Formulation of Flakes made from mocaf-black rice-tapioca high in protein and dietary fiber by soy and jack bean flour addition

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Abstract. The aim of this study is to determine the chemical and sensory properties of flakes made by mocaf-black rice-tapioca supplemented with soy and jack bean flour as a breakfast alternative high in protein and dietary fiber, we conducted a factorial randomized design experiment. Treatments factors consist of type of supplementation flour (D): D1 = soybean flour, D2 = jack bean flour and percentage of supplementation flour (K): K1= 10%, K2 = 20% and K3 = 30%. Analyzed variables were 1) Chemical properties (water content, ash content, total fat, total protein, carbohydrate by difference, and dietary fiber) and 2) sensory properties. The hedonic test was conducted to determine the level of consumer acceptance of 50 semi-trained panelists. Chemical data were analyzed by F-test, and Duncan's Multiple Range Test (DMRT) and Sensory data were analyzed by Friedman test. The best treatment combination in this study was D2K1 (jack bean flour: 10%). Flakes D2K1 has 9.43 % (wet basis/wb) water content, 1.58  % db ash content, 5.76 % db protein content, 4.95% db fat content, 78.29 % db carbohydrate by difference content and 17.08 % db fiber content. The hedonic test values were texture 3.7 (like a little), colour 3.6 (like a little), aroma 3.8 (like a little), and flavour 3.6 (like a little).

Keywords: mocaf, black rice, jack bean flour, soybean flour, flakes

1. Introduction

Flakes is one of the breakfast menus that is accepted and liked by the general public because of its practical nature with good taste. Flakes are one of the cereal products in the form of flakes or slabs. Based on SNI 01-427-1996 flakes belong to the group of cereal milk foods, which is instant powder made from milk powder and cereal with the addition of other food ingredients and or without permitted food additives. Flakes usually made from cereals such as rice, wheat or corn and tubers such as potatoes, cassava, sweet potatoes, and others. Generally, in the flakes market made from flour, the use of ingredients other than flour is done to optimize the use of local food ingredients.

Mocaf is the main ingredient of this study. According to Subagio (2008), Mocaf (Modified Cassava Flour) is flour from cassava which is processed through the principle of modification of cassava cells by fermentation so that it can provide characteristic changes of flour produced. Mocaf has wheat-like characteristics which are physically whiter, softer, has a neutral taste, so it is good to substitute flour (up to 80%) in the manufacture of bakery products such as cookies, biscuits, noodles, and flakes.
Agustia et al. have researched mocaf-based products namely biscuits (2017) and noodle (2018). According to Ridwansyah and Yusraini (2013), mocaf has a low glycemic index value, 3.23% fiber content and 89.9% carbohydrate (starch) which will support the crispy texture of flakes. Much research has been carried out on making flakes from local foodstuffs, including from taro, green beans, and bananas by Sukasih and Setyadjit (2012). While Riana et al. (2015), examined the high protein breakfast made from a mixture of full-fat rice and soybeans. Flakes was rich in fiber based on type III arrowroot resistant starch.

In addition to mocaf, to increase the level of flakes fiber, other ingredients containing high food fiber are used, namely black rice. According to Ok et al. (2001), black rice has a dietary fiber and hemicellulose content of 7.5% and 5.8%, respectively, while white rice is only 5.4% and 2.2%, respectively. Besides that, the content of black rice protein is 8.5% from sosoh white rice which is 6.8%. According to Navam et al. (2014), barley breakfast cereals and peanut-enriched rice flour can be added to the children's breakfast menu to reduce the incidence of protein malnutrition. The quality of flakes in this study was enhanced by the addition of starchy material, namely tapioca starch, to produce flakes that were softer, crispy and easily digested. According to Syamsir et al. (2011) tapioca starch has a reasonably high growth power, which is ± 15% and starch digestibility values ranging from 81.99% - 92.32%. In making these flakes, tapioca percentages were 5% constant in all treatments.

One of the breakfast requirements (flakes) according to SNI 01-427-1996 is that it contains a minimum of 5% protein, so the flakes mocaf : black rice : tapioca needs to add with a protein source, one of them is nuts, soybean, and jack bean. Based on the List of Food Ingredients (DKBM) in 2005, soybeans contained 40.40 grams of protein per 100 grams of soybeans. The quality of soy protein is equivalent to animal protein because the amino acid content is not significantly different from animal proteins derived from animal protein (Winarsi, 2010). Soybean fiber content is also quite high, namely 4.9 grams per 100 grams of soybeans compared to the recommended fiber requirement of 25 grams a day (Naingolan and Adimunca, 2005). Meanwhile, according to Sudiyono (2010), jack bean has a high nutritional value that is carbohydrate 60.1%; 30.36% protein and 8.3% fiber. Jackbean protein content approaches soybeans and has an outstanding balance of amino acids and high bioavailability so that it can be a source of protein and an alternative substitute for soybeans whose availability is still obtained by import.

