Emirates Journal of Food and Agriculture. 2023. 35(6): 562-568
doi: 10.9755/ejfa.2023.v35.i6.3111
http://www.ejfa.me/

RESEARCH ARTICLE

Used rice and banana flour to formulated nutritious snacks for elderly

Dewi Desnilasari[1]*, Lia Ratnawati[2], Dita Kristanti[3], Riyanti Ekafitri[2], Diki Nanang Surahman[2]

[1]Research Center for Applied Microbiology, National Research and Innovation Agency, Indonesia. Jl. Raya Jakarta-Bogor No.Km.46, Cibinong, Kec. Cibinong, Kabupaten Bogor, Jawa Barat 16911, [2]Research Center for Appropriate Technology, National Research and Innovation Agency, Indonesia. Jl. K.S. Tubun No. 5 Subang, 41213 West Java, Indonesia, [3]Research Center for Food Technology and Processing, National Research and Innovation Agency, Indonesia. Jl. Jogja-Wonosari km 31,5 Playen Kab. Gunungkidul 55861, Yogyakarta, Indonesia

ABSTRACT

In this study, different rice flours (white, red, and black rice) were mixed with two banana (“Ambon” and “Nangka”) flours to formulate snacks for the elderly. This study aimed to obtain the characteristics and quality of the banana flakes made with different rice and banana flours and determine the best combination for the elderly. The following were assessed in this study: the chemical properties (moisture, ash, protein, fat, carbohydrate, TDF, total sugar, mineral, inulin, TAC, and antioxidant activity), physical properties (color, hardness, and fracturability) and sensory evaluations. The results of our study showed that banana flakes made from black rice flour and ’Nangka’ banana flour had the highest contents of potassium, magnesium, zinc, and antioxidant activity. Furthermore, the texture of this formulation showed less hardness and high fracturability. However, all formulations showed the same acceptability on sensory evaluations based on the overall parameters. Thus, although banana flakes made from black rice flour and ‘Nangka’ banana flour are highly recommended for the elderly because of their texture and nutrients, using other formulations is also edible and can be consumed for health benefits.

Keywords: Antioxidant activity; Banana flake; Banana flour; Elderly; Inulin; Rice flour

INTRODUCTION

The elderly make up the largest part of the world’s population in developed and developing countries. The erdely’s food must contain sufficient nutrients, following their calorific requirements, must have a balanced distribution of energy in terms of macronutrients and other factors, and the physical characteristics of food must be in accordance with the physiological limitations of the elderly (which are usually centered on the senses, mastication, and digestion) (Satusap et al. 2014; Giacalone et al. 2016), so it will be reduce possibility of degenerative and mal nutrition diseases in erderly However, Flakes are one of the ready-to-eat food products that are suitable for the elderly. Besides being high in energy, flakes are also rich in nutrients. However, flake products available on the market are made from wheat. Flakes can be made from raw materials other than wheat, namely banana flour. Several studies related to banana flakes have been carried out including flakes made from banana flour combining with rice, corn flour, and modified cassava flour (Surahman et al. 2019); banana flakes from various varieties of bananas (Ratnawati and Afifah 2017); fortified banana flakes with iron and folate (Ekafitri et al. 2019); and flake formulations from ripe and unripe banana flour, flake made from brown rice and green beans flour (Aurore et al. 2009; Satusap et al. 2014). According Ratnawati and Afifah (2017), banana flakes contain levels of ash, protein, fat and carbohydrates respectively 2.40-2.99%, 7.38-9.19%, 4.71-8.32%, and 77.78-82.65%. Meanwhile, according to Surahman et al. (2019) banana flakes made with the addition of rice flour have the best product characteristics compared to the addition of corn flour and modified cassava flour, which contain 3.24% of ash, 3.19% of crude fiber, 7.35% of protein, 2.14% of fats and 83.45% of carbohydrates. However, there has not been any development of banana-based flakes for erderly. Because of this, in this study further banana flakes will be made which are formulated using banana flour and rice flour.

