The Quality of Snack Bar with Jack Bean Tempeh Flour and Red Dragon Fruit Albedo Extract Substitution

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ABSTRACT

The snack bar is a grab-and-go food with wheat flour as the primary component. In this context, exploring alternative substitute ingredients is necessary to strengthen food security, reduce Indonesia's dependence on wheat, and increase the nutritional content of snack bars. Generally, snack bars have a high-carbohydrate content. In this research, wheat flour was substituted with jack bean (*Canavalia ensiformis*) tempeh flour to enhance protein content, and red dragon fruit (*Hylocereus polyrhizus*) albedo extract was used to improve fiber content. Therefore, this research aimed to determine the chemical, physical, microbiological, and organoleptic properties, and to identify the best formulation of snack bars using jack bean tempeh flour and red dragon fruit albedo extract as substitutes. A Completely Randomized Design (CRD) method was used with four formulation treatments. The ratios of wheat flour, jack bean tempeh flour, and red dragon fruit albedo extract in the formulation were 100:0:0 (K), 80:15:5 (A), 65:25:10 (B), and 50:35:15 (C), respectively. Significant differences were analyzed on chemical, physical, and microbiological results using One-Way ANOVA and followed by a post-hoc Duncan Multiple Range Test (DMRT). The snack bar results ranged from 9.62-18.47%, 1.13-2.40%, 16.81%-19.53%, 6.01-9.76%, 52.56-65.26%, 0.96-11.24%, 2.09-11.27%, and 15.55-32.02 N moisture, ash, fat, protein, carbohydrates, insoluble fiber, soluble fiber contents, and hardness, respectively. The microbial test met the requirements for contamination according to the Indonesian Food and Drug Authority (BPOM). The best formulation for the snack bar was identified in treatment B (65:25:10).

Keywords: *Canavalia ensiformis*; fiber; *Hylocereus polyrhizus*; protein; snack bar

INTRODUCTION

The lifestyle of modern society needs practical food products, such as snack bars. In this context, snack bars are ready-to-eat products consumed as emergency food (Indrawan et al., 2018). These products use oats as the main ingredient, lacking essential amino acids such as lysine, methionine, and threonine (Ramírez-Jiménez et al., 2018). Wheat is also used as the main ingredient, but the flour is a highly imported commodity in Indonesia (Ladamay & Yuwono, 2014). Snack bars are expected to have additional benefits for health and be a source for daily nutritional needs with high protein and fiber from jack bean tempeh flour and the albedo of red dragon fruit extract.

Jack bean (*Canavalia ensiformis*) is a local bean commodity with a protein content of 28.6% (Susanti et al., 2013). This commodity contains cyanide (HCN) and

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phytic acids as toxic and anti-nutritional compounds, respectively (Gavi & Martati, 2018). The reduction of the compounds can be achieved by fermentation into tempeh. The processing of tempeh can also increase protein digestibility, soluble fiber, fine starch granules, and the protein content (Herawati et al., 2019). A flouring process must be carried out since tempeh with a high water content cannot be stored for a long time (Astawan et al., 2015). The substitution of jack bean flour in wheat food bar increases water, protein, fat, ash, and carbohydrate content (Rahmawati and Wirawan, 2021). Previous research shows that substituting jack bean tempeh flour for almond in snack bars increases protein, moisture, carbohydrates, and hardness. However, ash, fat, fiber content, and sensory acceptance are reduced (Abidin et al., 2020).

Red dragon fruit peel (*Hylocereus polyrhizus*) is a waste comprising 30-35% (Aprilia & Rakhmawati, 2021). This waste has the potential for high fiber content, which is 6.55% (Morais et al., 2021), specifically the albedo parts (Rafiq et al., 2018). Red dragon fruit albedo can be processed into an extract, simplifying the processing of the ingredients. Previous research showed that the red dragon fruit albedo extract could act as a binding agent in coconut milk ice cream (Kho et al., 2022). Snack bars with jack bean tempeh flour and red dragon fruit albedo extract are expected to increase the protein and fiber content. Based on the description, this research aimed to determine the chemical, physical, microbiological, and organoleptic properties of snack bars, and also to identify the optimal formulation using jack bean tempeh flour and red dragon fruit albedo extract as substitutes.