One important physical characteristic of flakes is crispness. Amylose and amyllopectin content in different starches will affect the value of product crispness. According to Haryadi (1994) the matrix of starch, protein, and fiber formed by mixing two types or more of flour which has different characteristics, will form a compact structure and may cause the texture of the final product to become hard. Hard and too compact textured flakes can be conditioned into porous by adding NaHCO3 (Sodium Bicarbonate) which can produce gas (CO2) during the heating process so that it can increase the developing power and crispness of the product. The percentage of NaHCO3 addition in this study is 0.5% referring to Purnamasari and Putri’s research (2015).

This study was conducted to determine the chemical dan sensory properties of flakes made by mocaf : black rice: tapioca with bean flour addition in order to produce flakes with high protein and dietary fiber and favorable sensory properties. The use of mocaf, black rice and bean flour addition (soy and jack bean) in flakes production is one of the breakthrougs to provide food rich in protein and dietary fiber based on local potency.

2. Materials and methods

2.1. Materials

Mocaf (modified cassava flour) as the main ingredient used in our study, was obtained from Badamita Rakit Banjarnegara, jack bean from Bogor, black rice, tapioca, sugar flour, salt, and sodium bicarbonate was acquired from Intisari Store in Purwokerto. The various chemicals for chemical analysis according to the procedure we used The tools we used were tools for flour production and
flakes production including analytical scale, oven, blender, sieve filter 60 mesh and 80 mesh, granular mold, etc. and tools for chemical analysis.

2.2. Methods
This study conducted in the Laboratory of Agricultural Technology in the Department of Agricultural Technology, located in General Soedirman University. The present study was conducted from April to October 2018.

Our study used a randomized factorial design. The treatment factors consisted of type of supplementation flour (D): D1 = soybean flour, D2 = jack bean flour and percentage of supplementation flour (K): K1 = 10%, K2 = 20% and K3 = 30%. From the two factors, there were 6 (2x3) treatments, such as D1K1, D1K2, D1K3, D2K1, D2K2, and D2K3. Each treatment was repeated four times; thus, there were 24 treatment combinations. The present study was employed in several stages, i.e., black rice flour production, jack bean flour production, soybean flour production, and flakes production.

2.2.1. Black rice flour production. Black rice sorted then washed and then dried using cabinet dryer at 55-60°C for ± 24 hours or until they were dried and broken. The dried black rice was then finely ground and sifted using 60 mesh filter, packed and sealed until ready to use. Black rice flour production.

2.2.2. Black rice flour production. Black rice sorted then washed and then dried using cabinet dryer at 55-60°C for ± 24 hours or until they were dried and broken. The dried black rice was then finely ground and sifted using 60 mesh filter, packed and sealed until ready to use. Black rice flour production.

2.2.3. Jack Bean Flour Production. Jack beans inserted in a filter cloth and tied with plastic or rubber straps, then boiled in NaOH 3% solvent for 7-8 minutes and washed in water flow while being washed until pH neutral. After that, blanched for 30 minutes, sliced and dried using cabinet dryer at 55-60°C for ± 24 hours or until they were dried and broken, then finely ground and sifted using 80 mesh filter, packed and sealed until ready to use (Agustia et al., 2016).

2.2.4. Soybean Flour Production. Soybean washed and soaked for 12 hours and then washed again until clean. Then boiled for 15 minutes and cooled and peeled the husk. The next process is steamed for 15 minutes and drained. Dried in a dryer cabinet temperature of 55°C until dry fractures (24 hours). Crushed and sieved to 60 mesh size sieve to produce soybean flour.

2.2.5. Flakes Production. Mocaf-black rice- tapioca and supplementary flours (soy and jack bean flour) with the proportion according to the treatment were mixed thoroughly with other ingredients, i.e. 5% butter, 30% granulated sugar, 1.2% salt, 0.5% baking soda, 5% ovalet, 0.5% vanilla and ± 100% of water. Then steam for 15 minutes (pre gelatinization). The dough was pressed using noodle mold with scale 3 thickness ± 1mm. Then cut off with the size 1.5 cm x 1.5 cm and arranged in baking pan baked with 130°C for ± 20 minutes. Flakes packed and sealed until ready to use.

