Formulation of snack bars made from black rice bran (Oryza sativa L.) and sweet potato flour (Ipomoea batatas L.)

Siswanti¹, R B K Anandito¹, E Nurhartadi¹, R B Agustiani¹

¹ Food Science and Technology Department, Sebelas Maret University, Surakarta, Indonesia

Email: siswanti@staff.uns.ac.id

Abstract. The availability of healthy snacks in Indonesia is very limited, and their unhealthy consumption could lead to obesity. Snack bars are examples of snacks in the market with wheat flour being used as the raw material. However, black rice bran and sweet potato flour are local raw materials that could replace it. Therefore, the aim of this research is to obtain the best formula for snack bars using black rice bran and sweet potato flour. A Completely Randomized Design (CRD) was used in this research with one-factor, namely ratio of black rice bran and sweet potato flour (10:90, 20:80, 30:70, 40:60, 50:50) (%w/w). Furthermore, the best formulation of snack bars based on physical, chemical and sensory characteristics was F3 (30% black rice bran:70% sweet potato flour). It was composed of 6g of black rice bran, 14g of sweet potato flour, 10g of whole milk, 12g of powdered sugar, 0.25g of vanilla, 8g of egg white, 4g of liquid margarine, and 8g of water. Furthermore, it has moisture, ash, protein, fat, carbohydrates, dietary fiber, total calories, vitamins B1, and antioxidant activity of IC₅₀ contents, namely 20.9%, 3.1%, 7.5%, 12.6%, 76.8%, 12.5%, 84.9 kcal/25 g; <0.25 ppm and 443.2µg/mL, respectively. This snack bar has a hardness level of 6.8 N and higher levels of dietary fiber and antioxidant activity than the commercial ones.

Keywords: Antioxidant, black rice bran, dietary fiber, snack bars, sweet potato flour

1. Introduction

Snacks are small quantities of food that are consumed between meals, and a high consumption could lead to obesity which is usually seen in both children and adults. This disorder could lead to several degenerative diseases, including diabetes mellitus, cancer, high blood pressure, heart disease, and stroke. Choosing healthy snacks in order to being full before the time for meals could be an attempt to prevent weight gain and cause obesity. Healthy snacks are food that contains sufficient micronutrient components and bioactive compounds. One of the bioactive components with physiological functions such as anti-cancer, maintaining cholesterol and blood sugar levels is dietary fiber [1]. Its benefits include facilitating bowel movements, preventing constipation, reducing the risk of heart disease and cholesterol levels in the blood [2].

The consumption of snack food is generally in small portions with nutritional content around 10% of daily energy needs [3]. Snack bars are solid food products in the form of bars, containing a mixture of various dry ingredients such as cereals, nuts, dry fruits with good nutritional and sensory characteristics because of their high carbohydrate, protein, fat and mineral content when compared to...
other snacks [4,5]. They are commercially made from wheat flours that are usually imported. Therefore, it is necessary to modify the raw material for snack bars by replacing them with local raw materials. Inferring from the available variety, they were developed in Indonesia with a variety of non-wheat flour commodities as raw materials, such as processed rice products [3], sweet potato and black soybean [6], white millet (Panicum miliceum L.), peanut [7], rice bran and corn flours [8], brown rice and mung bean flours and snack bars based on black rice and mung bean flours [9,10]. Previous researches have examined the use of rice bran. However, the studies did not focus on the antioxidant activity and dietary fiber in the snack bars produced. Therefore, this study aims to analyze snack bars based on black rice bran and sweet potato flour, which have high advantages of antioxidant activity, dietary fiber, and low calories.

