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An Innovation of High-Energy and Protein Biscuits Made of Black Rice Flour Substituted With Mung Bean Flour

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ABSTRACT

This study was aimed to determine the public acceptance and the nutritional contents of the black rice flour biscuits substituted with mung bean flour. A completely randomized design with various amount of substituted mung bean flour (MBF) in the black rice flour (BRF) biscuits was used as the experimental design. The ratios of the BRF-to-MBF were 60: 20; 50: 30, and 40:40. The acceptance test used was the hedonic test with the lowest and the highest scores of 1 and 9, indicating "extremely unfavorable" and "extremely favorable" criteria, respectively. The content of carbohydrates (using Luff School method), ash (using the dry method), protein (using Kjeldahl method), water (using oven drying methods), crude fiber (using the gravimeter method), lipids (using the Soxhlet extraction method), and anthocyanins (using the pH-differential method) was determined and evaluated. The analysis of differences in the acceptability of the biscuits was performed using an ANOVA test, followed by the Tukey HSD test. The results showed that there were differences in people's acceptance of black rice flour biscuits substituted with mung bean flour for the overall indicators, i.e., the color and taste of the black rice biscuits. The most preferred biscuits were biscuits with a composition of 40% black rice flour and 40% substituted mung bean flour with a mean value of 7.2. The nutritional content of the black rice biscuits was as follows: the content of energy of 447- 465 kcal, carbohydrates of 58.4-60.9%, protein of 7.14-9.15%, lipids of 20.3-22.2%, ash of 2.3%, moisture of 5.25-8.65%, fiber of 1.3-2.3% and anthocyanin of 20-37ppm. The production of BRF40: MBF40 (40% black rice flour and 40% mung bean flour) biscuits was highly recommended, in addition to the optimum baking time as the future work.

Keywords: Black rice flour; mung bean flour; biscuits; energy; protein.

1. INTRODUCTION

Biscuits are dry food products prepared by baking dough made from wheat flour with or without substitution, fat, other food additives and other permitted food additives (National Standardization Agency, 2011). The average consumption of cookies or biscuits in Indonesia increased in 2014-2018 by 33.3% (Agricultural Data Center and Information System, 2018). The high consumption of biscuits caused an increase in wheat imports from 2014 to 2018 to 10.1 million tons (Statistical Center Bureau, 2018). Wheat is the main ingredient of wheat flour. The latter is the basic ingredient of biscuits. To reduce the wheat flour consumption and reduce the wheat imports, it is necessary to diversify local food into flour. Black rice is a diversified local food that has high energy and anthocyanin content (Wanti *et al.*, 2015). Another local food, namely mung beans, has a high protein and fiber content (Astawan, 2009). Cookies using a mixture of rice flour and peanut flour will improve protein quality (Bassinello *et al.,* 2011).

Black rice (*Oryza sativa* L. Indica) is a functional food due to its high anthocyanin content (Kristamtini *et al.*, 2017), colored rice with a high potential as an antioxidant (Hosoda *et al.*, 2018). The antioxidant activity of black rice was reported of 46.20 % (Wanti *et al.*, 2015) and 30.99% in the black rice flour (Muktisari & Hartati, 2018). Black rice contained 351 kcal of energy, 20.1 g of fiber, and 1.3 g of fat (Ministry of Health Republic of Indonesia, 2018). Gluten-free black rice flour (Ito *et al.*, 2019) contains 9.97% protein, 9.25% fat, 2.60% crude fiber (Hidayat *et al.,* 2019a). Mung beans (*Phaseolus radiatus* L) are legumes that have high nutritional content. It contained 323 kcal of energy, 22.9 g of protein, 1.5 g of fat, 7.1 g of fiber, and 7.5 g of Fe (Ministry of Health Republic of Indonesia, 2018). While, mung bean flour contained 23.25 % of protein, water of 9.01%, fat of 2.61% (Ekafitri *et al.*, 2014) and free of gluten (Vasundhra *et al.*, 2018)

Based on the description above, it has been known that biscuit consumption has increased and was the most consumed snacks after milk (Fathonah *et al*., 2014). In addition, the market demand for non-gluten biscuits (gluten is found in wheat) was getting higher (Foschia *et al*., 2016), especially people with gluten allergy, including celiac sufferers (Chakrabarti *et al.,* 2019). Therefore, non-gluten biscuits were investigated with a mixture of brown rice flour (BRF), mung bean flour (MBF) and corn starch (CS).

