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Sensorial and chemical characterization of snack bar with variation of gembolo flour (*Dioscorea bulbifera*) and arrowroot starch (*Marantha arundinaceae* L.)

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Abstract

Non-communicable diseases such as diabetes mellitus, stroke, and other cardiovascular diseases have grown rapidly in the last 10 years. Non-communicable diseases can be caused by poor diet and various types of unhealthy foods. Along with the development of the times, snack bars increasingly become a trend as one of the healthy food products. On the other hand, the economic value of local tubers such as gembolo (*Dioscorea bulbifera L.*) and arrowroot tuber (*Marantha arundinaceae* L.) is still low. Both are known to have good functional value especially in dietary fiber, which is potential to be used as raw materials in the development of high fiber snack bar formulation. This research was conducted to evaluate the sensorial and chemical characteristics of developed gembolo and arrowroot composite snack bar of various formulations. The research design was a randomized complete design of one factor with five different formulations; gembolo and arrowroot composite in the ratio of 10:40, 20:30, 30:20, 40:10, 50:0 mixed with other snack bar ingredients. Sensory analysis was conducted followed by chemical analysis including water content, ash, protein, fat, carbohydrate, reducing sugar, resistant starch, and dietary fiber. Based on the results of the sensory analysis, the snack bar with the formulation of 40% gembolo flour and 10% arrowroot starch (F4) was the most preferred formula, where the snack bar was crunchy, less bitter, pleasant odor, and a slightly dark color. Water content, ash, protein, reducing sugar, resistant starch, and dietary fiber content increased with the addition of gembolo flour, while the fat content decreased. The developed snack bars contained 7.91 to 8.38 of dietary fiber. This study indicated that a healthy and nutritious snack bar could be made from gembolo and arrowroot.

1. Introduction

Roots and tuber crops are important cultivated staple energy sources, second to cereals, generally in tropical regions in the world. Nutritionally, roots and tubers have a great potential to provide economical sources of dietary energy, in the form of carbohydrates (Chandrasekara and Kumar, 2016). There are many of tubers in Indonesia that can be potentially developed such as gembolo (*Dioscorea bulbifera L.*) and arrowroot tuber (*Marantha arundinaceae* L.). Gembolo is a kind of tubers from *Dioscorea* family that grows abundantly as wild plants in Indonesia but not widely used. Several studies have shown hypoglycemic, antimicrobial, and antioxidant activities of *Dioscorea* sp. extracts (Kelmanson *et al*., 2000; Chan *et al*., 2004). Gembolo has several bioactive compounds such as dioscorin, diosgenin, and inulin which are beneficial for health. These bioactive compounds can enhance the body's defense mechanisms (immunomodulators), reduce the risk of metabolic diseases (hypercholesterolemia, dyslipidemia, diabetes, obesity), and prevent cancer and inflammation (Prabowo *et al*., 2014). The gembolo extract is also rich in polyphenolic compounds, especially flavonoids and catechin, which have contributed to its pronounced antioxidant and antidiabetic properties (Gao *et al*., 2002; Bhandari and Kawabata, 2004; Ghosh *et al*., 2012). The inulin content of gembolo had the highest value among other *Dioscorea* tubers with an inulin content of 1.61 mg/g (Winarti *et al*., 2013). Many researchers have investigated the medical potency of gembolo, including the action of preventive and therapeutic properties against several ailments such as arthritis, cancer, diabetes, gastrointestinal disorders, high cholesterol and inflammation due to diosgenin, a steroid saponin, present (Ghosh *et al*., 2014). Copper nanoparticles synthesized by gembolo has α-amylase and α-glucosidase inhibitory

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activity (Ghosh *et al*., 2015). Gembolo tubers contain high carbohydrates (19.8%) with glucomannan as the main polysaccharide. Arrowroot (*Maranta arundinaceae* L.) is one of the tubers which is highly potential to be used to make manufacture pastries, noodles, and white bread. Arrowroot tubers are beneficial to health due to the lower glycemic index as low as 14 (Marsono, 2001). Cookie bars from foxtail millet, arrowroot, and kidney bean also have a glycemic index of 37.6 (Lestari *et al*., 2017).