Indonesia is rich in various varieties of bananas, both plantain and banana. The types of plantain bananas that are recommended to be made into flour include the Tanduk,

***Corresponding author:**
Dewi Desnilasari, Research Center for Applied Microbiology, National Research and Innovation Agency, Indonesia. Jl. Raya Jakarta-Bogor No.Km.46, Cibinong, Kec. Cibinong, Kabupaten Bogor, Jawa Barat 16911. **E-mail:** dewi.desnilasari@gmail.com

Received: 29 December 2022; **Accepted:** 10 April 2023

Kapas, Raja, Kepok, Siang, and Nangka varieties (Fatemeh et al. 2012; Kumalasari et al. 2021). While banana varieties that are commonly made into flour are the Cavendis, Dream, and Ambon varieties (Abbas et al. 2009; Alkarkhi et al. 2011; Ratnawati and Afifah 2017). Each variety has different ingredients which will give different nutritional values and functional properties to the product (Kumalasari et al. 2021). Besides being rich in bananas, Indonesia is also a rice-producing country. According to Rifin (2022), Indonesia's rice production in 2018/2019 reached nearly 40 million tons. In Indonesia, it consists of various types of rice, such as white, red and black rice. Pigmented rice varieties were reported as potential sources of antioxidants; therefore, they were used as viable sources of antioxidants such as phenolic components and anthocyanins for functional foods (Yawadio et al. 2007; Agustin et al. 2021). The phenolic acid content of black rice is 7.4–10.5 mg/100 g) and red rice varieties is 1.4–3.4 mg/100 g (Sompong et al. 2011). Agustin et al. (2021) stated that brown rice and black rice have antioxidant activity with IC_{50} values of 6.65-12.87 μg/mL and 43.02 μg/mL, and have antidiabetic activity. Agustin et al. (2021) also stated that pigmented rice has different ingredients, so its application to processed products will have different effects. Therefore, this study aims to produce banana flakes for erderly which are formulated from different varieties of banana flour with the addition of pigmented rice flour, and evaluate its physicochemical and sensory characteristics. It is hoped that this research can find the most suitable formulation for the elderly to improve their health.

MATERIALS AND METHODS

Materials

White, red, and black rice (Menak merk) were bought from Cibeusi, Subang, West Java, Indonesia. Rice flour was made as follows: each variety of rice was washed and soaked in water for 30 mins, after which the rice was drained; then, the rice was ground using a disk mill to reduce the particle size and sieved using a 40-mesh sieve. The banana flour varieties 'Ambon' and 'Nangka,' eggs, skim milk powder, and baking powder was bought from the local market in Subang, West Java. Steviosa was bought from the M & H Farm, Bogor. The general diagram of experiment is shown in Fig. 1.

Preparation of banana flake according (Ratnawati and Afifah 2017) with modification

The banana flakes were prepared in the pilot plant bakery of the Research Center for Appropriate Technology, National Research and Innovation Agency, Subang, West Java, Indonesia. The formulation of the banana flakes is shown in Table 1. In the first step, eggs and steviol were mixed using a mixer with a high-speed level until the mixture became thick and fluffy and expanded in volume. Then, other ingredients were added, and the mixture was stirred well using a mixer with a low-speed level. The banana flake dough was sheeted to the thickness of 2 mm and baked in a deck oven at 120°C for 6 mins. Then, the half-baked dough was cut into sizes of 2 × 2 cm. Subsequently, it was baked again at 120°C for 10 mins. After cooling, the banana flakes were placed in aluminum bags and stored at 28°C until further analysis.

Chemical properties analysis

Proximate,total sugar, total dietary fiber (TDF) and mineral analysis

Moisture, ash, total sugar, and fat contents were evaluated by following Indonesian National Standard procedures (BSN 1992). Protein content was analyzed using a DuMaster protein analyzer (DuMaster D-480, Buchi, Switzerland). Total carbohydrate was calculated using *by difference method*. The TDF content of the banana flake was determined by AOAC methods (AOAC, 1995), and mineral analysis was performed using atomic absorption spectrophotometry (AAS, GBC 932AA, Australia) according to the AOAC (1995).

Inulin content analysis

Inulin content was analyzed using HPLC (Agilent 1260 Infinity II, USA) with column specification: Agilent Hi-plex H (7.7 x 300 mm). The HPLC operating conditions are as follows: flow rate 0.6 ml/min, column temperature 60°C, refractive index detector and sample injection volume 10 μl. Extraction of inulin samples followed the method described by Beckers et al. (2007).