METHODS

Materials

The materials used were jack bean tempeh from Teger Food Yogyakarta, red dragon fruit peel collected from fruit salad shop waste in Yogyakarta Indonesia, sugar, salt, margarine, full cream milk powder, medium protein wheat flour, vanilla essence, Kjeldahl-tablets contain K_2SO_4, $CuSO_4$ x $5H_2O$ (Büchi, Flawil, Switzerland), and sulfuric acid (Mallinckrodt, Kentucky, USA). Boric acid, methyl red-bromo cresol green, sodium hydroxide, hydrochloric acid, hexane, ethanol, and acetone (Merck, Darmstadt, Germany). Plate Count Agar (PCA) Medium and Potato Dextrose Agar (PDA) Medium (Oxoid, Basingstoke, United Kingdom).

Jack Bean Tempeh Flour and Red Dragon Fruit Albedo Extract Preparation

Jack bean tempeh was sliced thinly and steamed for 15 minutes. Then, sliced tempeh was placed in the oven at 60 °C for 22 hours (UN450, Memmert, Germany). Dried tempeh was reduced in size with a grinder and sieved using a 60-mesh sieve (Retnaningsih et al., 2020, with modification).

Table 1. The formula of a snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute

Ingredients	Formulation treatment			
	K	A	B	C
Dry ingredients				
Wheat flour (g)	100	80	65	50
Jack bean tempeh flour (g)	-	15	25	35
Full cream milk powder (g)	10	10	10	10
Salt (g)	1	1	1	1
Vanilli (g)	1	1	1	1
Wet ingredients				
Red dragon fruit albedo extract (g)	-	5	10	15
Sucrose solution (mL)	20	20	20	20
Melted margarine (mL)	40	40	40	40
Water (mL)	15	15	15	15

The red dragon fruit peel was cleaned with running water, and the albedo was separated from the peel using a knife. Red dragon fruit albedo was added to water in a 1:1 ratio and reduced in size with a blender until a puree was formed. The puree was extracted. The extract was stored in an airtight jar and refrigerated (Fadhilah et al., 2021, with modification).

Snack Bar Formulation

The snack bar was formulated with four different treatments, as shown in Table 1. The ratios of wheat flour, jack bean tempeh flour, and red dragon fruit albedo extract were 100:0:0 (K), 80:15:5 (A), 65:25:10 (B), and 50:35:15 (C).

Dry ingredients, including wheat flour, jack bean tempeh flour according to the treatment, full-cream milk powder, salt, and vanilla, were mixed and stirred. Liquid ingredients, such as melted margarine, sugar solution, water, and red dragon fruit albedo extract, were also mixed. Liquid and dry ingredients were mixed and stirred until homogeneous, and the formed dough was kneaded until smooth. The dough was put into the oven at 120 °C for 50 minutes, cooled outside the oven for 15 minutes, and baked at 120°C for 1 hour to obtain snack bars (Singgano et al., 2019, with modification).

Proximate Analysis

Water, ash, fat, protein, and carbohydrate contents were analyzed using gravimetric, Soxhlet, Kjeldahl, and by-difference methods, respectively (Latimer, 2023).

Fiber Analysis

The insoluble fiber content test was performed by adding 1 g of fat-free samples to 100 mL of 1.25% H_2SO_4 solution. Additionally, the solution was heated until boiling and filtered through Whatman filter paper, whose constant weight was known. The residue left on the filter paper was washed with 100 mL of boiling deionized water (Aquadest) and 100 mL of a 3.25% NaOH solution. The filtrate was heated for 30 minutes and filtered through filter paper. Subsequently, the residue was rinsed with 100 mL of deionized water (Aquadest). The filter paper was dried and weighed until a constant final weight was obtained (Latimer, 2023).