2. METHODS

The raw materials used to make non-gluten biscuits were black rice flour (BRF), mung bean flour (MBF) (Figure 1) and corn starch (CS). The color of BRF was soft purplish gray while MBF showed a soft ivory yellow color. Due to the same uses of corn starch, the treatment was about the comparison of the use of BRF and MBF with ratios of 60:20; 50:30 and 40:40. Other additives such as fined sugar, margarine, egg white, powdered milk and baking powder (Table 1) were also used.

Table 1. The composition of the black rice and mung bean flour in the prepared biscuits.

Material	Weight of each ingredient in the biscuits (g)		
	BRF60:MBF20	BRF50:MBF30	BRF40:MBF40
Black Rice Flour	**180**	**150**	**120**
Mung bean flour	**60**	**90**	**120**
Corn Starch	60	60	60
Margarine	125	125	125
Refined sugar	165	165	165
Liquid milk	80	80	80
Egg white	70	70	70
Baking powder	3	3	3

The study design used a simple randomized design with 3 treatments i.e., BRF60: MBF20, BRF50: MBF30, and BRF40: MBF40, with 3 replications. The initial preparation was made by making black rice flour as previously reported (Arifianti *et al.,* 2012). A good quality black rice was chosen. It was washed using running water twice and soaked for 30 minutes. The black rice that has been soaked was dried for 30 minutes.

The black rice was then ground to 100 mesh using a flouring machine.

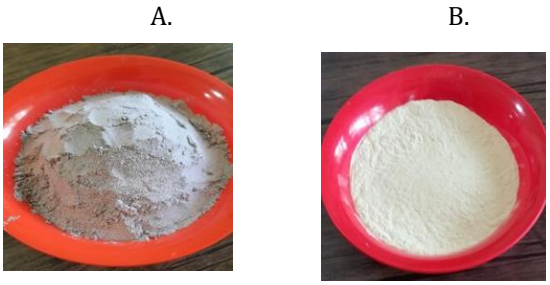

Figure 1. A. Black rice flour and B. mung bean flour used as the ingredients of the biscuits.

The biscuit making was carried out in accordance with what previously reported by Fathonah *et al*. (2019). The stages of making biscuits were mixing margarine and fined sugar for 2 minutes, adding and mixing with the egg whites for 1 minute followed by adding and mixing milk, black rice flour, mung bean flour, cornstarch flour and the filtered baking powder for ± 1 minute. The dough was put into a biscuit mold and printed on a baking sheet. The mold results were baked in an electric oven with a temperature above 160 ^{o}C, lower than 140 ^{o}C for 20 minutes. The baking sheet was turned in every 5 minutes to get an even heating. The cooked biscuits were lifted and cooled for 15 minutes and packed in a plastic packaging with a thickness of 0.5 mm (Fathonah *et al.*, 2019).

The Hedonic test of the biscuits were carried out by consumer panelists consisted of 80 people, with the hedonic test scale of 1-9 (Table 2). The value of 1 and 9indicated "extremely unfavorable" and "extremely favorable" criteria, respectively (Meilgaard *et al.*, 2007). The ash content was analyzed using the dry method, protein was using the Kjeldahl method, water content was using oven drying methods, crude fiber was using the gravimetric method, fat was using Soxhlet extraction method, anthocyanins were using the pH-differential method (AOAC, 2010). The data analysis of the hedonic and nutrition content test was carried out using a one-way analysis of variance or ANOVA and the Tukey HSD advanced test (Minium *et al.,* 1993).

Table 2. The acceptability criteria of the black rice biscuits with mung bean flour substitution.

Intervals	**Acceptability**
1.0 – 1.8	Extremely unfavorable
1.9 – 2.7	Poorly unfavorable
2.8 – 3.6	Fairly unfavorable
3.7 – 4.5	Unfavorable
4.6 – 5.4	Neutral
5.5 – 6.3	Moderately favorable
6.4 – 7.2	Favorable
7.3 – 8.1	Very favorable
8.2 – 9.0	Extremely favorable

3. RESULTS AND DISCUSSION

The resulting black rice biscuits showed a purplish black color. The use of black rice flour of 60% gave a purplish black color. The color intensity decreased by decreasing the black rice fluor composition to 40% (Figure 2) resulting a grayish color. The biscuits with a composition of BRF-to-MBF of 40: 40 showed a crunchy texture, with the dominant color, aroma and taste of the black rice than those of mung beans.