Black rice bran has the highest total anthocyanin value when compared to brown and white rice bran. Furthermore, the phenolic compound in black rice is also greater than brown and white rice bran [11]. It is the highest antioxidant activity among the three compounds found in black rice bran. This antioxidant activity was influenced by the high levels of anthocyanins found in black rice bran. Furthermore, the antioxidant activity of crude bran oil was due to the levels of tocopherol, γ-oryzanol, and β-carotene [12]. Similar to regular flour, the purple sweet potato flour is white with a slightly purplish color which changes to dark purple after being exposed to water [13]. This sweet potato flour could also be used as a filler for the wheat flour in snack bars. Therefore, this study examines the effect of black rice bran and purple sweet potato flour composition on the physical, chemical and sensorial characteristics of snack bars as a healthy food.

2. Research methods

2.1 Materials and Equipment

The main ingredients were black rice bran which was obtained from Abdi Bumi Lestari Farmer Group, Geneng Hamlet, Karangpandan Village, Karangpandan District, Karanganyar Regency, and sweet potato flour which was obtained from Omah Telo, Popongan Village, Karanganyar Regency. Additional ingredients were refined sugar, margarine (Blue Band), whole milk, and eggs, which were obtained from Pasar Gede, Surakarta. As reference, the commercial snack bars used was Fitbar, which was made from oats, quinoa, and whole wheat.

The chemicals that were used for analysis include: concentrated H₂SO₄, K₂SO₄, CuSO₄, 45% NaOH, 4% H₃BO₃, 0.1 N HCl, n-hexane, benzoic acid, O₂ gas, petroleum ether, Na-phosphate, 4N HCl, pepsin enzyme, 95% ethanol, α-amylase enzyme, acetone, celite, vitamin B1 standard, Na-hexane sulfonate, glacial acetic acid, aquabidest, methanol, and DPPH reagent. The equipments used to analyse the moisture, ash, fat, protein, calories (bomb calorimeter), and vitamin B1 contents (HPLC) (mobile phase used a mixture of phosphate buffer and methanol (55:45), with a flow rate of 0.5mL per minute. In addition, the detector used was the UV-VIS with a wavelength of 254nm.), and texture analysis (Lloyd's Texture Analyzer TXT 32).

2.2 Research stages

2.2.1 Roasting process of black rice bran

The time required for roasting black rice bran was 3 to 5 minutes with a temperature of 110 to 130°C until the distinctive aroma was released. The purpose of roasting was to ripen and dry the black rice bran. Another reason was for the formation of aroma and minimizing rancidity due to fat oxidation [14].

2.2.2. Production of snack bars

The production of snack bars was carried out by mixing dry ingredients (roasted black rice bran, sweet potato flour, whole milk powder, refined sugar, and vanilla) with wet ones (egg white, liquid margarine, and water) to form a dough. The dough was molded with a size of (8x2x1) cm and baked at 160°C for 20 minutes.
2.2.3. Formulation of snack bars

Table 1 shows the formulation of snack bars

| Ingredients          | F1   | F2   | F3   | F4   | F5   |
|----------------------|------|------|------|------|------|
| **Main ingredients** |      |      |      |      |      |
| Black rice bran      | 2    | 4    | 6    | 8    | 10   |
| Sweet potato flour   | 18   | 16   | 14   | 12   | 10   |
| **Other ingredients**|      |      |      |      |      |
| Whole milk           | 10   | 10   | 10   | 10   | 10   |
| Refined sugar        | 12   | 12   | 12   | 12   | 12   |
| Vanilla              | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Egg white (mL)       | 8    | 8    | 8    | 8    | 8    |
| Liquid Margarine     | 4    | 4    | 4    | 4    | 4    |
| Water (mL)           | 8    | 8    | 8    | 8    | 8    |

Notes:
F1 = 10% black rice bran: 90% sweet potato flour, F2 = 20% black rice bran: 80% sweet potato flour, F3 = 30% black rice bran: 70% sweet potato flour, F4 = 40% bran black rice: 60% sweet potato flour, F5 = 50% black rice bran: 50% sweet potato flour.