Total anthocyanins content (TAC) analysis and antioxidant activity

The spectrophotometric approach was used to calculate the TAC (Sompong et al. 2011). Anthocyanins were extracted using acidified methanol (85:15 v/v methanol and 1 M HCl) at a solvent to sample ratio of 1:10. The extract absorbance was measured at 525 nm after centrifugation (UV-Vis 1900, Shimadzu, Japan). Anthocyanins were extracted with acidified methanol (methanol and 1 M HCl, 85:15, v/v) with a solvent to sample ratio of 1:10. After centrifugation, the extract absorbance was measured at 525 nm (UV-Vis 1900, Shimadzu, Japan) TAC was expressed as mg cyanidin 3-glucoside equivalent per 100 g flour.

The DPPH radical-scavenging ability of the flakes was evaluated according to Sompong et al., (2011). The reaction mixture contained 300 μlextract and 1.5 ml DPPH solution, The mixture was incubated for 40 mins in the dark at room temperature. The absorbance was read at 515 nm using a spectrophotometer (UV-Vis 1900, Shimadzu, Japan). Ascorbic acid (vitamin C)was as standard.

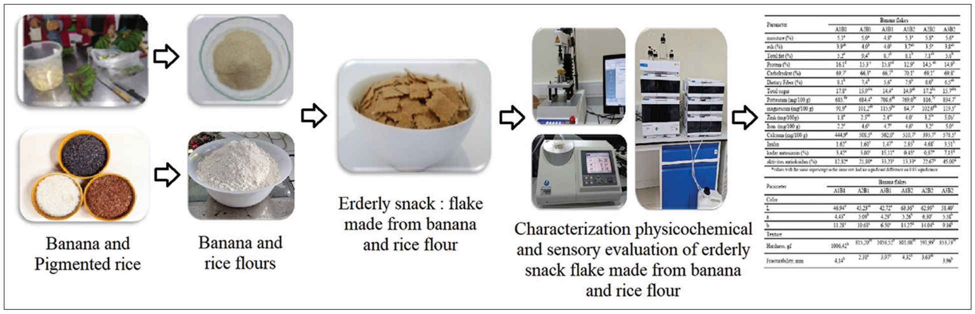

Fig 1. General diagram of experiment.

Table 1: Formulations of the banana flakes

Ingredient	Formulation (%)					
	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2
Banana puree	25.90	25.90	25.90	25.90	25.90	25.90
White rice flour	22.00	-	-	22.00	-	-
Red rice flour	-	22.00	-	-	22.00	-
Black rice flour	-	-	22.00	-	-	22.00
Ambon banana flour	16.00	16.00	16.00	-	-	-
Nangka banana flour	-	-	-	16.00	16.00	16.00
Skim Milk	15.00	15.00	15.00	15.00	15.00	15.00
Ripe Banana Flour	5.00	5.00	5.00	5.00	5.00	5.00
Egg	15.00	15.00	15.00	15.00	15.00	15.00
Baking Powder	1.00	1.00	1.00	1.00	1.00	1.00
Steviol glycoside	0.10	0.10	0.10	0.10	0.10	0.10

A1 indicates white rice flour, A2 indicates red rice flour, and A3 indicates black rice flour. B1 indicates 'Ambon' banana flour, and B2 indicates 'Nangka' banana flour.

Physical properties analysis

The sample color was measured using a colorimeter (NH3, China) with three replication. Color characteristics such as L, a, and b were provided. The texture properties of the samples were analyzed based on the hardness and fracturability using a texture analyzer TA.XTPlus (Stable Micro System, Surrey, UK) with probe three-point bending rig (type HDP/3PB). The setting of compression strength of the samples was: test mode, compression; test speed, three mm/s; target mode, distance; and distance, 4 mm.

Sensory evaluation of the banana flake

Sensory evaluation of the banana flakes was performed with a panel of 30 elderly (aged >50 years). The assessment of sensory evaluation using the score hedonic range with 1 (very much dislike), 2 (dislike), 3 (slightly dislike), 4 (fair), 5 (rather like), 6 (like), 7 (like very much).

Statistical analysis

The data obtained in this study represents an average of triplicate analyses. These data were analyzed using ANOVA, followed by the Duncan test with a significance level of 5%.