2.2.6. Chemical Analysis. Flakes were analyzed for its nutrient quality, including water content (oven method), ash content (gravimetric method), protein content (micro-Kjeldahl method), fat content (Soxhlet method), and carbohydrate by difference (Soedarmadji et al., 1984) and dietary fiber (enzymatic method).

2.2.7. Sensory Analysis. Sensory test (Mozkowitz et al., 2012) was performed to determine consumers acceptance levels of texture, colour, aroma, and flavour regarding flakes. This hedonic test was performed on flakes without adding milk or anything. They performed by 50 semi-trained
panelists (previously trained, so that they knew specific parameters to be tested). The test used a scoring method. This test usually provides quantitative values with the scores (numbers) that have been agreed previously; i.e., in the range of 1 (the lowest score) to 5 (the highest score).

2.2.8. **Statistic Analysis.** The chemical data were analyzed by using analysis of variance (ANOVA) or Fisher’s exact test (F test) at 95% confidence level. If there were significant effects, the analysis was continued with Duncan’s multiple range test (DMRT) at a significance level of 5%; sensory data were analyzed by using the Friedman test. The best treatment combination determined by effectiveness index.

3. **Result and Discussion**

3.1. **Chemical Properties**
The chemical properties of the flakes are shown in Table 1.

| Data                           | Water (%wb) | Ash \(^a\) (%db) | Protein (%db) | Fat (%db) | Dietary Fiber \(^a\) (%db) | Carbohydrate (%db) |
|-------------------------------|-------------|------------------|---------------|-----------|----------------------------|-------------------|
| Effect of type of suplementation flour (D)\(^b\) |             |                  |               |           |                            |                   |
| D1                            | 10.682      | ± 0.63           | 2.567 ± 0.33  | 8.117 ± 1.65 | 4.168 ± 0.66               | 12.285 ± 1.29     |
| D2                            | 10.290      | ±1.32            | 1.570 ± 0.86  | 7.670 ± 2.03 | 4.203 ± 0.86               | 16.435 ± 1.91     |

| Effect of persentase of supplementary flour (K)\(^b\) |          |                  |               |           |                            |                   |
| K1                            | 10.130     | ±0.99            | 2.030 ± 0.21  | 6.125 ± 0.65 | 4.673 ± 0.58               | 13.985 ± 3.71     |
| K2                            | 10.618     | ±1.49            | 2.133 ± 0.56  | 8.378 ± 0.34 | 4.423 ± 0.67               | 14.310 ± 2.59     |
| K3                            | 10.710     | ±0.50            | 2.043 ± 0.66  | 9.177 ± 0.70 | 3.463 ± 0.31               | 14.785 ± 2.27     |

| Effect of interaction (DxK)\(^b\) |          |                  |               |           |                            |                   |
| D1K1                           | 10.830     | ±0.99            | 2.480 ± 0.21  | 6.495 ± 0.70 | 4.400 ± 0.46               | 10.895 ± 0.48     |
| D1K2                           | 10.830     | ±0.72            | 2.650 ± 0.40  | 7.745 ± 4.60 | 4.605 ± 0.27               | 12.350 ± 0.86     |
| D1K3                           | 10.385     | ±0.47            | 2.570 ± 0.46  | 10.110 ± 3.50 | 3.500 ± 0.46               | 13.610 ± 0.86     |
| D2K1                           | 10.430     | ±0.21            | 1.580 ± 0.12  | 5.755 ± 0.70 | 4.945 ± 0.37               | 17.075 ± 0.47     |
| D2K2                           | 10.405     | ±0.56            | 0.56 ± 1.90   | 2.34 ± 0.37  | 0.41 ± 0.04                | 16.270 ± 1.69     |
| D2K3                           | 10.05 ± 1.15 | ±1.61 ± 2.64   | 9.010 ± 4.240 | 3.79 ± 1.81 | 1.515 ± 1.81               | 15.960 ± 3.45     |

\(^a\)Values in the same column with the same superscript letters were not significantly different (p>0.05; DMRT at 5% level)

\(^b\)D1 : Soy bean flour, D2 : Jack bean flour, K1 : 10%, K2 : 20%, K3 : 30%
3.1.1. Water and Ash Content. Data on water and ash content of the flakes are shown in Table 1. Data shows that the type of flour supplementation treatment has a significant effect only on ash content. Neither the treatment of the flour supplementation percentage nor the interaction between two treatments did not significantly affect the water and ash content of the flakes. The water content ranges 9.43% to 11.04%. This is not compatible with the quality requirements of SNI 01-427-1996, that the flakes water content is maximally 3%. Products that require crisp textures such as flakes are expected to have a moisture content <10%. Ash content of the flakes ranges from 1.52% to 2.65%. The levels of ash flakes are in accordance with SNI quality requirements, namely a maximum of 3%. According to Nurali et al. (2010), flakes made from sweet potatoes with the addition of 30% soybean have 4% ash content.