A B C

Figure 2. The black rice biscuits substituted with mung bean flour with different compositions: A. BRF 60: MBF 20, B. BRF 50: MBF 30 and C. BRF 40: MBF 40

The acceptance test for the three biscuits with different compositions of black rice and mung bean fluor showed almost the same results in every aspect of the assessment, with the lowest score of 6.20 indicating a "moderately favorable" criterion for the black rice taste, and the highest score 7.84 indicating a "very favorable" criterion for the crunchy texture. Based on Table 3, it was known that the BRF 40: MBF 40 biscuits showed the highest acceptance value on 5 attributes of acceptance, i.e., overall, aroma, texture, sweetness and taste of black rice. Therefore, these biscuits will be used for new product development in the community service program under the Campus Intellectual Product Business Development Program.

Table 3. The assessment results of the biscuits' acceptance test.

Acceptability Attribute	**Formulation**		
	BRF60:MBF20	**BRF50:MBF30**	**BRF40:MBF40**
Overall	7,15[a]	7,44[a]	7,64[b]
Color	6,84[a]	6,52[b]	6,38[b]
Aroma	7,53	7,48	7,58
Black rice Aroma	6,35	6,58	6,43
Crispiness	7,68	7,66	7,84
Sweetness	7,45	7,53	7,64
Black rice flavor	6,20[a]	6,43[a]	**6,71[b]**

Different alphabet superscripts ([a,b]) in the same row indicated a significant difference.

The results of statistical tests showed that there was a significant difference in the acceptability of black rice flour biscuits substituting mung bean flour on the overall indicators, color and taste of black rice. This suggested that black rice flour showed a more dominant effect on the biscuits than mung bean flour did.

Overall, the biscuits of BRF 40: MBF 40 achieved the highest biscuit acceptability. The different composition of the two types of flour gave a balance to the attributes of color, aroma, texture and taste of the biscuits. The aroma and taste of black rice were dominant, reduced by the use of more mung bean flour. In addition, black rice flour with a higher softness and starch content compared to mung bean flour resulted in a preferred crispy texture. The starch content of black rice flour was 69.78% (Khansa, 2017), while mung bean flour had 42.11% starch content (Triwitono *et al.,* 2017).

The most preferred biscuit color was with the ingredient formula BRF60: MBF20 with a dark-grayish purple color. This was due to the dark purple color of black rice flour (tended to black due the anthocyanin content) (Febriana *et al.*, 2014; Thiranusornkij, 2018), such as cyanidin-3-glucoside and peonidin-3-glucoside (Park *et al.*, 2008) and compounds from flavonoids (Tantipaiboonwong *et al.,* 2017). Due to the color of the peeled mung bean flour (it was light yellow) (Fathonah *et al.,* 2018), the addition of the mung bean flour caused an increase in the yellowish

color of the biscuits (Pradipta & Putri, 2015), resulting in biscuits with a darker purple color.

The substitution of mung bean flour on black rice biscuits gave a difference in the taste attributes. This showed that the taste of black rice was getting less and less by increasing the mung bean substitution. The taste of black rice was distinctive; rather tasteless and unpleasant (Febriana *et al.*, 2014). The addition of black rice flour by 50% gave a taste that was disliked by the panelists while the addition of 10% black rice flour was considered to have a better taste in baby instant porridge (Arifianti *et al.*, 2012). The increase in the addition of black rice fluor resulted in the bakpao with more black rice taste, leading to the decrease in the level of panelists' preference (Hidayat *et al.*, 2019a).

The results of statistical tests showed that there were significant differences in the content of energy, carbohydrates, protein, water, crude fiber and anthocyanin with more mung bean flour substitution. The energy content of the three biscuits was above 400 kcal ranging from 444 to 463 kcal (Table 4), which was classified as a high energy product. This value was almost the same as the energy of the biscuits with 60% arrowroot and 20% red bean flour (446.61 kcal) (Irmawati *et al.*, 2014). While, the mung bean biscuits with a substitution of 20% wheat flour and 20% cornstarch produced 445-454 kcal of energy (Setyaningsih *et al.,* 2019). The serving size for the biscuits prepared in this study was 55 grams (FDA, 2009). These biscuits could contribute around 12.4% with an energy sufficiency of 2,000 kcal. This energy content consists of carbohydrates, protein and lipids. The more mung bean flour substitutes, the smaller the energy, carbohydrate and fat content. However, the biscuits would contain a higher amount of protein. This was due to the higher energy, carbohydrate and lipid contents in the black rice flour compared to those in the mung bean flour.