RESULTS AND DISCUSSION

Chemical properties of the banana flakes

Proximate

The proximate composition of the six formulations of banana flakes is presented in Table 2. The moisture content of banana flakes was 4.80%–5.80%, which was not significantly different among the different formulations ($p > 0.05$). However, ash values were significantly different among the treatments and ranged from 3.52% to 4.03%. The moisture and ash contents of banana flakes in this study are higher than the moisture and ash contents of banana flakes in Ratnawati & Afifah (2017) study which was 1.01-4.40% and 2.40-2.99%.

Protein is an essential nutrients responsible for multiple functions and affect flake preparation, such as in texture and in vitro digestion (Chung et al. 2014). The protein content of the banana flakes was 12.85–16.09%, and the highest protein content was found in banana flakes made from white rice and 'Ambon' banana flour. Banana flakes made with 'Ambon' banana flour had higher protein content than those made with 'Nangka' banana flour because of the higher protein content in 'Ambon' banana flour. According to Ratnawati and Afifah (Ratnawati and Afifah 2017), the protein content in banana flake made from 'Ambon' banana flour was higher than in other banana varieties, such as Raja and Kepok. The elderly require protein to gain mass, strength, and function of muscle that progressively decrease with increasing age, thereby hindering their ability to live independently and enjoy a good quality of life (Baum et al. 2016).

The carbohydrate content of the banana flakes ranged from 66.29% to 70.09%, and the highest carbohydrate content was found in the banana flakes made from white rice flour and 'Nangka' banana flour. This was expected because the starch content in 'Nangka' banana flour is higher than in 'Ambon' banana flour. The total carbohydrate content in all the formulations were almost 70%; thus, banana flakes from all the six formulations are considered good carbohydrates sources (Sompong et al. 2011).

Table 2: Chemical properties of the banana flakes

Parameter	Banana flakes					
	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2
Moisture (%)	5.12±0.21[a]	5.02±0.37[a]	4.80±1.14[a]	5.25±0.43[a]	5.80±0.51[a]	5.56±0.36[a]
Ash (%)	3.92±0.07[ab]	3.97±0.06[b]	4.03±0.10[b]	3.73±0.09[ab]	3.52±0.50[a]	3.84±0.06[ab]
Fat (%)	5.22±3.00[a]	9.45±1.51[c]	8.66±4.01[b]	8.07±3.40[b]	7.05±1.16[ab]	5.82±0.61[b]
Protein (%)	16.09±0.07[d]	15.27±0.45[c]	15.84±0.47[cd]	12.85±0.48[a]	14.49±0.06[ab]	14.95±0.02[b]
Carbohydrate (%)	69.66±2.94[c]	66.29±1.49[a]	66.67±3.37[b]	70.09±3.20[c]	69.14±1.42[c]	69.84±0.61[c]
TDF (%)	8.11±0.51[b]	7.39±0.93[b]	5.61±0.35[a]	7.90±1.47[b]	8.01±0.91[b]	6.53±0.93[ab]
Total sugar (%)	17.81±0.96[c]	15.87±1.18[abc]	14.42±1.59[a]	14.94±1.32[ab]	17.24±1.78[bc]	15.75±0.99[abc]
Potassium (mg/100 g)	685.62±10.12[a]	684.44±11.34[a]	708.57±28.52[ab]	768.98±60.23[bc]	816.51±7.88[c]	834.71±61.82[c]
Magnesium (mg/100 g)	91.88±6.55[a]	101.21±14.09[ab]	115.94±5.53[bc]	84.74±0.70[a]	101.96±1.17[ab]	119.51±15.60[c]
Zinc (mg/100 g)	1.81±0.01[a]	2.49±0.62[ab]	2.37±0.42[ab]	4.02±0.96[c]	3.19±0.03[bc]	4.97±2.84b[c]
Iron (mg/100 g)	2.22±0.46[a]	4.57±2.36[a]	4.73±1.34[a]	4.56±1.74[a]	2.89±0.47[a]	3.77±1.55[a]
Calcium (mg/100 g)	444.90±23.76[a]	508.49±54.32[a]	501.98±55.18[a]	510.69±82.83[a]	395.70±85.61[a]	578.53±221.69[a]
Inulin (%)	1.62±0.19[a]	1.60±0.30[a]	1.47±0.21[a]	2.85±0.13[b]	4.68±1.06[c]	3.51±0.32[b]
TAC (mg/100g)	3.42±0.18[a]	5.00±0.16[c]	15.11±0.59[e]	0.45±0.02[a]	0.87±0.05[a]	7.15±0.47[d]
Antioxidant activity (mg E vit C/100 g)	17.19±2.57[b]	51.30±2.77[c]	60.23±0.86[e]	8.23±1.07[a]	55.57±0.20[d]	69.96±3.18[f]

*values with the same superscript in the same row had no significant difference at p = 0.05.