2.2.4. Sample analysis

Chemical properties such as moisture, ash, fat, protein, carbohydrate, and dietary fiber contents were analyzed using thermogravimetric, dry ashing, Soxhlet extraction, micro-Kjeldahl, difference, and enzymatic methods [15]. While the antioxidant activity of IC50, vitamin B1, and total calories was analyzed with the DPPH reduction [16], HPLC [17], Bomb Calorimeter methods. Furthermore, analysis of the physical properties was carried using the Lloyd Texture Analyzer [18]. The sensory analysis used is a hedonic test scoring method [19].

2.3. Statistical analysis

This study used a completely randomized design (CRD) with one factor, namely the ratio of black rice bran and purple sweet potato flour formula as the basic ingredients for snack bars. The data obtained were analyzed using the SPSS and One Way Analysis of Variances (ANOVA) method. A significant difference result was obtained using the Duncan's Multiple Range Test (DMRT) at the 5% significance level.

3. Result and Discussion

3.1 Sensory Properties of snack bars

The sensory analysis used the hedonic test scoring method to determine the level of panelist acceptance of snack bars using the senses of sight, smell and taste. Furthermore, 25 untrained panelists were used in the acceptance scoring test. Snack bars were arranged in the form of blocks with a size of (8x2x1) cm. The sensory assessment test involved 5 scales, namely 1 (very much dislike), 2 (dislike), 3 (neutral), 4 (liked) and 5 (really like it). The results of the sensory analysis of snack bars are presented in the Table 2. Based on the research, the snack bar formulations F2, F3, and F4 were in the same range, while formulations F1 and F5 were in the neutral range. This showed that the comparison between black rice bran and sweet potato flour in the product formula had affected the panelists' acceptance for the product.
3.2 Physical properties of snack bars

Samples F1, F3, and F4 were in same range of hardness. Based on these results, it was found that the lowest fracture power was F1 with a pressure of 6.3 ± 0.54 N. While the highest fracture power was F2. The fracture strength of snack bars was influenced by the binder and the characteristics of the raw material used. Differences in the raw materials for snack bars, which are rice cereal, rice crispy, and rice popcorn, caused a higher result than the snack bars of F1, F3, and F4. Snack bars of black rice bran and sweet potato flour was made from ingredients that were dry, therefore the fracture was lower. When compared to the snack bars of black rice, green bean [10], brown rice and green bean flours [9], it also had a lower fracture power.

### Table 2. Sensory characteristics of snack bars

| Formulation | Parameter | Color | Aroma | Taste | Texture | Overall |
|-------------|-----------|-------|-------|-------|---------|---------|
| F1          |           | 3.6 ± 0.81<sup>b</sup> | 3.0 ± 0.91<sup>a</sup> | 2.7 ± 0.99<sup>a</sup> | 2.8 ± 0.83<sup>a</sup> | 2.8 ± 0.71<sup>ab</sup> |
| F2          |           | 3.4 ± 0.72<sup>b</sup> | 3.5 ± 0.78<sup>b</sup> | 3.1 ± 0.98<sup>ab</sup> | 3.0 ± 0.93<sup>ab</sup> | 3.3 ± 0.83<sup>c</sup> |
| F3          |           | 3.3 ± 0.87<sup>b</sup> | 3.4 ± 0.77<sup>ab</sup> | 3.3 ± 0.99<sup>b</sup> | 3.1 ± 0.87<sup>a</sup> | 3.4 ± 0.72<sup>c</sup> |
| F4          |           | 2.8 ± 0.99<sup>a</sup> | 3.6 ± 0.63<sup>b</sup> | 3.1 ± 0.98<sup>ab</sup> | 3.1 ± 0.96<sup>a</sup> | 3.1 ± 0.68<sup>bc</sup> |
| F5          |           | 2.6 ± 0.93<sup>a</sup> | 3.4 ± 0.81<sup>ab</sup> | 2.6 ± 0.93<sup>a</sup> | 2.7 ± 0.88<sup>a</sup> | 2.7 ± 0.66<sup>a</sup> |

Notes: The same letter notation in the same column shows no significant difference (<i>p</i>≤0.05).