The carbohydrate content of black rice flour biscuits was 58.3-61.1% with the carbohydrate content of the black rice and mung bean fluor of 64.46% (Hidayat *et al.*, 2019b) and 62.11% (Ekafitri *et al.*, 2014), respectively. This was in line with what was previously reported for arrowroot flour biscuits (carbohydrate content of 72.19%) (Irmawati *et al.,* 2014) and 60% mung bean biscuits (carbohydrate content of 62.57-65.02%) (Setyaningsih *et al.,* 2019),

Table 4. Results of biscuits nutritional content.

Nutrition	Biscuit type			
	BRF60:MBF20	BRF50:MBF30	BRF40:MBF40	SNI 2973-2011
Energy (kkal)*	463[a]	458[b]	444[b]	-
Carbohydrate (%)*	61.1[a]	59.3[b]	58.3[c]	-
Protein (%)*	7.2[a]	8.7[b]	9.2[c]	Min 5
Lipids (%)	21.8	21.3	20.5	-
Ash (%)	2.3	2.3	2.3	-
Water (%)*	5.3[a]	6.7[b]	8.7[c]	Max 5
Crude fiber (%)*	2.5[a]	1.8[b]	1.2[c]	Max 0.5
Antocyanin (ppm)*	37.0[a]	29.1[b]	19.8[c]	-

Different alphabet superscripts ([a,b,c]) in the same row indicated a significant difference.

Black rice flour biscuits substituted with mung bean flour gave a protein content of 7.14-9.15%. This was possibly affected by the protein content in the raw material and the egg white used. Black rice flour contained protein of 9.97% (Hidayat *et al.*, 2019a), while mung bean flour contained 23.25% of protein (Ekafitri *et al.*, 2014). Egg whites contained 12% of protein (Rosidah, 2019). It was reported that black rice muffins gave a high protein content of 8.11% (Lima *et al.,* 2017). While, a 19.66% protein was given by acha flour cookies substituted 30% mung bean flour (Nanyen *et al.,* 2016), 6.4 to 7.3% by yellow corn flour biscuits (Fathonah *et al.,* 2018) and very high protein content (20.14 g/100 g) in tempeh bran biscuits (Sarbini *et al.,* 2009). These high protein biscuits were considered as a good protein source for increasing growth in toddlers, school children, adolescents, pregnant and lactating women, as well as during healing (Sizer & Whitney, 2020).

The fat content of in the biscuits made of black rice flour substituted with mung bean flour was quite high, i.e., 20.29-22.17% due to the high fat content of raw materials and margarine (Riskiani *et al.*, 2014). The fat content in black rice was 9.25% (Hidayat *et al.*, 2019a), that of mung bean flour was 2.61% (Ekafitri *et al.*, 2014), and margarine. Vegetable fats were mostly unsaturated fatty acids such as eicosapentaenoic acid (EPA) and deoxyribonucleic acid (DHA), as well as margarines made from vegetable fats such as nuts, seeds and coconut. EPA and DHA changed the cell activity and structure in cell membranes in ways that promoted the healthy tissue function. In babies and children, DHA can help the internal brain communication, and reduce the inflammation associated with aging, normal growth, visual acuity, immune system function, and brain development (Sizer & Whitney, 2020). The fat content of cookies was 4.58% (Nanyen *et al.*, 2016), 14.03% in Muffins with black rice (Lima *et al.*, 2017), 18.3 to 21.7% in yellow corn biscuits (Fathonah et al., 2018).

Black rice flour biscuits substituted with mung bean flour had an ash content of 2.26-2.39%. The factor affecting the ash content of the biscuits was the ash content of the raw materials (Riskiani *et al.*, 2014). Black rice flour contained 1.64% of ash (Hidayat *et al.*, 2019a) while mung bean flour contained a fairly high ash content of 3.02% (Ekafitri *et al.*, 2014). Ash content of 3.53% in acha flour cookies substituted for mung bean flour (Nanyen *et al.,* 2016) and 0.95-1.74% in biscuits made of 60% mung bean, 20% wheat flour and 20% cornstarch (Setyaningsih *et al.*, 2019).