Total dietary fiber (TDF) and total sugar

The TDF content of the A3B1 banana flakes formulation was significantly lowest ($p < 0.05$) than other formulations. The highest TDF content was found in banana flakes made from white rice flour and 'Ambon' banana flour (8.11%). The TDF content of flake made from white and red rice flour, both mixed with 'Ambon' and 'Nangka' banana flour were not significantly different. This indicated that flakes made with black rice flour had lower dietary fiber content than white and red rice flour. The TDF contents in white rice, red rice, and black rice flours were 8.93%, 12.55%, and 9.46%, respectively (data not shown). However, during the processing of red and black rice flours, the rice husk was not passed through the sieve; therefore, the fiber was not included in the rice flour. Oghbaei and Prakash (2016) showed that sieving during finger millet flour processing could reduce dietary fiber by almost 50%.

The highest total sugar was also found in banana flakes made from white rice and 'Ambon' banana flours (17.81%). Steviol glycoside is commonly used commercially as a low-calorie, noncariogenic substitute for sucrose. When compared to sucrose, it can reduce the total sugar content of a product. Furthermore, several research using both animal models and human volunteers have convincingly demonstrated the positive effects of this substance. (Ceunen and Geuns 2013). Therefore, we used stevioside in this study for the preparation of different formulations of banana flakes.

Mineral content

Banana flakes were rich in minerals such as potassium, magnesium, zinc, and iron. Banana flakes made from black rice and 'Nangka' banana flours had the highest potassium (834.71 mg/100 g), magnesium (119.51 mg/100 g), zinc (4.97 mg/100 g), and iron contents (3.77 mg/100g). 'Nangka' banana flour has high potassium content. According to Wall (2006), bananas include minerals such as calcium, phosphorus, magnesium, salt, and high potassium amounts of up to 2.7%.Moreover, black rice also contains iron and zink minerals (Chen et al., 2003; Kumar and Roshini, 2020). Calcium, iron, and zinc content of black rice in mg/kg were 60.70-347.82, 21.35-30.30, and 6.45-20.25, respectively (Nashrurrokhman et al. 2019). Black rice contained of 23.39-59.91 mg/100g of calcium, 5.68-13.37 mg/100g of iron, 2.65-3.21 mg/100g of zinc, 138.09-151.29 mg/100g of magnesium, and 150.00-231.72 mg/100g of potassium (Chen et al. 2019).

Inulin content

Banana flour was used in flake production because of because of inulin content, which had a many health benefits. Shoaib et al. (2016) reported that inulin functions as a dietary fiber, has a low caloric value, can reduce the risk of high concentrations of triacylglycerol being digested by human enzymes, and produces remarkable fiber-alike results on the effectiveness of the gut. Inulin also stimulates the development and metabolism of many bacteria in the colon, particularly *Bifidobacteria* and *Lactobacilli*, promoting their growth (Karimi et al. 2015). Banana flakes made from different combinations showed significant differences in the inulin content ($p < 0.05$), ranging from 1.47% to 4.68%. Banana flakes made from red rice flour and 'Nangka' banana flour had the highest inulin content, whereas banana flakes made from white rice flour and 'Ambon' banana flour had the lowest inulin content (Table 2).