### Table 3. Physical characteristics (hardness) of snack bars

| Raw material of snack bars | Max. (N) |
|---------------------------|----------|
| snack bars F1             | 6.3± ± 0.54 |
| snack bars F2             | 11.7± ± 0.13 |
| snack bars F3             | 6.8± ± 0.61 |
| snack bars F4             | 6.4± ± 0.26 |
| snack bars F5             | 9.1± ± 1.86 |

Notes: The same letter notation in the same column shows no significant difference (<i>p</i>≤0.05).

Snack bars with black rice bran and purple sweet potato flour had a softer texture and easier to chew than other snack bars. According to Kusumastuty (2015), snack bar texture is influenced by ingredients composition, mold thickness, roasting time and roasting temperature. High water content in the material would make the texture becomes soft. Furthermore, low starch content would absorb less water in order for more rice bran composition to be added. This would result in a decreased water content in order for the texture of the snack bar to be more easily destroyed. Rapid warming at high temperatures causes a change in the texture of foods [20].

3.3 Chemical properties of snack bars

Chemical characteristics of snack bars black rice bran and sweet potato flour compared to the reference (Fitbar) are presented in Table 4. Fitbar was used as a comparison to determine the chemical composition contained in each formulation. It is one of the commercial snack bars that is high in fiber, free from cholesterol and fat trans, and has a low-calorie content.

An increased addition of black rice bran to the formulation caused a lower moisture content in snack bars. However, the increased addition of rice bran caused low compactness of the ingredients, therefore the moisture in the mixture did not have a strong bond. The lower the starch, the lesser the quantity of water [21]. The fat content value in these snack bars was 14% much lower than the “Fitbar”. Furthermore, the difference in the raw materials used in manufacturing snack bars has an influence on the fat content produced. According to Jauhariah and Ayustaningwarno (2013), snack bar based on rice cereal has a 12.9% fat content, while that of food bars based on bran and corn flours according to Kusumastuty <i>et al.</i>, (2015) are between 18.34 to 18.74%. The high amount of black rice bran in the
formulation of snack bars caused high protein contents. Furthermore, the addition of black rice bran to the 50% formulation did not cause significant differences in the protein content of the snack bars. The average protein level of snack bars from black rice bran and sweet potato flour was lower than the “Fitbar”. Based on the research by Jauhariah and Ayustaningworo (2013), rice crispy-based snack bar has a value of 5.80 ± 0.38% protein content and rice-based snack bar 5.43 ± 0.14%. Rice-based snack bar has a protein content of 6.32 ± 0.44% [22].

Table 4. Chemical characteristics of snack bars

| Chemical components       | F1     | F2     | F3     | F4     | F5     | Fitbar |
|--------------------------|--------|--------|--------|--------|--------|--------|
| Moisture (% wb)          | 23.9±0.52a | 22.4±0.50a | 20.9±0.42b | 20.0±0.21a | 20.6±0.27ab | 7.7±0.19f |
| Ash (% db)               | 2.8±0.47d | 2.9±0.45a | 3.1±0.44a | 3.4±0.46a | 3.6±0.50a | 2.7±0.13i |
| Fat (% db)               | 9.1±0.81a | 10.2±0.25a | 12.6±0.83b | 12.8±0.57b | 13.6±0.97b | 14a     |
| Protein (% db)           | 7.2±1.28c | 7.3±1.06a | 7.5±0.97a | 7.8±1.01c | 8.3±1.30a | 12c     |
| Carbohydrates (% db)     | 80.8±0.91e | 79.6±0.74a | 76.8±0.54b | 76.0±0.96a | 74.5±0.9a | 71.3±013i |
| Calories (kкал/25 g)     | 88.0±0.11 | 89.3±1.14 | 84.9±1.06 | 83.8±0.78 | 89.4±0.24 | 90i     |
| Dietary fiber (% db)     | 11.8±0.75 | 12.9±0.06 | 12.5±0.14 | 14.8±0.20 | 13.2±0.42 | 4f      |
| Vitamin B1 (ppm)         | <0.25   | <0.25   | <0.25   | <0.25   | <0.25   | <0.25   |
| Antioxidant activity     | 1269.7  | 1545.5  | 443.2   | 1070.4  | 582.5   | 2181.4  |
| (µg/mL)                  |         |         |         |         |         |         |