Nowadays, there is an increasing trend in the consumption of functional food products. This has greatly influenced the use of composite flours in which flours from locally grown crops replace a portion of wheat flour in food products (Olatunde *et al*., 2019). Various flour and starch are being developed to increase the use of local tubers and increase the variety of foods. One of the famous food products, snack bar can be produced using various types of ingredients and flour. Snack bar, a convenient and healthy ready-to-eat food which supplies balance nutrients (protein, fat, minerals, vitamins, calories, and carbohydrate) and to abate hunger (King, 2006; Ryland *et al*., 2010) is continuing to increase in sales. Snack bars with high dietary fiber have been developed for people with chronic diseases, especially non-communicable diseases such as diabetes. Dietary fiber is a component of polysaccharides that are not starch (non-starch polysaccharides) forming plant structures such as cellulose, hemicellulose, pectin, gum, lignin and others (IOM, 2005). Dietary fiber cannot be digested by human digestive enzymes and physically consists of water-soluble and water-insoluble dietary fibers. Many researches had reported about the development functional snack bar containing dietary fiber from fruit, jeriva flour (Sun-Waterhouse *et al*., 2010; Ho *et al*, 2016; Silva *et al*., 2016). However, snack bar formulation using gembolo flour as the main ingredient is not yet reported. This research was aimed to produce snack bars from gembolo and arrowroot composite and to determine the sensorial and chemical characterization of the developed snack bar.

2. Materials and methods

2.1. Materials

Gembolo tuber was obtained from Mertelu, Gedangsari, Gunungkidul, Yogyakarta. Arrowroot starch, black rice flour, tapioca, inulin, sorbitol, coconut oil, CMC, and skimmed milk powder were obtained from the local market in Yogyakarta. The materials used for the analysis include aquadest, petroleum ether, sodium hydroxide (NaOH), Sodium thiosulfate, sulfuric acid (H_2SO_4), 5% boric acid, BCG-MR indicator, celite, 0.02 M HCl (Merck), Nelson reagent (Nelson A-Nelson B), arseno-molybdate solution, pepsin enzyme, α-amylase enzyme, amyloglucosidase enzyme, pH 1.5 KCl -HCl buffer, buffer Trismaleate (0.1 M, pH 6.9), sodium acetate (0.4 M, pH 4.75), 4 M potassium hydroxide (KOH) solution, 2 M hydrochloric acid (HCl), glucose assay kit solution, 1% pepsin enzyme, pancreatin enzyme, alpha-amylase enzyme (Sigma), phosphate buffer solution (0.1M, pH 6), 1N HCl, 1 N NaOH, 95% ethanol solution, and acetone solution.

2.2. Preparation of gembolo flour

Gembolo tubers were processed into flour as described by Herlina *et al.* (2015). Gembolo tubers were peeled, washed with clean water, sliced into small pieces and dried using a cabinet dryer at 50-60°C for 24 hrs. The dried slices were milled using a hammer mill and sieved using a 100-mesh size. The flour was then packed inside bags and stored at room temperature.

2.3. Production of snack bar

The preparation of snack bars was carried out according to Sekar *et al.* (2013) with slight modification following the five different formulations as shown in Table 1.

Table 1. Formulation of *Snack Bar*

Formula	Gembolo Flour (%)	Arrowroot Starch (%)	Black Rice Powder (%)	Tapioca (%)
F1	10	40	40	10
F2	20	30	40	10
F3	30	20	40	10
F4	40	10	40	10
F5	50	0	40	10

All flours were mixed together. Then, 110 mL of water was added and mixed to form a smooth mixture for 10 mins. The dough was then milled using extruder machine with a mold diameter about 0.2 cm. The extruded dough was steamed for 10 mins, cooled at room temperature for 30 mins, and then dried using a cabinet dryer at 60°C for 6 hrs. The dried extrudate was then deep fried in coconut oil, crushed to small crumbs, and spun for 10 mins before adding with a binder to make a whole snack bar. The binder was consisted of inulin, sorbitol, coconut oil, CMC, and skimmed milk powder. The snack bar was then placed on a tray and waited for a few minutes until set. The compact snack bar was then cut with the size of a commercial snack bar on the market, which is 1.2 x 2.4 x 9.0 cm, then shaped and wrapped using metalize package.