The high-water content of 5.25-8.65% in black rice flour biscuits substituted with mung bean flour with a baking time of 20 minutes was exceeding the SNI limit (5.0%). The high-water content would reduce the stability and the shelf life of the biscuits. The water content of the raw material (Riskiani *et al.*, 2014) and the temperature and duration of roasting could be the factors affecting the water content of the biscuits. The water content in black rice flour was 7.08% (Hidayat *et al.*, 2019a), while mung bean flour had a water content of 9.01% (Ekafitri *et al.*, 2014). A higher water content (10.1%) was reported for pumpkin biscuits substituted with mung bean flour (Irmayanti *et al.*, 2017), and 5.11-6.75% for mung bean biscuits with an optimal baking time of 17 minutes (Setyaningsih *et al.*, 2019). Roasting at 260°C would accelerate the evaporation of water in black rice cakes (Lee *et al.,* 2008). In this study, the roasting rate was 150 ^{o}C for 20 minutes, but the moisture content obtained still exceeded the number required by Indonesian National Standard. A further study on an optimal temperature and time of roasting. Milk powder biscuits were baked at 250 ^{o}C (as the top heat) / 230 ^{o}C (as the bottom heat) for 12 mins (Gallagher *et al.*, 2005), cassava biscuits were baked at 160 °C for 30 mins (Obadina *et al.*, 2014), and biscuits made of 50% corn flour, 40% wheat flour and 10% cornstarch baked at 170^{o}C for 15 mins (Fathonah *et al.*, 2018), the best biscuit was produced with the temperature of 190 °C and 16.5 mins baking (Panghal *et al.*, 2018).

Black rice flour biscuits substituted with mung bean flour showed a fiber content of 1.26-2.29%. Acha flour cookies substituted with mung bean flour showed a higher fiber content of 5.70% (Nanyen *et al.*, 2016). The factor affecting the fiber content in biscuits is the fiber content of the raw material. The fiber content contained in black rice flour is 2.60% (Hidayat *et al.*, 2019a), the fiber content in mung bean flour is 7.5 g (Fathonah *et al.,* 2018). Mung bean flour biscuits, biscuit fiber content increased due to the percentage of mung bean flour use (Pradipta & Putri, 2015). Soluble fiber can lower the human's blood cholesterol and can help control the blood glucose. This would be considered as an action that can increase your chances of fighting heart disease and diabetes. Insoluble fiber can relieve constipation, lower the risk of diverticulosis, hemorrhoids, and appendicitis, and reduce the risk of colon and rectal cancer (Nanyen *et al.*, 2016; Sizer & Whitney, 2020)

Black rice flour biscuits substituted with mung bean flour contained anthocyanins of 20-37 ppm. The anthocyanin content was low when compared to that of black rice of 2.9 mg/100 g (Hartati, 2013). Anthocyanin content of various products varied depending on the types of the raw materials, e.g., 5.26-10.31 mg/L for sponge cake from several rice flour (Anggraini *et al.*, 2017), the low gluten muffins with 50% black rice flour of 27.54 ± 2.22 mg cyanidin-3-glucoside (C3G)/100 g dry weight (DW), the gluten free muffins of 46.11 ± 3.91 mg C3G/100 g DW (Croitoru *et al.,*

2018), and 20.84% for the chiffon cake with the addition of 100% black rice flour (Mau *et al.,* 2016). Anthocyanins were important for health, i.e., warding off free radicals, antioxidants, cancer, coronary heart disease, liver dysfunction and degenerative diseases (Hambali & Nurmansyah, 2014).

4. CONSLUSIONS

The most preferred black rice biscuits was those biscuits with 40% black rice, 40% mung bean flour, and 20% corn flour, with acceptability value on 5 attributes (overall, fragrant aroma, crisp texture, sweet taste and black rice taste) of 7 and the overall aspect acceptability of 7.64. The substitution treatment of mung bean flour gave a significant difference in the overall attributes, color and taste of black rice.

The nutritional content of the three types of biscuits was almost the same, but it showed the difference in the energy, carbohydrate, protein, water and anthocyanin content. The biscuits with the ingredient formula of BRF60: MBF20 gave an energy content of 465 kcal, carbohydrates of 60.9%, protein of 7.1%, fat of 22.2%, ash of 2.7%, water of 5.3%, fiber of 2.3%, and anthocyanins of 37 ppm. The biscuits with the ingredient formula of BRF50: MBF30 resulted in an energy content of 458 kcal, carbohydrates of 59.2%, protein of 8.7%, fat of 21.4%, ash of 2.4%, water of 6.6%, fiber of 1.6%, and anthocyanin of 29 ppm. The biscuits with the ingredient formula of BRF40: MBF40 resulted in an energy content of 447 kcal, carbohydrates of 58.4%, protein of 9.15%, fat of 20.3%, ash of 2.3%, water of 8.7%, fiber of 1.3%, and anthocyanins of 20 ppm.

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