Notes: The same letter notation on the same line indicates that there is no significant difference (p≤0.05). Information on the nutritional value of “Fitbar” on the package, (Fauzia, 2016). The experiment and treatment data was thice repeated.

The calorie value of snack bars had a value between 83.8 to 89.3 kcal with a serving size of 25g. This value is slightly lower than the snack bar commercial (Fitbar), which has 90 calories per 25g serving. The nutritional content per serving of a snack is generally 10% of daily calories (2,000kcal) [23], therefore the calorie needed in a snack is only 200kcal. The highest calorie value was in snack bars F2 with a calories value of 89.3 kcal per 25g serving. The means that it meets the needs of daily calories as a snack, and anyone could eat the snack bars from black rice bran and sweet potato flour as much as 2.24 pieces. The difference between raw materials used in the manufacturing process influenced the calorie value of the product. The snack bars from black rice bran and sweet potato flour had a higher calorie value, compared to the ones from black rice bran and green bean flour, which had a calorie value of 90.76 kcal / 25g [10]. Furthermore, snack bars from brown rice flour and green bean flour of 93.91 kcal / 25g [9], and the ones made from rice bran flour and cornflour had a calorie value of 121.7 kcal / 25g [8]. While snack bars made from white millet flour and beans had a calorie value of 113.6 kcal / 25g [7].

A food product could be considered high in fiber when it has a dietary fiber content of not less than 6g / 100g of product [24]. Products that are claimed to be sources of fiber or contains it must have a dietary fiber content of not less than 3g / 100g of product. This concludes that the snack bars of black rice bran and sweet potato flour could be considered as high-fiber foods. The value of dietary fiber content in the snack bars was much higher compared to the control (Fitbar). The dietary fiber content of black rice bran was 11.5% [25]. The content of dietary fiber in sweet potato flour was only about 4.72% [26]. Sample F3 has the highest antioxidant activity, and snack bars made from black rice bran and sweet potato flour had a higher antioxidant activity than Fitbar. The more anthocyanin content and total phenol in the material caused the antioxidant activity to increase [11]. Determination of the best formula for snack bars from black rice bran and sweet potato flour was carried out by weighting test, using the method of Sullivan et al., (2015) [27] (Table not shown). Based on the weighting test results, F3 (30% black rice bran and 70% sweet potato flour) was the formula chosen when compared with others.

4. Conclusion

The best formula for the snack bars consists of 6g of black rice bran, 14g of purple sweet potato flour, 10g of whole milk, 12g of refined sugar, 0.25g of vanilla, 8g of egg whites, 4g of margarine, and 8g to water with a hardness level of 6.8N. The selected snack bar formula contains moisture, ash, protein, fat, carbohydrates, total calories, dietary fiber and vitamin B1 contents, and antioxidant activity.
of IC_{50} of 20.9%, 3.1%, 7.5%, 12.6%, 76.8%, 12.5%, 84.9 kcal / 25g <0.25 ppm and 443.2 µg / ml respectively. In addition, the snack bars had fat content and total calories that were equivalent to commercial snack bars, and higher dietary fiber and antioxidant activity.

Acknowledgements
The author is grateful to LPPM-UNS for their assistance in carrying out this research through the 2017 UNS PNBP Fund Grant Scheme for Fundamental Research Scheme (RF-UNS) with contract number 623 / UN27.21 / PP / 2017 on April 10th, 2017. During the research and publication, there was no conflict of interest from all parties.