2.4. Sensory analysis

The method of Kartika (1992) was used for sensory analysis, including hedonic and descriptive analysis. The snack bar was subjected to sensory analysis with thirty untrained panelists to evaluate the samples. For hedonic analysis, the panelists were asked to rate samples for color, odor, flavor, taste, and overall acceptance using a 7-point hedonic scale, where 1 was extremely unacceptable and 7 was extremely acceptable. For descriptive sensory analysis, panelists were asked to rate samples for texture, taste, odor, and color using 7-point hedonic scale, where 1 was extremely not crunchy and 7 was extremely very crunchy for texture; 1 was very bitter and 7 was extremely not bitter for taste; 1 was extremely unpleasant and 7 was extremely pleasant for odor; and 1 was very dark and 7 was very light for color.

2.5 Chemical analyses

Chemical analyses include proximate and functional analyses were determined to three selected snack bar products based on the high sensory analysis scores. The proximate analysis consisted of water content, ash, protein, and fat (AOAC, 1995). Carbohydrate was determined by difference. Reducing sugar was determined according to the method described by AOAC (1970). Resistant starch was determined with modified Burlap methods (Goni *et al*., 1996), while dietary fiber was estimated with the enzymatic-gravimetric method (Asp *et al*., 1983).

2.6 Statistical analysis

The research design used was a completely randomized design with a single factor namely the difference in composition of gembolo flour and arrowroot starch. A total of three selected products based on panelists preferences were continued with chemical analysis tests with three repetitions of treatment and three replications of each analysis. Statistical analysis was performed using SPSS 16 software. Data were analyzed by one-way ANOVA and continued with Duncan Multiple Range Test with a significance level of 5%.

3. Results and discussion

3.1 Sensory Analysis

Figure 1 shows the end product of the developed snack bar of gembolo and arrowroot composite.

Sensory evaluation is a scientific discipline used to determine, analyze, and interpret the reactions of the consumers to the characteristics of foods and other materials perceived by the senses of sight, smell, touch, taste, and hearing (Stone *et al*., 2012). The sensory analysis results can be seen in Table 2 for hedonic sensory analysis and Table 3 for descriptive sensory analysis.

Figure 1. Photograph of snack bar

Table 3. Descriptive sensory analysis of snack bar

Sample	Parameters			
	Color	Texture	Taste	Odor
F1	3.21[a]	3.79[a]	4.29[a]	4.61[a]
F2	3.86[a]	3.96[ab]	4.57[ab]	4.68[a]
F3	3.46[a]	4.54[bc]	4.89[b]	4.75[a]
F4	3.64[a]	4.79[c]	5.07[b]	5.07[a]
F5	3.86[a]	4.57[bc]	4.64[ab]	4.54[a]

Same alphabet superscript in the same column indicate no significant difference at 95% confidence interval.

It was found that the addition of gembolo flour in snack bars with a percentage of 10-50% gave a significant difference in texture, taste and overall acceptance. Otherwise, for color and aroma parameters, the results obtained were not significantly different. Hedonic sensory analysis showed that panelists liked and accepted the product. The addition of gembolo flour gave an acceptable texture. Descriptive sensory analysis showed that F4 snack bar had the highest score of 4.79 and the most significant different sample compared to the others ($P<0.05$). For the taste parameter, F4 snack bar was the most preferred with a score of 4.80. In the descriptive sensory analysis, F4 snack bar also had the highest score of 5.07 which meant the snack bar tasted not bitter. F1 and F2 snack bars were not significantly different, but both were significantly different from samples F3, F4, and F5. As for the odor parameter, F2, F4, and F5 snack bars were not significantly different. F1 and F3 snack bars were significantly different. Descriptive sensory analysis showed that all the snack bars' odor was not significantly different. Nevertheless, F4 snack bar had the highest score of 5.07 which meant