The filtrate from the insoluble fiber analysis was used to isolate the soluble fiber content. Furthermore, the filtrate was added with 200 mL of 96% ethanol and put in a water bath at 60 °C for 1 hour. Whatman filter paper with a constant weight was added with 0.25 g of celite. The solution was filtered and washed with 2 × 10 mL of 78% ethanol, 2 × 10 mL of 96% ethanol, and 2 × 10 mL of acetone. The filter paper was dried and weighed until the final constant weight was obtained. The insoluble fiber (%) was determined by dividing the filter weight difference between the final and initial by the sample weight and then multiplied by 100%. The soluble fiber (%) was determined by dividing the filter weight difference between the final and initial and also celite by the sample weight and then multiplied by 100% (Latimer, 2023).

Physical Analysis

The snack bar texture test was carried out using a texture analyzer. The hardness was measured through a texture analyzer with a spherical probe (FRTS-50 NI, IMADA, USA). The hardness of the samples was determined under a one-cycle compression mode. The test was conducted with a displacement of 10 mm from the point of contact and a speed of 2 mm/s.

Microbiology Analysis

The total plate count (TPC) analysis was performed by using 1 g of sample, which was diluted with 9 mL of Aquadest and then diluted to a concentration of 10^(-3). Each dilution was prepared at 1000 µL and inoculated into PCA medium using a pour plate method. Petri dishes were incubated at 37 °C for 48 hours. The TPC (CFU/g) was determined by dividing the number of colonies by the volume of sample plated, and multiplying by the corresponding dilution factor (Latimer, 2023).

Organoleptic Analysis

A total of 30 panelists participated in the sensory evaluation of the snack bar samples. The panelists were college students aged 18–23 years, in good health, and free from any illness at the time of testing. Each sample weighed 20 g and was individually served. Each panelist evaluated one snack bar from the formulation using a four-point hedonic scale, where 1 and 4 showed "very dislike" and "very like," respectively. The evaluated sensory attributes included color, taste, aroma, and texture. During the evaluation, panelists were instructed to taste each sample, record scores for each attribute, and rinse palates with mineral water to minimize the effects of residual flavor. The overall preference of the samples was determined using a ranking test (Meilgaard et al., 2019).

Statistical Analysis

Test results data were analyzed using variance analysis (ANOVA) at a significance level of $\alpha = 0.05$ to determine the effect of each treatment on the variables. The analysis was continued with Duncan's Multiple Range Test (DMRT) when the variations were significant. The

Duncan test was conducted to determine the significant differences between treatments.

RESULTS AND DISCUSSION

Proximate Analysis

The proximate analysis included the determination of water, ash, fat, protein, and carbohydrate content. The analysis was performed on jack bean tempeh flour, red dragon fruit albedo extract, and snack bar. Table 2 shows the results of the proximate analysis on jack bean tempeh flour.

The water content in jack bean tempeh flour was 5.51%. These results were different from Affandi et al. (2020), who obtained a water content of 10.91% in jack bean tempeh flour. The difference was caused by the variation in drying temperature. This research used a drying temperature of 60 °C in the process of making flour, while Affandi et al. (2020) adopted 55 °C. The drying temperature was directly and inversely proportional to the evaporation rate and water content (Riansyah et al., 2013).

The ash content in jack bean tempeh flour from this research was 1.30%. The result was in line with Affandi et al. (2020), who obtained an ash content of 1.55%. This is also in line with the results of Purwandari et al. (2024), which stated that jack bean tempeh has an ash content of 1.71%.

The fat content in jack bean tempeh flour was 4.05% as shown in Table 2. The fat content was lower than the research by Affandi et al. (2020), who obtained 5.55%. This was caused by the differences in fermentation time when making tempeh. The duration of fermentation was directly proportional to the loss of fat content in food products (Rizal et al., 2022; de Reu et al., 1994). Affandi et al. (2020) used a 36-hour fermentation time for tempeh production, while the tempeh used in this research was fermented for 48 hours.

