking process.

e. Overall

The overall parameter test was conducted using a milk mixture by pouring milk on the flakes when serving. This was done because, in general, flakes are consumed with milk as a breakfast food. Based on the analysis, it was found that the results of treatments T1, T2, and T3 had a significant effect, while treatment samples T4 and T5 did not have a significant effect. Therefore, it was concluded that the treatment of black soybean flour with the addition of bangle had a significant effect on the organoleptic test values of the overall parameters. The overall parameter organoleptic test values with formulation variations in each treatment between black soybean flour and bangle ranged from 2.66 to 3.73. Flakes from treatments T1, T2, and T3 were still acceptable to panelists, with an average rating of "like", whereas treatment samples T4 and T5 were accepted by panelists with an average rating of "rather like". The treatment most acceptable to panelists was the one with a ratio of 90% black soybean flour to 10% bangle, which received the maximum acceptance.

CONCLUSION

Flakes based on black soybean flour with the addition of bangle in formulation T5 (80% black soybean flour: 20% bangle) have good-physical and chemical properties, making it safe for consumption and have the potential to be a functional food high in fiber and antioxidants.

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CONFLICT OF INTEREST

The author hereby declares that there is no conflict of interest with other parties. This research is purely the result of the author's trial and error analysis.

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