Table 2. Hedonic sensory analysis of snack bar

Sample	Parameters				
	Color	Texture	Taste	Odor	Overall acceptance
F1	4.57[a]	3.50[a]	4.03[a]	4.13[a]	4.10[a]
F2	4.40[a]	3.90[a]	4.37[a]	4.43[ab]	4.33[ab]
F3	4.53[a]	4.47[b]	4.63[c]	4.73[b]	4.70[bc]
F4	4.53[a]	5.00[c]	4.80[c]	4.60[ab]	5.03[c]
F5	4.73[a]	5.07[c]	4.60[c]	4.37[ab]	4.80[bc]

Same alphabet superscript in the same column indicate no significant difference at 95% confidence interval.

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the odor was pleasant. All the developed snack bars were not significantly different for the color parameter. F4 snack bar showed the highest overall acceptance score. This result indicated that the F4 snack bar was the most preferred by panelists, with the sensory characteristics of crunchiness, less bitter, pleasant odor and a slightly dark color. From the overall acceptance analysis, the snack bar with the addition of 30-50% (F3-F5) of gembolo flour was significantly different from the snack bar with the addition of 10% (F1) and 20% (F2) gembolo flour. The higher the addition of gembolo can increase the bitter taste because of diosgenin which belongs to the saponin group known to cause the bitter properties in gembolo. The addition of gembolo flour and arrowroot starch in the right proportion can increase the panelists preference for the snack bar. From the sensory analysis, snack bars with 30% (F3), 40% (F4), and 50% (F5) gembolo flour addition scored the highest level of preference.

3.2 Chemical analysis

Proximate analysis includes water content, ash, fat, protein, carbohydrate, and functional properties include reducing sugar, resistant starch, and dietary fiber was done on the gembolo flour, arrowroot starch, and the three selected most preferred snack bars. The results of chemical analysis of gembolo flour and arrowroot starch are shown in Table 4 while Table 5 shows the proximate analysis of the snack bar.

The water content analysis in the three preferred snack bars was significantly different. The increase of the moisture content of the snack bar can be related to the higher addition of gembolo flour. The main content of gembolo flour is a glucomannan polysaccharide which has a higher binding capacity to water (Herlina, 2012). The water content obtained from the present study had the same level with the result reported in fruit-based functional snack bars (5.6-11.7%), but lower than the result reported for fruit bars made from date paste (Parn *et al*., 2015) and novel energy snack bars (Ho *et al*, 2016). The value of ash (0.89-1.07%) was comparable to those reported for snack bars contained apple polyphenol extract (1.03%) and inulin with apple polyphenol extract (1.33%) (Sun-Waterhouse *et al*., 2010). The protein content of the snack bars increased with more addition of gembolo flour because gembolo flour has higher protein content than arrowroot starch. The present study showed snack bar had higher protein (11.61-12.19%) than fruit-based functional snack bars and fruit bar made from date paste by 1.07-2.74 and 2.22-4.06%, respectively (Sun-Waterhouse *et al*., 2010; Parn *et al*., 2015). While the fat content and carbohydrate content decreased with the addition of gembolo flour. The decrease in the fat contents may be attributable to the addition of gembolo flour which is lower in the fat content than arrowroot starch. The fat content (8.82-9.04%) was comparable with the snack bar added soy flour (9.32%) (Yadav and Bhatnagar, 2016).