The protein content of jack bean tempeh flour was 29.40%. The result of this study is in line with the findings of Affandi et al. (2020) and Purwandari et al. (2024), which stated that the protein content of jack bean tempeh was 27.92% and 31.6%, respectively. The higher protein content was attributed to the longer fermentation time used in tempeh production. The fermentation process increased the protein content due to the decrease in carbohydrate and lipid content (Rizal et al., 2022; de Reu et al., 1994).

The carbohydrate content of jack bean tempeh flour was 59.70%. This result is in line with the previous research, which was 68.67% (Rahmawati et al., 2018).

Table 2. Proximate analysis of jack bean tempeh flour (%)

Characteristics	Jack bean tempeh flour*	Jack bean tempeh flour (Affandi et al., 2020)	Jack bean tempeh (Ramli et al., 2021)
Water	5.51 ± 0.14	10.91 ± 0.11	8.77 ± 0.49
Ash	1.30 ± 0.001	1.55 ± 0.13	1.40 ± 0.06
Fat	4.05 ± 0.03	5.55 ± 0.17	9.22 ± 0.17
Protein	29.40 ± 0.04	27.92 ± 0.60	32.12 ± 0.97
Carbohydrate	59.70 ± 0.21	65.04 ± 0.43	44.87 ± 1.99

*Data presented in the form of mean ± standard deviation (n = 3).

Table 3. Proximate analysis of red dragon fruit albedo extract

Characteristics	Red dragon fruit albedo extract *	Red dragon fruit albedo puree (Kho et al., 2022)	Red dragon fruit peel (Morais et al., 2021)
Water	96.55 ± 0.12	91.31 ± 0.88	88.56
Ash	0.38 ± 0.04	1.11 ± 0.12	2.08
Fat	0.05 ± 0.00	0.34 ± 0.02	0.70
Protein	0.32 ± 0.01	0.97 ± 0.01	0.47
Carbohydrate	2.70 ± 0.12	5.72 ± 0.85	8.09

*Data are presented in the form of mean ± standard deviation (n = 3).

Table 4. Proximate analysis of snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute (%)

Characteristics	Snack bar (wheat flour: jack bean tempeh flour: red dragon fruit albedo extract)*			
	100:0:0 (K)	80:15:5 (A)	65:25:10 (B)	50:35:15 (C)
Water	9.62 ± 0.35[a]	11.53 ± 0.25[b]	12.82 ± 0.15[c]	18.47 ± 0.55[d]
Ash	1.13 ± 0.06[a]	1.30 ± 0.10[a]	1.73 ± 0.20[b]	2.40 ± 0.00[c]
Fat	17.98 ± 0.25[a]	19.53 ± 0.13[b]	18.42 ± 0.05[c]	16.81 ± 0.03[d]
Protein	6.01 ± 0.06[a]	6.84 ± 0.12[b]	7.84 ± 0.14[c]	9.76 ± 0.10[d]
Carbohydrate	65.26 ± 0.10[a]	60.81 ± 0.25[b]	59.18 ± 0.21[c]	52.56 ± 0.45[d]

*Data is presented in the form of mean ± standard deviation (n = 3). Numbers with different letters in the same row show a significant difference at a 95% confidence level.

The carbohydrate content calculated using by difference method was affected by the variation in other proximate analysis results, such as water, ash, fat, and protein (Priharyanto et al., 2022).

The water content of red dragon fruit albedo extract was 96.55% (Table 3). These results were higher than the research by Kho et al. (2022), who obtained 91.31%. The red dragon fruit albedo extract used in this research was prepared by diluting it to 1:1 with water before blending.

The ash, fat, and protein content of red dragon fruit albedo extract were 0.38%, 0.05%, and 0.32%, respectively. These results were different from the research by Kho et al. (2022), who obtained 1.11% ash, 0.34% fat, and 0.97% protein content. The previous study used red dragon fruit albedo puree, whereas this research used red dragon fruit albedo extract.