References
[1] Marsono Y 2008 Jurnal Teknologi Pangan dan Gizi. 7 19–27
[2] Kusharto CM 2006 Jurnal Gizi Dan Pangan 1 45–54
[3] Jauhariah D and Ayustaningwarno F 2013 Journal of Nutrition College 2 250–261
[4] Rahman T, Luthfiyanti R and Ekafitri R 2011 Optimization of the banana-based food bars production 295–302
[5] Nadeem M, Salim R, Muhammad Anjum F, Murtaza MA and Mueen-Ud-Din G 2012 The Scientific World Journal
[6] Avianty S and Ayustaningwarno F 2014 Jurnal Aplikasi Teknologi Pangan 3 98–102
[7] Anandito RBK, Nurhartadi E, Siswanti and Nugrahini, VS 2015 Agritech 36 23 – 29
[8] Kusumastuty I, Ningsih LF and Julia AR 2015 Journal of Human Nutrition College 1 68–75
[9] Fauzia VR 2016 Formulation and Characterization of Snack Bars Based of Brown Rice Flour (Oryza sativa) and Mung Bean Flour (Phaseolus radiatus L.) as an alternative of healthy snacks. Essay. Faculty of Agriculture, Universitas Sebelas Maret, Surakarta.
[10] Lisa S 2016 Formulation And Characterization Of Snack Bar Based Withblack Rice Flour (Oryza Sativa L.) and Mung Bean Flour (Phaseolus Radiatus) As The Alternative Of The Healthy Snack. Essay. Faculty of Agriculture, Universitas Sebelas Maret, Surakarta.
[11] Widarta IWR, Nocianitri KA and Sari LPIP 2013 Jurnal Aplikasi Teknologi Pangan 2 75–79
[12] Mumpuni PD and Ayustaningwarno F 2013 Journal of Nutrition College 2 350–357.
[13] Amanto BS, Atmaka W and Apriliyanti T 2017 Study Of Phsycochemical And Sensory Properties Of Sweet Potato (Ipomoea batatas Blackie) With Drying Process Variance. National Seminar Proceedings. Faculty of Agriculture of Sebelas Maret University 1 788–793
[14] Cynthia GCL, Sugiyono and Haryanto B 2009 Jurnal Teknologi dan Industri Pangan, 20 32–40
[15] AOAC 2000 Official Method of Analysis. Association of Official Analytical Chemists (Washington DC)
[16] Prakash A, Rigelhof F and Miller E 2001 Antioxidant Activity. Medallion Laboratories Analytical Progress 19 1–4.
[17] Ariani NLK, Suaniti NM and Sibarani J 2015 Cakra Kimia Indonesia 3 1 – 8
[18] De Man MJ 1997 Food Science (ITB Press, Bandung)
[19] Setyaningisih D, Apriyantono and Sari, MP 2010 Sensory Analysis for Food Industry and Agro (IPB Press, Bogor)
[20] Pratama RI, Rostini I and Liviawaty E 2014 Jurnal Akuatika 5 30-39
[21] Harzau H and Estiasih T 2013 Jurnal Pangan dan Agroindustri 1 138-147
[22] Hakim VP and Ayustaningwarno F 2013 Journal of Nutrition College 2 431-438
[23] Larasati AS and Ayustaningwarno F 2013 Journal of Nutrition College 2 514–522
[24] BPOM 2011 Processed food label provisions no HK.03.1.23.11.11.0990 (Retrieved from www.bpom.go.id) [November 16, 2016]
[25] Gul K, Yousuf B, Singh AK, Singh P and Abas A 2015 A review Bioactive Carbohydrates and Dietary Fibre 6 24–30
[26] Nintami AL and Rustanti N 2012 Journal of Nutrition College 1 382–387
[27] Sullivan WG, Wicks EM and Koeling C 2015 Engineering Economy 16th Edition (Pearson Education Ltd, London)