TAC and antioxidant activity

Banana flakes made from white rice and 'Ambon' banana flours or 'Nangka' banana flour had the lowest TAC and antioxidant activity (Table 2). The highest TAC was found in banana flakes made from a mixture of black rice and 'Ambon' banana flour (15.11 mg/100g), followed by banana flakes made from black rice and 'Nangka' banana flour (7.15 mg/100g). Similarly, the highest antioxidant activity was found in banana flakes made from a mixture of black rice and 'Nangka' banana flour (69.96 mg E vit C/100 g), followed by banana flakes made from a mixture of black rice and 'Ambon' banana flour (60.23 mg E vit C/100 g). Banana flakes made from red rice flour had lower TAC and antioxidant activity than banana flakes made from black rice flour. Colored rice varieties were reported as potential sources of antioxidants; therefore, they were used as viable sources of antioxidants for functional foods (Yawadio et al. 2007). The TAC of red and black rice varieties were ranged from 0.3 to 1.4 and 109.5 to 256.6 mg/100 g, respectively (Sompong et al. 2011). The high antioxidant activity in banana flakes made from black rice flour can be attributed to the phenolic acid content of black rice. The phenolic acid content of black rice (7.4–10.5 mg/100 g) is higher than red rice varieties (1.4–3.4 mg/100 g) (Sompong et al. 2011). Chen et al. (2019) (Chen et al. 2019) also reported that the total phenolic content of black rice (429.61-606.71 mg/100g) was higher than white rice (122.94-197.13 mg/100g).

Physical properties

Color

Table 3 shows the color parameters of banana flakes. Banana flakes made from white rice flour had the highest L value (46.94 and 63.36) because white rice flour does not contain an anthocyanin pigments as in red or black rice. Black rice is more purplish than black. It is sold as unmilled rice with fiber-rich black husks. When the black rice is cooked, it turns deep purple. It was reported that black rice (*Heugjinjubyeo*) contains many anthocyanins pigments (Ryu et al. 2003).

The entire banana flake sample had positive values ranging from 4.29 to 6.30, implying that all banana flakes tend to be red. The b value was also positive (6.50–14.27), implying that banana flakes could also be yellow. The b value was the lowest in banana flakes made from black rice flour because this flour had the highest anthocyanin content (Table 3); therefore, banana flakes made with black rice flour were the darkest.

Hardness and fracturability

The hardest banana flakes were those made from black rice flour mixture and 'Ambon' banana flour (1058.52 gf), and the softest banana flakes were those made from a mixture of red rice and 'Nangka' banana flour (599.99 gf). The highest fracturability was observed in the banana flake made from white rice flour, and 'Nangka' banana flour (4.32 mm). The lowest fracturability was found in the banana flake made from a mixture of red rice and 'Ambon' banana flours. The differences in the fracturability are attributed to the ratio of amylose and amylopectin in the composite flour. If the composite flour have a high amylopectin content and low amylose content, the crispiness increased while the hardness decrease(Ratnawati and Afifah 2017). The amylose content of the white rice flour is lower than that of black rice flour (Krisbianto et al. 2016). However, the results of our study do not corroborate this fact because the ratios of amylose and amylopectin change after the flour is mixed.

Table 3: Physical properties of the banana flakes

Parameter	Banana flakes*					
	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2
Color						
L	46.94±0.00^{b}	45.23±2.67^{ab}	42.72±2.03^{a}	63.36±1.02^{d}	62.99±1.07^{d}	58.40±1.92^{c}
a	4.43±0.01^{a}	5.09±0.12^{b}	4.29±0.50^{a}	5.26±0.13^{b}	6.30±0.41^{c}	5.58±0.22^{b}
b	11.28±0.02^{c}	10.68±0.67^{c}	6.50±0.82^{a}	14.27±0.23^{d}	14.04±0.96^{d}	9.16±0.32^{b}
Texture						
Hardness (gf)	1006.42±160.20^{b}	815.20±72.30^{ab}	1058.52±314.07^{b}	801.08±42.40^{ab}	591.99±72.28^{a}	853.73±333.57^{ab}
Fracturability, (mm)	4.14±1.03^{b}	2.28±0.82^{a}	3.97±0.72^{b}	4.32±0.83^{b}	3.63±0.18^{ab}	3.96±0.57^{b}

*values with the same superscript in the same row had no significant difference $p < 0.05$.

Table 4: Sensory evaluation of the banana flakes

Parameter	Banana flakes*					
	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2
Color	5.27±0.98^{b}	5.53±0.94^{b}	4.47±1.41^{a}	5.20±1.06^{b}	5.33±0.80^{b}	5.23±1.28^{b}
Aroma	5.10±1.06^{a}	4.70±0.95^{a}	5.60±0.93^{b}	5.33±0.84^{b}	5.37±0.81^{b}	5.50±0.94^{b}
Taste	4.90±1.42^{ab}	4.77±1.25^{a}	5.37±1.03^{ab}	5.20±0.85^{abc}	5.43±1.01^{bc}	5.67±0.99^{c}
Crispiness	5.20±1.24^{ab}	5.00±1.14^{ab}	5.60±1.28^{b}	4.77±1.19^{a}	5.43±1.17^{ab}	5.43±1.30^{ab}
Overall	5.03±1.03^{ab}	4.87±1.01^{ab}	5.50±1.07^{b}	5.00±0.79^{ab}	5.43±0.82^{b}	5.40±1.07^{ab}

1: very much dislike; 2: dislike; 3: slightly dislike; 4: fair; 5: rather like; 6: like; 7: very much like. *values with the same superscript in the same row had no significant difference at $p < 0.05$.