The carbohydrate content in the red dragon fruit albedo extract was 2.70%. These results were lower than Kho et al. (2022), who obtained 5.72% because this research used extracted red dragon albedo.

The water content of snack bars showed a significant difference between treatments with a 95% confidence level. Snack bars in this research had a water content of 9.62% to 18.47% (Table 4). These results were lower than Romadhon et al. (2021), who obtained a water content of 17.33-20.63% in the Saga tree seed flour and dried jackfruit snack bar. Lower water content suggested better snack bar quality due to a longer shelf life and a lower risk of microbial contamination (Shah & Mir, 2022).

The substitution of jack bean tempeh flour and red dragon fruit albedo extract caused an increase in the water content. The increase was due to the use of red dragon fruit albedo extract, which had a high-water content (96.55%). The water content of the raw materials used affected the snack bars (Romadhon et al., 2021).

The ash content of the snack bars in Table 4 ranged from 1.13% to 2.40%, showing a significant difference between treatments. These contents were lower than those reported by Romadhon et al. (2021), who obtained 2.44-2.75% in a snack bar made with saga tree seed flour and dried jackfruit. The lower ash content in this research showed a higher quality and better results. This was because food products with lower ash content had a reduced risk of discoloration and were more stable during storage (Pangestuti & Darmawan, 2021).

The substitution of jack bean tempeh flour and red dragon fruit albedo extract caused an increase in the ash content of snack bars. The increase was due to jack bean tempeh flour, which had a higher ash content than wheat flour. Jack bean tempeh and wheat flour had an ash content of 1.30% and 0.47%, respectively. The main mineral compound found in jack bean tempeh is magnesium, with a concentration of 99.76 µg/g (Gabriel et al., 2011). The red dragon fruit albedo extract does not have a high effect on the ash content of snack bars (Table 3).

The fat content of snack bars showed a significant difference between treatments with a 95% confidence level. Snack bars in this research had a fat content of 16.81-17.98%. These results were lower than the research conducted by Subamia et al. (2020), who obtained a fat content of 20.54% in snack bars with 60% wheat and 40% tofu dregs flour. The fat content of snack bar treatments A and B was higher compared to K. This was due to the higher fat content of jack bean tempeh flour, which was 4.05% (Table 2), compared to wheat flour at 0.98%. The fat composition of jack bean is good for health due to low trans-fat, which was 0.03% linolelaidic acid, and dominated by unsaturated fat of 36.8–47.4% oleic acid (Sridhar & Seena, 2006). The fat content of treatment A, B, and C snack bars

decreased within the treatment. This was caused by the high water content of the red dragon fruit albedo extract, leading to a decrease in the percentage composition of fat (Fellows, 2000). The fatty acid composition of red dragon fruit peel was dominated by 6.17% oleic acid (Vijayakumar et al., 2018).

The protein content of snack bars showed a significant difference between treatments with a 95% confidence level. Snack bars in this research had a protein content of 6.01% to 9.76% higher than that of USDA (2022) snack bars (6.67%). The protein content of snack bars did not meet the requirements for high-protein food product claims, according to the Indonesian Food and Drug Authority (2016b), which was a minimum of 21% protein.

The substitution of jack bean tempeh flour and red dragon fruit albedo extract caused an increase in the protein content of the snack bars. The increase was due to jack bean tempeh flour, which had a higher protein content (29.40%) than wheat, according to the USDA (2019), which was 10.3%. The dominant essential amino acid compositions in the jack bean were leucine and lysine at 7.05% and 6.54%, respectively (Okomoda et al., 2016). Red dragon fruit albedo extract did not highly contribute to the protein content of the snack bar.

The carbohydrate content of snack bars showed a significant difference between treatments with a 95% confidence level. Snack bars in this research had a carbohydrate content of 52.56-65.26%. Substitution performed in the treatment increased the water, ash, and protein content, thus decreasing the carbohydrate calculated with the by-difference method (Romadhon et al., 2021).

