Effect of okara flour and soybean flour composition on the chemical and sensory characteristics of snack bars

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Abstract. This study aimed to analyze the effect of varying compositions of okara flour (tofu residue) and soybean flour on the physicochemical and organoleptic characteristics of snack bars. The utilization of okara as a substitute material was driven by its potential to reduce waste from tofu processing industries while enhancing the product's nutritional value through its fiber and protein content. The combination with soybean flour was expected to balance the nutritional profile and improve the product's functional properties. The experimental design used was a Completely Randomized Design (CRD) with five treatment levels and three replications. The treatment levels comprised the following ratios of okara flour to soybean flour: 15%:85%, 25%:75%, 35%:65%, 45%:55%, and 55%:45%. The analyzed parameters included chemical analysis (moisture, fat, protein, and fiber content) and organoleptic tests (hedonic quality and multiple comparison tests). The results showed that the ratio of okara flour to soybean flour had a highly significant effect on moisture content and overall preference, a significant effect on color, aroma, and specific preference attributes, but no significant effect on organoleptic color, aftertaste, adhesiveness, chewiness, or overall multiple comparison scores. The 15%:85% ratio produced snack bars with the best characteristics.

1 Introduction

The growing public awareness of healthy eating patterns has driven various innovations in the development of functional food products that are not only delicious but also nutritious and environmentally friendly [1]. One popular functional food product is snack bars. Snack bars, or convenient bar-shaped snacks, are easy to consume and are often developed with specific health claims such as being high in fiber, protein, or energy [2]. Alongside the increasing demand for healthy snacks, it is essential to explore alternative ingredients that can enhance nutritional value while supporting sustainability principles within the food industry.

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Okara, or soybean pulp, is a by-product of soymilk and tofu production that has not yet been optimally utilized. In Indonesia, okara is commonly used as animal feed, even though nutritionally, it still contains crude dietary fiber, protein, as well as various vitamins and minerals [3]. The utilization of okara as an alternative food ingredient holds great potential for improving the efficiency of soybean processing while simultaneously reducing the burden of organic waste [3].

On the other hand, soy flour, as a primary product derived from whole soybeans, contains high levels of protein, isoflavones, and dietary fiber, which play a role in preventing degenerative diseases such as diabetes, cancer, and cardiovascular disorders [4]. The combination of soy flour and okara offers the potential to produce snack bars with a more balanced nutritional profile-particularly in terms of plant-based protein and dietary fiber-while also supporting food innovation based on agro-industrial by-products.

However, the influence of okara flour and soybean flour composition on the physical, chemical, and organoleptic characteristics of snack bar products has not been systematically studied. The proportion of these two ingredients is presumed to significantly affect moisture content, protein, fat, crude fiber, and organoleptic values, all of which influence consumer acceptability. Therefore, this study was conducted to examine the effect of varying compositions of okara flour and soybean flour on the characteristics of snack bars. The findings of this research are expected to provide a scientific basis for the development of healthy snack products made from agro-industrial by-products that are nutritionally rich, consumer-preferred, and contribute to reducing food waste.

2 Materials and methods

2.1 Materials

The materials used in this study include okara flour from a tofu factory in Terentang Baru Village, Batin XXIV Subdistrict, Batanghari Regency; Soybean flour of the Fooldaltern brand; Chocolate spread; Madurasa-brand honey; palm sugar; salt; margarine; cashew nuts; rice crispies; vanilla; and eggs. The chemical reagents used during the analytical procedures were potassium sulfate (K_2SO_4, sulfuric acid (H_2SO_4), sodium hydroxide (NaOH), methyl red indicator, phenolphthalein (PP) indicator, hexane, and hydrochloric acid (HCl). The equipment used in this research included an oven, cake molds, a 60-mesh sieve, a blender, a digital scale, a dessicator, a Soxhlet apparatus, a color reader, and standard laboratory glassware required for the analyses.

2.2 Research design

The research employed a Completely Randomized Design (CRD) with five treatments, consisting a ratios of Okara flour to soybean flour as follows: 15%:85% (F1); 25%:75% (F2); 35%:65% (F3); 43%:55% (F4); and 55%:45% (F5). Each treatment was replicated four times, resulting in a total of 20 experimental units.

2.3 Research design

2.3.1 Preparation of okara flour

The preparation of okara flour followed a modified method from Yuniarti [5], consisting of pressing, steaming, roasting, drying, grinding, and sieving. The pressing stage was carried out manually by squeezing the okara using a filter cloth. Steaming was performed by steaming the okara for 30 minutes at 100 ºC. The roasting stage involved roasting the okara over low heat for 15 minutes. Drying was done by sun-drying the okara under direct sunlight until the moisture content reached 5.6%. The next step was grinding using a blender, followed by sieving with a 60-mesh sieve.

