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Physical properties, antioxidant activity, and hedonic quality of food bars processed from moringa seed (*Moringa oleifera*) mixed with dried tomato and flaked corn ('Jagung Titi')

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Abstract

Food bars are solid, bar-shaped snacks that are made of a variety of dry components such as grains, nuts, and dried fruits. The physical, chemical, and hedonic characteristics of the processed food bars are significantly influenced by the raw material components. The product with the best physical and hedonic characteristics in the previous study's 100% moringa seed-based snack bar antioxidant activity value was still about 60%. This study aimed to optimize the characteristics of physical, hedonic, and antioxidant activity of processed snack bars. Two fillers were combined in varying amounts as part of the ingredients: tomato (50%, 60%, and 70%) and titi corn (50%, 60%, and 70%). According to the findings, all treatments produced brightness (L*) values between 5.09 and 9.19 with a*-0.93 to 2.57 and b* 13.85 to 28.37, and hardness values between 45 and 88 Newton (using texture analyzer). Antioxidant activity ranged from 60% to 88%, and the hedonic test revealed that moringa seed food bars with the addition of 60% tomato and 70% locally grown peeled corn had the highest level of preference. These foods were yellowish brown to glossy brown in color, had a distinct aroma, didn't taste bitter, and were solid and compact in texture.

1. Introduction

Moringa seed food bars are an effort to optimize functional compounds by adding moringa seeds to solid bar-shaped snacks made from a combination of the main dry ingredients such as grains, nuts, and fruit then bound together with the help of a binder as a binding agent from sucrose, honey, milk, chocolate, and several other ingredients. Moringa seed fortification can increase food bars' functional compounds, including antioxidant activity, dietary fiber, antimicrobials, and bioactive compounds, including alkaloid compounds, flavonoids, phenolics, and triterpenoids/steroids (Ikalinus *et al.*, 2015), as well as ascorbic acid, sterols, tocopherols and flavonoids (Tsaknis *et al.*, 1998; Lala and Tsaknis, 2002). The protein content of Moringa seeds reaches 35.97% (Olagbemide and Philip, 2014), higher than the origin of other plant parts. Kumar *et al.* (2022) reported that moringa seeds contain a high level of protein content (~52%) consisting of all the essential amino acids and could also act as a potential source of functional protein isolates applied in food and biomedical industries.

Although Moringa seeds are rich in bioactive compounds, they need certain treatments to be applied as food products due to their very bitter and harsh flavor. The stages of the treatment process reduce the shortcomings that seem to have an impact on reducing the percentage of antioxidant activity and several other nutritional components, such as protein.

A study by Idayati and Kartiwan (2022) reported that due to the process during the processing of food bars fortified by 100% moringa seeds, the percentage of antioxidant activity, total phenolic, and vitamin C dropped to 60% in the final product produced. To anticipate the decline that occurs, other raw materials are needed to complement the functional content of moringa food bars, both in quality and quantity. The kinds of fruits selected were tomatoes and papaya with nutritional content including vitamins A, C, K, potassium folate, thiamin, niacin, and pyridoxine, as well as phytochemical compounds, especially phenolic compounds, and carotene. The carotene is mostly in the form of lycopene, which gives the ripe tomato fruit its red color (Marti *et al.*, 2016; Soytong *et al.*, 2021). The use of oven-dried tomatoes, according to Tan *et al.* (2021), is better in reducing lycopene degradation. In terms of its antioxidant activity, results also showed no

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significant difference compared to freeze-dried tomatoes. Meanwhile, the East Nusa Tenggara region's traditional dish, known as "Jagung Titi", is made by frying half-cooked "Pena molo fatu" yellow maize variety before it is pounded into flat sheets. It is expected that adding "jagung titi" as a source of carbohydrates will increase the amount of nutrients and phytochemicals in food bars products, including vitamins (A, B, E, and K), minerals (Mg, P, and K), phenolic acids (ferulic acid, coumaric acid, and syringic acid), carotenoids and flavonoids (anthocyanins), and dietary fiber (Siyuan *et al.,* 2018). Additionally, flaked corn might make the snack bar's texture crispier, thus enhancing its hedonic value.

This study aimed to design a combination of dry ingredients of moringa seed food bars with tomato and cornflakes to form the best physical property profile, which is a very important quality attribute to determine the assessment of the final product produced. Therefore, an objective physical property analysis would further support the hedonic test analysis from panelists, which tends to be subjective. Furthermore, the analysis of physical properties, antioxidant activity, and hedonic tests would in turn produce food products in the form of food bars with optimal functional value that are favored by consumers as an effort to diversify local food ingredients.