The substitution of jack bean tempeh flour and red dragon fruit albedo extract decreased the carbohydrate content of the snack bar. This was caused by red dragon fruit albedo extract, which had a lower carbohydrate content of 2.70% compared to wheat flour, 10.3% (USDA, 2019). This is also due of higher protein and fat content in jack bean tempeh flour compared to wheat flour.

Fiber Analysis

Fiber is a complex compound that cannot be hydrolyzed by human enzymes. Insoluble fiber, such as cellulose, hemicellulose, lignin, and chitosan, has a bulky effect on the body, which increases excretion. Soluble fiber, including pectin, gum, and inulin, can lower blood cholesterol, slow stomach emptying, and possess a prebiotic effect (Galanakis, 2019).

The jack bean tempeh flour contained 11.66% soluble fiber (Table 5). The high content of soluble fiber found in jack bean tempeh flour was caused by fermentation (Syahadi et al., 2022). It is also due to the increase of beta-glucan during fermentation with *Rhizopus oligosporus* in beans (Rizal et al., 2022). Jack bean tempeh flour's insoluble fiber content was 3.17%. These results were consistent with Ramli et al. (2021), who obtained an insoluble fiber content of 3.62%.

The soluble fiber content of red dragon fruit albedo extract was 21.34%, with a standard deviation of 2.20%. These results were also in line with Morais et al. (2021), who reported a soluble fiber content of 22.91%. The pectin content in red dragon peel is 18.88% and is classified as a low-methoxyl type (Tristanto et al., 2024). Red dragon fruit's insoluble fiber content was 36.44% in line with Morais et al. (2021), who reported 34.34%.

The soluble fiber content of snack bars showed a significant difference between treatments with a 95% confidence level. Substitution of jack bean tempeh flour and red dragon fruit albedo extract caused an increase in the soluble fiber content. This was due to the soluble fiber content of jack bean tempeh flour and red dragon fruit albedo extract of 11.66% and 21.34%,

Table 5. Fiber analysis of jack bean tempeh flour (%), red dragon fruit albedo extract (%dry basis), and snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute (%)

Fiber content	Jack bean tempeh flour*	Red dragon fruit albedo extract*	Snack bar (wheat flour: jack bean tempeh flour: red dragon fruit albedo extract)**			
			100:0:0 (K)	80:15:5 (A)	65:25:10 (B)	50:35:15 (C)
Soluble	11.66 ± 1.07	21.34 ± 2.20	2.09 ± 0.70^{a}	6.59 ± 0.26^{b}	9.16 ± 0.32^{c}	11.27 ± 0.81^{d}
Insoluble	3.17 ± 0.06	36.44 ± 0.77	0.96 ± 0.11^{a}	6.66 ± 0.76^{b}	8.39 ± 0.10^{c}	11.24 ± 0.35^{d}
Total	14.82 ± 1.02	57.78 ± 1.51	3.05 ± 0.75^{a}	13.24 ± 0.62^{b}	17.52 ± 0.35^{c}	22.51 ± 1.05^{d}

*Data are presented in the form of mean ± standard deviation (n = 3).
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Table 6. Hardness of snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute (N)

Snack bar (wheat flour: jack bean tempeh flour: red dragon fruit albedo extract)	Hardness*
Commercial	32.68
100:0:0 (K)	32.02 ± 1.01[a]
80:15:5 (A)	21.43 ± 1.44[b]
65:25:10 (B)	18.40 ± 0.93[c]
50:35:15 (C)	15.55 ± 0.45[d]

*Data is presented in the form of mean ± standard deviation (*n* = 3). Numbers with different letters in the same column show a significant difference at a 95% confidence level.

respectively. These values were higher than the fiber content of wheat flour, according to USDA (2019), which was only 2.7%. Legumes, such as jack beans, and red dragon fruit peel had a dominant soluble fiber composition of gum and mucilage (Murray & Pizzorno, 2010) and pectin (Jamilah et al., 2011), respectively.