3.1.2. Protein and Fat Content. Data on protein and fat levels of flakes mohiro can be seen in Table 1. Data shows that the type of flour supplementation, the percentage of flour supplementation, and the interaction both, did not significantly affect the protein and fat level of the flakes. The protein content of flakes ranges from 5.76% to 10.11%. There is a tendency for the flakes protein content to increase with the increasing percentage of peanut flour addition. According to Astawan and Hazmi (2016), soy flour contains proteins of 46.10%, while according to Windrati et al. (2010), jack bean contains 37.61% protein. Agustia et al. (2016) reported that instant tiwul from cassava flour substituted with germination of soybean flour and jack bean flour had protein levels of 12.04% and 6.24% respectively.

The fat levels of the flakes were quite low ranging from 3.43% to 4.95% (Table 1). This is due to the low-fat content of the flakes constituents, including mocaf fat levels of 2.72% (Mulyani et al., 2015), jack bean’s fat content ranged from 0.2% to 3% (Van der Maesen and Somaatmaja, 1993), and black rice’s fat content is 1.9% (Mangiri et al., 2016).

3.1.3. Dietary Fiber Content. The fiber content in food is called by food fiber or dietary fiber which is very good for human health. According to Kendall et al. (2010), food fiber and crude fiber is a different thing. The crude fiber is a carbohydrate polymer with ten or more monomer units, which are not hydrolyzed by endogenous enzymes in the human small intestine. Based on the results of the statistical analysis (Table 1), the type of flour supplementation treatment had a significant effect, the treatment of the percentage of supplementation flour did not significantly affect the dietary fiber content, while the interaction of both was not significant. Baker and Holden (2006) state that more than 75.3% of ready-to-eat breakfast cereal brands have a dietary fiber content of less than 5%. Flakes food fiber content in this study is quite high, ranging from 10.89% to 17.08% when compared with the results of the study by Budijanto et al. (2012) who examined cereals made from grits of corn and bran that only had a dietary fiber content of 8.19%.

Flakes in this study contain high dietary fiber, so it is suitable for alternative high-fiber breakfast. According to Fuentes-Zaragoza et al. (2010), food fiber is known to have physiological functions that can provide a protective effect on the incidence of several diseases, such as obesity, diabetes mellitus, colon cancer, and cardiovascular disease.

3.1.4. Carbohydrate by difference. The statistical test results (Table 1) showed that the treatment of the type of flour supplementation, the percentage of flour supplementation and their interaction did not significantly affect carbohydrate levels. The average value of flakes carbohydrates from the lowest and highest were 83.82% and 87.71% respectively. Carbohydrate levels tend to decrease with increasing percentage of supplementation flour. According to Sugito and Hayati (2006), carbohydrates in a product that are analyzed by difference are influenced by other nutritional components, so the higher the components of other nutrients, the lower the carbohydrate content and vice versa. Based on the quality requirements of cereal milk SNI No. 01-4270-1996 the value of carbohydrate by difference has fulfilled the specified requirements, namely a minimum value of 60%.
3.2. Sensory Properties

3.2.1. Texture / Crispness. Flakes crispness is the most important sensory properties, which are easily broken, such as chips or chips. The desired score is between 3 (neither like nor dislike) and 4 (like a little) or around 3 (neither like nor dislike). Statistical analysis (Table 2) showed that the combination of flour supplementation and the percentage of supplementation flour had no significant effect on texture flakes. Flakes have a texture score ranging from 3.4 - 3.8 (like a little). According to Hermanianto et al. (2000), differences in texture flakes are caused by differences in protein, fat and crude fiber and also the amount of starch in raw materials, especially amylose and amyllopectin in starch. The crisp nature of flakes given by the results of starch gelatinization and the addition of sodium bicarbonate is intentionally added to the flake mixture. According to Purnamasari and Putri (2015) research, the addition of 0.5% sodium bicarbonate can increase the crispness of taro flakes with a value of 3.10 (crispy).