3.3 Functional properties

Functional properties of snack bar include reducing sugar, resistant starch, and dietary fiber was shown in Figure 2. Reducing sugar and resistant starch content in

Table 4. Chemical characteristics of gembolo flour and arrowroot starch

Parameter	Amount (% wet basis)	
	Gembolo flour	Arrowroot starch
Water content	8.44±0.98	7.52±0.28
Ash	2.98± 0.86	1.53±0.66
Protein	3.43±0.53	1.88±0.45
Fat	0.85±0.15	1.47±0.55
Carbohydrate	41.69	52.20
Reducing sugar	7.18±0.40	5.90±0.42
Resistant starch	9.15	6.25
Dietary fiber	26.28±0.008	23.25±0.004

Table 5. Proximate analysis of snack bar

Parameter	Amount (%)		
	F3	F4	F5
Water content	7.35±0.25^{a}	7.78±0.09^{b}	8.22±0.39^{c}
Ash	0.89±0.04^{a} (0.96±0.05)	0.95±0.05^{a} (1.03±0.07)	1.07±0.04^{a} (1.17±0.04)
Protein	11.61±1.12^{a} (12.53±1.22)	11.98±1.46^{a} (12.99±1.59)	12.19±1.29^{a} (13.28±1.41)
Fat	9.04±0.52^{a} (9.76±0.56)	8.99±0.60^{a} (9.75±0.65)	8.82±0.73^{a} (9.61±0.79)
Carbohydrate	71.11^{a} (76.75)	70.30^{a} (76.23)	69.70^{a} (75.94)

Same alphabet superscript in the same column indicate no significant difference at 95% confidence interval.
Figures without parenthesis are based on dry basis while figures with parentheses are based on wet basis.

snack bar increased with more addition of gembolo tuber due to higher reducing sugar and resistant starch than arrowroot starch. Resistant starch content in F3-F4 snack bars were 6.66%, 9.30%, and 10.6% respectively. Ramirez-Jimenez *et al.* (2017) reported that resistant starch of snack bars with bean flour was from 7.07 to 9.83% respectively.

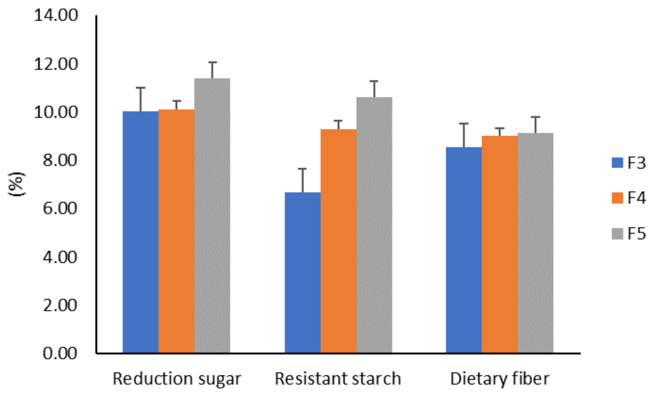

Figure 2. Functional properties of snack bar

The dietary fiber content in the developed snack bars increased with more addition of gembolo tuber. Gembolo flour contained higher dietary fiber than arrowroot starch which caused the higher dietary fiber content in the developed snack bars. The dietary fiber content in snack bar with formulations of F3, F4, and F5 were 7.91%, 8.30%, and 8.38% wet basis and 8.54%, 9%, and 9.13% dry basis respectively. The results of dietary fiber in F3, F4, F5 were higher than the other research. Sun-waterhouse *et al*. (2010) reported the dietary content of fruit-based functional snack bar was 5.13% wet basis. Silva *et al*. (2016) reported that dietary fiber of snack bars added of jeriva flour was 6.66%.

4. Conclusion

In conclusion, snack bars with addition of 30-50% gembolo flour were the most acceptable snack bar based on the hedonic and descriptive sensory analysis. F4 snack bars had the best sensory characteristic whereby the snack bar was crunchy, less bitter, pleasant odor and a slightly dark colour. Water content, ash, protein, reducing sugar, resistant starch, and dietary fiber content of the snack bars increased with the addition of gembolo powder, while the fat content was decreased. Preferred snack bars contained 7.91 to 8.38% of dietary fiber. This study indicated that a healthy and nutritious snack bar made from gembolo flour and arrowroot starch can help to prevent non-communicable diseases, especially diabetes. From this result, detailed studies concerned with analysis of glycemic index of the selected product was suggested to be carried out further.

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