The insoluble fiber content of snack bars reported a significant difference between treatments with a 95% confidence level. The substitution of jack bean tempeh flour and red dragon fruit albedo extract increased the insoluble fiber content of snack bars. This was due to the high insoluble fiber content of jack bean tempeh flour and red dragon fruit albedo extract at 3.17% and 36.44%, respectively. The values were higher than in wheat flour at 2.7%, as reported by the USDA (2019). Jack bean and red dragon fruit peel contained the dominant component of insoluble fiber in the form of lignin, at 0.11% and 37.18% of the total, and carbohydrate component, respectively (Jamilah et al., 2011; Sridhar & Seena, 2006).

The total fiber content of snack bars showed a significant difference between treatments with a 95% confidence level. Snack bars with jack bean tempeh flour and red dragon fruit albedo extract substitution had a total fiber content of 13.24–22.51%. This was higher than commercial snack bars, which were 4.6%. The fiber content also met the requirements for high-fiber food product claims, according to the Indonesian Food and Drug Authority (2016b), which reported a minimum fiber content of 6% for a high-fiber claim.

Physical Analysis

Hardness is an important parameter that determines the physical characteristics of food products. This parameter refers to a product's ability to maintain shape when subjected to applied pressure. The increased compressive force shows that the hardness value of the product is also higher (Listyaningrum et al., 2018). The results of the snack bar hardness test are shown in Table 6.

The hardness of the snack bar showed a significant difference between treatments at a 95% confidence level. The level of hardness of control snack bars is nearly the same as commercial types (Table 6). The hardness value in this research was in line with commercial snack bars compared to previous research by Listyaningrum et al. (2018), who obtained 5.51-10.67 N.

The substitution of jack bean tempeh flour and red dragon fruit albedo extract caused a decrease in the hardness value. The decrease was attributed to the addition of red dragon fruit albedo extract, which had a high-water content of 96.55% (Table 2). Therefore, the water content of a product and the hardness value were inversely proportional (Engelen, 2018). The increase in protein and fiber content also reduced the hardness of snack bars. The high content of protein and fiber in raw ingredients could increase water absorption and the formation of pores in the dough to produce softer food products (Bayu et al., 2022).

Microbiology Analysis

Microbiological quality is a key indicator used to determine food products. This indicator reports the level of safety for consumption and food durability during storage (Atma, 2016). The results of the snack bar microbiology test are shown in Table 7.

Higher substitutions of jack bean tempeh flour and red dragon fruit albedo extract tend to increase the TPC value of the snack bar because of the water content. High amounts of free water in food tend to have a

Table 7. Microbial analysis of snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute (CFU/g)

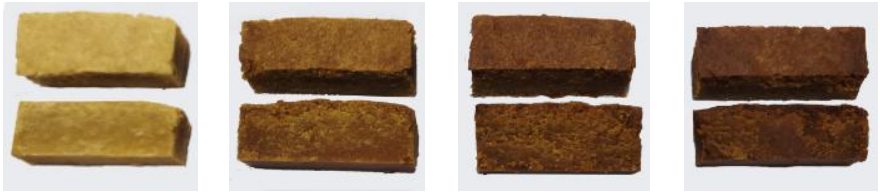
Snack bar (wheat flour: jack bean tempeh flour: red dragon fruit albedo extract)	Total Plate Count (TPC)*
100:0:0 (K)	$2.01 \times 10^3 \pm 1.75 \times 10^{3\,a}$
80:15:5 (A)	$4.20 \times 10^3 \pm 2.36 \times 10^{3\,a}$
65:25:10 (B)	$5.43 \times 10^3 \pm 5.03 \times 10^{2\,a}$
50:35:15 (C)	$6.42 \times 10^3 \pm 4.82 \times 10^{3\,a}$

*Data is presented in the form of mean ± standard deviation (*n* = 3). Numbers with different letters in the same column show a significant difference at a 95% confidence level.