There is a tendency that flakes with an increasing percentage of supplementary flour have a lower texture. According to Deny (2008), the higher the protein contained in food products can cause inhibition of expansion because protein binds starch so that the product becomes hard, while the presence of high amounts of amylose will produce hard and solid products.

| Data       | Texture | Colour a | Aroma a | Flavour a |
|------------|---------|----------|---------|-----------|
| Chi Sq hit | 9.6371  | 60.2143  | 23.72   | 26.8686   |
| Chi Sq 0.05| 11.070  | 11.070   | 11.070  | 11.070    |
| Comparison | 54.8153 | 54.8153  | 54.8153 | 54.8153   |

**Table 2.** Sensory properties of flakes

| Treatment | Total rankings |
|-----------|----------------|
| D1K1      | 181 ± 1.61     |
| D1K2      | 163 ± 1.34     |
| D1K3      | 203 ± 1.44     |
| D2K1      | 182.5 ± 1.42   |
| D2K2      | 171 ± 1.48     |
| D2K3      | 149.5 ± 1.31   |

**Mean value of each treatment**

| Treatment | Texture | Colour | Aroma | Flavour |
|-----------|---------|--------|-------|---------|
| D1K1      | 3.6 ± 1 | 3.7 ± 1 a | 3.3 ± 0.9 abc | 3.4 ± 1 abc |
| D1K2      | 3.4 ± 0.8 | 3.8 ± 0.9 a | 3.2 ± 0.8 bc | 3.0 ± 0.9 bc |
| D1K3      | 3.8 ± 0.9 | 3.8 ± 0.8 a | 3.3 ± 0.9 abc | 3.3 ± 1 abc |
| D2K1      | 3.7 ± 0.8 | 3.6 ± 0.9 a | 3.8 ± 1 a | 3.6 ± 0.8 ab |
| D2K2      | 3.5 ± 0.8 | 4.0 ± 1 a | 3.5 ± 0.7 ab | 3.8 ± 0.8 a |
| D2K3      | 3.3 ± 0.8 | 2.4 ± 0.8 b | 2.9 ± 0.9 c | 2.9 ± 0.8 c |

Values in the same column with the same superscript letters were not significantly different (p>0.05) in Friedman comparative test

3.2.2. Colour. Colour is one of the essential quality attributes in food products to determine the quality or degree of acceptance of a food (Winarno, 2004). The results of statistical analysis (Table 2) on colour flakes showed that the combination of the type of flour supplementation treatment and the percentage of supplementation flour had a significant effect on the colour of flakes. Flakes have colour scores ranging from 2.4 to 4.0 (neither like nor dislike – like a little). The colour of the flakes will be darker (brown) by the increasing percentage of supplementation flour which can reduce the preference of panelists for flakes. This brown discolouration caused by a non-enzymatic Maillard reaction. This reaction occurs due to heating in high temperatures caused by a mixture of sugar along with protein or amino acids derived from black rice, jack bean, and soybean (Winarno, 2004).
3.2.3. Aroma. The aroma of added ingredients (soybean and jack bean flour meal) is a factor that influences the unpleasant aroma (typical of product spoilage) in the result flakes products. Statistical test results (Table 2) show the treatment of the combination of types of flour supplementation and the percentage of starch supplementation had a significant effect on the aroma of flakes produced. The lowest and highest flakes aroma average values are 2.9 (neither like nor dislike) and 3.8 (like a little). The percentage of supplementation flour that is higher will cause more unpleasant odor, which will reduce the panelists’ preference for aroma. According to Prasetyo et al. (2014), biscuits with the addition of green bean flour have lower aroma values with the increasing number of green bean flour added.

3.2.4. Flavour. Flavour formed from a combination of experiences and sensations that we receive from the characteristics of a product (Burdock, 2002). In these flakes products, flakes strongly influenced by the treatment of the percentage of supplementation. The results of the analysis (Table 2) showed that the combination treatment of flour supplementation and the percentage of supplementation flour had a significant effect on flakes flavour. The results showed a trend of decreasing the value of flakes flavour with the increasing percentage of flour supplementation. Flakes flavour value ranged from 2.9 to 3.8 (neither like nor dislike - like a little).

Flavour "like a little" in Mohiro flakes with the percentage of flour supplementation addition which is increasing seems to be caused by the presence of a peculiar aroma of peanut products due to lipoxygenase enzyme activity. Agustia et al. (2017) reported that the instant tiwul from cassava flour substituted with jack bean flour up to 35% would decrease the panelist's favorite value for instant tiwul flavour.

4. Conclusion

The best treatment combination obtained from D2K1 flakes with jack bean flour addition with the percentage of 10%. Flakes D2K1 has 9.43 % (wet basis/wb) water content, 1.58 % db ash content, 5.76 % db protein content, 4.95% db fat content, 78.29 % db carbohydrate by difference content and 17.08 % fiber content. The hedonic test values were texture 3.7 (like a little), color 3.6 (like a little), aroma 3.8 (like a little), and flavor 3.6 (like a little).

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