Sensory evaluation

The average preference values of the banana flakes obtained by the hedonic rating test are shown in Table 4. Banana flakes received "rather like" preferences in color, aroma, taste, crispiness, and overall parameter. Based on the overall banana flake parameters, the highest value was the banana flakes made from black rice flour mixed with 'Ambon' banana flour. However, this value was not significantly different among the treatment. Thus, the preference value results indicate that all kinds of rice flours and banana flours can make banana flakes for the elderly.

CONCLUSIONS

Banana flakes made from black rice and 'Nangka' banana flours had the highest potassium, magnesium, and zinc contents as well as high antioxidant activity. Furthermore, the texture of this formulation had low hardness and high fracturability. However, all formulations had the same acceptability on sensory evaluation based on the overall parameter. Therefore, although banana flakes made using black rice flour and 'Nangka' banana flour was highly recommended for improving the health of the elderly, banana flakes prepared using other formulations were also acceptable.

ACKNOWLEDGEMENT

The authors are grateful to the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia for financing through INSINAS 2018, as well as the Research Centre for Appropriate Technology- National Research and Innovation Agency of Indonesia for providing experimental facilities.

Author's contributions

All authors contributed to the work presented in this manuscript. Dewi Desnilasari conducted the experiments, analyzed the data, and wrote the manuscript. Lia Ratnawati participated in the experiments related to analyzed chemical properties of the product and reviewed the manuscript. Dita Kristanti participated in the experiments related to antioxidant activity and anthocyanin content of the product and contributed to the review of the manuscript. Riyanti Ekafitri participated in the experiments related to the organoleptic testing of the product and contributed to the review of the manuscript. Diki Nanang Surahman participated in the experiments related to physical properties of the product and contributed to the review of the manuscript.

REFERENCES

Abbas, F. M. A., R. Saifullah and M. E. Azhar. 2009. Differentiation of ripe banana flour using mineral composition and logistic regression model. Int. Food Res. J. 16: 83-87.

Agustin, A. T., A. Safitri and F. Fatchiyah. 2021. Java red rice (*Oryza sativa* L.) nutritional value and anthocyanin profiles and its potential role as antioxidant and anti-diabetic. Indones. J. Chem. 21: 968.

Alkarkhi, A. F. M., Y. Shin and A. Mat. 2011. Comparing physicochemical properties of banana pulp and peel flours prepared from green and ripe fruits. Food Chem. 129: 312-318.

Aurore, G., B. Parfait and L. Fahrasmane. 2009. Bananas, raw materials for making processed food products. Trends Food Sci. Technol. 20: 78-91.

Baum, J., I. Kim and R. Wolfe. 2016. Protein consumption and the elderly: What is the optimal level of intake? Nutrients. 8: 359.

BSN. 1992. Standar Nasional Indonesia. SNI 01-2891-1992. Cara Uji Makanan Dan Minuman. BSN, Indonesia.

Ceunen, S. and J. M. C. Geuns. 2013. Steviol glycosides: Chemical diversity, metabolism, and function. J. Nat. Prod. 76: 1201-1228.

Chen, C. C., J. D. Hsu, S. F. Wang, H. C. Chiang, M. Y. Yang, E. S. Kao, Y. Ho and C. J. Wang. 2003. *Hibiscus sabdariffa* extract inhibits the development of atherosclerosis in cholesterol-fed rabbits. J. Agric. Food Chem. 51: 5472-5477.

Chen, X., X. Zhou, Z. Yang, C. Gu, Y. Tao, Q. Guo, D. Guo, H. Zhang, P. Xu, Y. Liao, Y. Wang, Q. Duan, X. Ran, L. Wang, Y. Li and X. Wu. 2019. Analysis of quality involving in minerals, amylose, protein, polyphenols and antioxidant capacity in different coloured rice varieties. Food Sci. Technol. Res. 25: 141-148.