Table 8. Organoleptic analysis of snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute

Characteristics	Snack bar (wheat flour: jack bean tempeh flour: red dragon fruit albedo extract)*			
	100:0:0 (K)	80:15:5 (A)	65:25:10 (B)	50:35:15 (C)
Color	2.97	2.8	**3.07**	2.73
Aroma	**3.40**	2.77	3.17	3.13
Taste	**3.27**	2.37	3.23	2.77
Texture	2.87	2.93	**3.17**	3.03
Average	3.13	2.72	**3.17**	2.92
Ranking	2	4	**1**	3

*1 = very dislike; 2 = dislike; 3 = like; 4 = very like



(a) (b) (c) (d)

Figure 1. Snack Bar Control (a); Treatment A (b); Treatment B (c); dan Treatment C (d).

higher level of contamination and lower durability. This is because free water in food products is a target for microorganism growth (Susilo et al., 2019). However, the Indonesian standard reports that the maximum TPC value is 1 x 10^4 CFU/g (Indonesian Food and Drug Authority, 2016a).

Organoleptic Analysis

An organoleptic test is conducted using human senses as a measuring tool. Generally, organoleptic tests in a food product include color, aroma, texture, and taste (Ernisti et al., 2018). The hedonic test is an organoleptic sensory analysis used to determine the level of preference and differences in the quality of similar products by giving a score to certain properties (Tarwendah, 2017). The hedonic snack bar organoleptic test results are shown in Table 8.

The color of the snack bar darkens with the addition of jack bean tempeh flour and red dragon fruit albedo extract. The dark color causes snack bar treatment C to have the lowest score and a less attractive appearance. The addition of jack bean tempeh flour and red dragon fruit albedo extract caused the color of the food product to darken or brown due to the presence of polyphenolic compounds binding to proteins (Gavi & Martati, 2018). Snack bar treatment K and A had a lower score than B because of pale color. Food products with pale colors had a lower level of preference for panelists (Maligan et al., 2018).

The aroma and taste parameters of the snack bar showed that treatment K, without any substitution, had the highest score. This could be due to the unpleasant aroma and taste of the jack bean tempeh, which had a rancid flavor and a bitter aftertaste (Gavi & Martati, 2018). The rancid flavor was caused by the hydrolysis of jack bean fat by the lipoxygenase enzyme, which produced a volatile compound such as ethyl phenyl ketone (Xiang et al., 2023). The bitter aftertaste was caused by bacteria during tempeh fermentation (Barus et al., 2008).

The sample treatment B had the highest score for the texture parameter. The panelists preferred a moderately firm snack bar texture, avoiding both extreme hardness and excessive softness (Pontang & Wening, 2021). The snack bar will be softer with the substitution of jack bean tempeh flour and red dragon fruit albedo extract.

The average score showed that snack bar treatment B was ranked as number one. Treatment B was a snack bar with 25% and 10% substitutions for jack bean tempeh flour and red dragon fruit albedo extract, respectively. These results reported that treatment B was the most preferred snack bar by the panelists.

CONCLUSION

In conclusion, the snack bar with jack bean tempeh flour and red dragon fruit albedo extract substitute increased the protein and fiber content. The results obtained were 9.62-18.47%, 1.13-2.40%, 16.81%-19.53%, 6.01-9.76%, 52.56-65.26%, 0.96-11.24%, 2.09-11.27%, and 15.55-32.02 N of moisture, ash, fat, protein, carbohydrates, insoluble fiber, soluble fiber contents, and hardness, respectively. The microbial test met the requirements for contamination according to the Indonesian Food and Drug Authority (BPOM). The best formulation of snack bars was observed in treatment B, which included substituting 25% and 10% jack bean tempeh flour and red dragon fruit albedo extract, respectively.

This research focused mainly on physicochemical and microbiological parameters, while factors such as long-term stability were not evaluated. The sensory evaluation was also conducted with a limited demographic group of panelists, which did not accurately represent broader consumer preferences.

CONFLICT OF INTEREST

All authors have no conflicts of interest.

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