2.3.2 Snack bar preparation

The snack bar preparation followed the method by Desiliani [6], consisting of the following stages: ingredient preparation, weighing of raw materials, mixing, molding, baking, cooling, and cutting to the desired size. The weighing process was adjusted according to the treatment ratios, with other ingredients including: sugar (35 g), salt (1 g), egg (30 g), margarine (35 g), honey (30 g), chocolate spread (60 g), cashew nuts (20 g), rice crispies (15 g), and vanilla (1 g).

The molding stage was carried out using a baking tray measuring 15 cm in length, 12 cm in width, and 1.5 cm in thickness. Baking was performed in an oven at a temperature of 110 ºC for 50 minutes. After baking, the snack bars were cooled at room temperature. Once cooled, the snack bars were cut into pieces and stored.

2.4 Parameters

2.4.1 Proximate analysis

The proximate analysis conducted in this study included the determination of moisture content, crude protein, crude fat, and crude fiber, following the method by Sudarmadji [7]. Before analysis, the samples were finely ground using a mortar and pestle. The prepared samples were then stored in airtight containers under dry, clean, and cool conditions and labeled for further analysis.

Moisture content was determined using the oven drying method. Crude fat was measured using the Soxhlet extraction method. Crude protein was calculated by multiplying the percentage of nitrogen by a conversion factor of 6.25. Crude fiber was determined using the gravimetric method, which involves sequential acid and alkaline hydrolysis, followed by drying, ashing, and calculating the difference in residue weight before and after combustion.

2.4.2 Organoleptic test

The organoleptic test followed the method of Setyaningsih [8] and was conducted by 25 semi-trained panelists who were students of Agricultural Product Technology at Jambi University. The test evaluated several sensory parameters, including color, aroma, taste, aftertaste, and texture (stickiness and ease of chewing), using a 5-point hedonic scale, where: 5 = like very much; 4 = like; 3 = slightly like; 2 = dislike; and 1 = dislike very much. In addition, a multiple comparison test for overall acceptability was conducted using a 7-point numerical scale, where: 7 = much more preferred than reference (R); 6 = more preferred than (R); 5 = slightly more preferred than (R); 4 = equally preferred as (R); 3 = slightly less preferred than (R); 2 = less preferred than (R); 1 = much less preferred than (R).

2.5 Data analysis

The experimental data were statistically analyzed using Analysis of Variance (ANOVA) at significance levels of 5% and 1%. If a significant effect was observed, it was followed by Duncan's New Multiple Range Test (DNMRT) as a post hoc analysis.

3 Results and discussion

3.1 Moisture content analysis

Based on the result of the analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DNMRT), the variation in the ratio of okara flour to soybean flour had a highly significant effect on the moisture content of the snack bars. Table 1 shows that treatment F5 had the highest moisture content, while F1 had the lowest. The higher the proportion of soybean flour in the snack bar formulations, the lower the resulting moisture content. In contrast, formulations containing a greater amount of okara flour resulted in higher moisture content

Table 1. Moisture content of snack bars with varying okara and soybean flour ratios

Okara Flour: Soybean Flour (%)	Moisture content (%)
15:85 (F1)	10.63^{a}
25:75 (F2)	11.45^{b}
35:65 (F3)	$12,5^{c}$
45:55 (F4)	13.75^{d}
55:45 (F5)	14.9^{e}

Note: different superscripts on the same column show that the values are significantly different at $p<0.05$ DNMRT test.

Okara flour contains a high level of crude fiber, particularly insoluble dietary fiber (IDF) [9]. This type of fiber has a complex structure with numerous hydroxyl groups that can bind large amounts of water [10]. Consequently, products formulated with a higher proportion of okara flour tend to have a higher moisture content [11] as these fibers absorb and retain water during the snack bar production process. In contrast, soybean flour contains less dietary fiber than okara flour [12], resulting in a lower water-binding capacity, which leads to lower moisture content in snack bars with higher proportions of soybean flour.

Moisture content is a critical parameter influencing the texture and shelf life of snack bars. For snack bars with a crispy texture, the ideal moisture content is approximately 3%, whereas for chewy-textured products, it can reach up to 10%. According USDA [13], the standard moisture content for snack bars is approximately 6.1% per 100 g. Based on Table 1, the formulation that most closely approaches the ideal moisture content is the 15% okara flour: 85% soybean flour ratio, which yielded a moisture content of 10.63%. Higher moisture levels than this may negatively affect product quality, particularly in terms of microbial stability, texture, and shelf life. Therefore, other formulations are not recommended due to their excessive moisture content.

3.2 Protein, fat, and crude fiber analysis

The best treatment, based on the flour of okara to soybean flour (15%:85%), yielded results as presented in Table 2: protein (4.5%), fat (22.19%), and crude fiber (6.28%).

Table 2. Protein, fat, and crude fiber content of the product with the best moisture content ratio.