Chung, H., A. Cho and S. Lim. 2014. Utilization of germinated and heat-moisture treated brown rices in sugar-snap cookies. LWT. Food Sci. Technol. 57: 260-266.

Ekafitri, R., N. Afifah, D. N. Surahman, N. K. I. Mayasti, F. L. Qodriah and W. Cahyadi. 2019. Evaluation of folic acid and iron stability, nutrition, and sensory value of banana flake. Biopropal. Ind. 10: 15-28.

Fatemeh, S. R., R. Saifullah, F. M. A. Abbas and M. E. Azhar. 2012. Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: Influence of variety and stage of ripeness. Int. Food Res. J. 19: 1041-1046.

Giacalone, D., K. Wendin, S. Kremer, M. B. Frøst, W. L. P. Bredie, V. Olsson, M. H. Otto, S. Skjoldborg, U. Lindberg and E. Risvik. 2016. Health and quality of life in an aging population-food and beyond. Food Qual. Prefer. 47: 166-170.

Karimi, R., M. Hossein and M. Ghasemlou. 2015. Application of inulin in cheese as prebiotic, fat replacer and texturizer : A review. Carbohydr. Polym. 119: 85-100.

Krisbianto, O., M. Astuti and Y. Marsono. 2016. Antihyperglycemic effect and antioxidants properties of black rice (*Oryza sativa* L. indica) cereal and anthocyanin extract on health and histopathology of hyperglycemic rats. Pak. J. Nutr. 15: 702-707.

Kumalasari, R., L. Vanadiani, R. Ekafitri, I. S. Nurminabari, D. Desnilasari, N. K. I. Mayasti and D. N. Surahman. 2021. Properties of Indonesian plantain cultivars during ripening and recommendation for flour ingredients. Czech J. Food Sci. 39: 35-41.

Nashrurrokhman, M., P. R. Sayekti, A. Safitri, Y. A. Purwestri and R. Pratiwi. 2019. Macronutrient and mineral contents of five local black rice (*Oryza sativa*) cultivars in Indonesia. Biodivers. J. Biol. Divers. 20: 3647-3653.

Oghbaei, M. and J. Prakash. 2016. Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. Cogent Food Agric. 2: 1-14.

Ratnawati, L. and N. Afifah. 2017. Physicochemical Properties of Flakes Made from Three Varieties of Banana. In: Proceedings of the 3rd International Symposium on Applied Chemistry. p. 020029.

Rifin, A. 2022. Marketed surplus of Indonesian rice production. Cogent Econ. Financ. 10: 2119694.

Ryu, S. N., S. Z. Park, S. S. Kang and S. J. Han. 2003. Determination of C3G content in blackish purple rice using HPLC and UV-Vis spectrophotometer. Korean J. Crop Sci. 48: 369-371.

Satusap, P., V. Chavasit, W. Kriengsinyos and K. Judprasong. 2014. Development of cereal and legume based food products for the elderly. Springerplus. 3: 1-8.

Shoaib, M., A. Shehzad, M. Omar, A. Rakha, H. Raza, H. Rizwan, A. Shakeel, A. Ansari and S. Niazi. 2016. Inulin : Properties, health benefits and food applications. Carbohydr. Polym. 147: 444-454.

Sompong, R., S. Siebenhandl-Ehn, G. Linsberger-Martin and E. Berghofer. 2011. Physicochemical and antioxidative properties of red and black rice varieties from Thailand, China and Sri Lanka. Food Chem. 124: 132-140.

Surahman, D. N., R. P. Rahayu, D. Desnilasari, R. Ekafitri, W. Cahyadi and T. Rahman. 2019. Formulation Banana Flake Using Different Type and Concentration of Fillers. In: IOP Conference Series: Earth and Environmental Science. p. 011001.

Wall, M. M. 2006. Ascorbic acid, vitamin A, and mineral composition of banana (*Musa* sp.) and papaya (*Carica papaya*) cultivars grown in Hawaii. J. Food Compos. Anal. 19: 434-445.

Yawadio, R., S. Tanimori and N. Morita. 2007. Identification of phenolic compounds isolated from pigmented rices and their aldose reductase inhibitory activities. Food Chem. 101: 1616-1625.