Replication	Protein (%)	Fat (%)	Crude fiber (%)
1	4.85	23.32	5.25
2	4.77	22.14	5.61
3	4.62	21.10	6.07
4	4.74	22.21	8.17
Average	4.75	22.19	6.28

The protein content, with an average of 4.75%, is relatively low compared to the USDA standard (8 g), which may be attributed to the dominance of soybean flour (85%) that has undergone defatting, thereby reducing its protein fraction [14]. Okara (15%), as a by-product of tofu processing, also contains less protein than whole soybeans [9]. The fat content, averaging 22.19%, is higher than the USDA reference value (20.4%), and this can be influenced by the composition of the raw materials. Although partially defatted, soybean flour still retains a significant fat content (typically 18-25%).

The fat contribution from okara flour should also be considered, as tofu processing does not completely remove fat. In addition, ingredients such as margarine, chocolate spread, and cashew nuts further contribute to the high fat content observed in the snack bars. The crude fiber content, with an average of 6.28%, shows considerable variation across replications. This is likely due to the heterogeneity of okara samples, which naturally contain insoluble dietary fiber components (such as cellulose and hemicellulose) [9] that are not evenly distributed.

3.3 Organoleptic test

Based on the result of the analysis of variance (ANOVA) for hedonic color evaluation, the ratio of okara flour to soybean flour did not have a significant effect on the hedonic quality of the snack bar's color, had a significant effect on aroma, and had a highly significant effect on taste. A more detailed overview is presented in Figure 1.

Figure 1 shows that in the color evaluation, formulation F1 was the most preferred by the panelists. The aroma of the snack bar was also best appreciated in F1, while the high proportion of okara in F5 led to a lower aroma score, likely due to the increased intensity of undesirable "beany" odors as the proportion of okara increased [15]. F1 also had the best taste, while F5 received the lowest score, attributed to its unpleasant, beany flavor. The aftertaste, with scores ranging from 2.72 to 3, indicates that the product was perceived as having little to moderate aftertaste. Differences in aftertaste among formulations were relatively small, but F offered a more neutral finish with a score of 2.84.

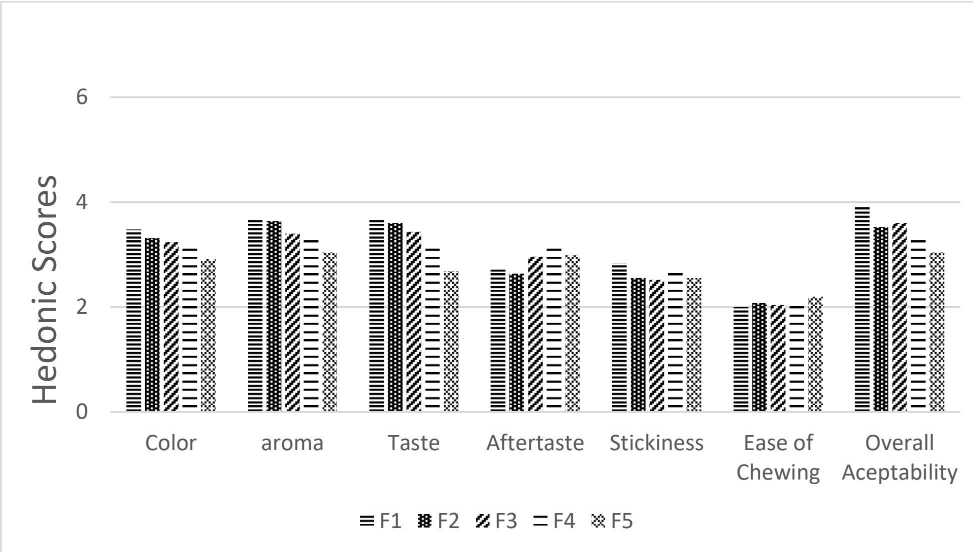

Fig. 1. The average hedonic quality scores of snack bars with various ratios of okara flour and soybean flour. The ratio of Okara flour (%) to soybean flour (%) is as follows : 15:85 (F1); 25:75 (F2); 35:65 (F3); 45:55 (F4); and 55:45 (F5).

Regarding stickiness, the scores ranged between 2.0 and 2.84, indicating that the texture was perceived as non-sticky to slightly sticky; the lower the scores, the closer it is to "non-sticky". Ease of chewing was rated between 2.00 and 2.20, meaning the product was easy to chew. In terms of overall acceptability, scores ranged from 3.04 to 3.92, meaning that the product was rated between slightly less preferred than R to equally preferred as R, with higher values indicating a closer similarity to the commercial reference product (Soyjoy).

4 Conclusions

The snack bar formulation with a 15%:85% ratio of okara flour to soybean flour produced the best results, containing 10.63% moisture, 4.75% protein, 22.19% fat, and 6.28% crude fiber. The product exhibited a pleasant aroma and taste with a mild aftertaste. Its texture was slightly sticky, easy to chew, and received an overall acceptability score comparable to commercially available products. The study confirmed okara as a suitable ingredient for snack bars, offering nutritional value and acceptable sensory quality. Future research was suggested to examine shelf life, storage stability, and the use of functional ingredients such as vegetable oils to enhance the product's health benefits.

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