2. Materials and methods

2.1 Plant materials

Materials used for this study consisted of moringa seeds, dried tomatoes of local varieties from Timor Island, local cornflakes (known as 'jagung titi' from local yellow corn of the "Pena molo fatu" variety) obtained from market in Timor Island Indonesia, and natural honey (78°Brix) obtained from South Central Timor Regency, East Nusa Tenggara (NTT) province. Roasted peanuts (moisture content 4%) were from the local market of Kupang city, NTT. Rice crackers purchased online from the online marketplace (Tokopedia, Indonesia), plain yogurt (Greenfields, Indonesia), ethanol 95%, v/v (Merck, Germany), and hexane pro analysis. 99% (Merck 104367), methanol 99.8% (Merck 1.06009.2500), α tocopherol standard (Sigma T3634), DPPH (2,2-diphenyl-1-picrylhydrazyl) (Sigma Aldrich MFCD00007231), and distilled water (Water one, Indonesia).

2.2 Preparation of dried tomato and local cornflakes ('Jagung Titi')

The preparation of dried tomatoes was carried out by following the method described by Wastawati and Marwati (2019) with slight modifications. Only tomatoes with a uniform size, fresh and had thick flesh were selected. All tomatoes were washed, and the seeds were removed through cross-cutting around 3 cm. Tomato fruit without seeds was then sprinkled with sugar solution (40%, v/v) and soaked overnight (24 h) at room temperature. The soaked tomatoes were then dried at 80°C for 16 h until the moisture content reached 10% and sliced into small cubes with a weight of 2 g. While 'Jagung Titi' was processed by soaking the cornflakes seeds (*Zea mays Certaina*) in clean water for 12 hours, and then draining. After that, it was roasted until half-cooked, then directly flattened by punching with a pestle.

2.3 Food bars processing

Food bars are processed according to the modified method of Kusumawardhani (2017), in which all ingredients were calculated from the total weight of moringa seeds (100%). The first processing step involved mixing dried ingredients, such as moringa seeds, with dried tomato treatments, with the following percentages: T1 = 50%, T2 = 60%, and T3 = 70%. For cornflakes, the percentages were as follows: J1 = 50%, J2 = 60%, and J3 = 70%. The mixture was then added with wet ingredients (150% yogurt, w/v) and (50% honey, w/v), and then baked.

2.4 Physical analysis of food bars

The color intensity of the samples was determined using the Colorimeter AMT-501 (Bunga et al., 2021), which measures the L*, a*, and b* values. The chroma (C) was then calculated using the formula :

$$C = \sqrt{a^2 + b^2}$$

which quantifies the color intensity. For texture analysis, the hardness (in grams) was measured using the Texture Analyzer Brookfield CT 3, and the peak force during the compression test was used as an indicator of hardness.

2.5 Antioxidant activity of food bars

The antioxidant activity was analyzed using the DPPH method (1,1-diphenyl-2-picrylhydrazyl) based on Idayati *et al*. (2019). Approximately 2 g of the sample was dissolved in methanol (2%, w/v). The resulting solution was then added with 1 mL of 200 µM DPPH diluted to 5 mL using methanol and let to incubate under dark conditions. For the blank solution, it was prepared by mixing 1 mL DPPH solution + 4 mL methanol and measured at a wavelength of 517 nm. The absorbance data obtained was then calculated by using the following formula:

$$\text{Antioxidant activity (\%)} = \frac{\text{OD blank solution} - \text{OD sample solution} \times 100\%}{\text{OD blank solution}}$$

Meanwhile, the physical test used Colorimeter AMT -501 (Bunga *et al*., 2021) for color variables, and Texture

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Analyzer Brookfield CT 3 for food bars' hardness texture.

2.5 Sensory analysis

Sensory analysis of the food bars was carried out using hedonic test by measuring the level of liking for the quality attributes of color, aroma, taste, texture, and the overall level of acceptance by 30 moderately trained panelists by assessing the quality attributes on a rating scale of 1 = very dislike, 2 = dislike, 3 = neutral, 4 = like, to a value of 5 = very like. The assessment was conducted by presenting each of the panelists with 9 samples of the food bar with a size of 4 × 2 × 1 cm.

2.6 Statistical analysis

Data from the physical and antioxidant activity on moringa seed food bars with the addition of tomato and cornflakes 'Titi' were repeated three times. The value of each parameter is the mean±standard deviation of error.

3. Results and discussion

3.1 Physical analysis

In addition to the nutritional content of food products, color is also among the most important quality assessments from the first impression of appearance. L represents the brightness of the color, from 0 to 100, the brighter the color of the sample, the higher the L value, while a represents a certain red-green color, and b represents yellow-blue. The results of the physical analysis of moringa seed food bars with the addition of tomato and local cornflakes using Color Intensity (Chroma) testing based on Bunga *et al.* (2021) and a texture analyzer tool to assess Hardness can be seen in Table 1.

The L* symbol in Table 2 showed a decreased tendency of brightness level with the increasing percentage of the tomatoes added. In contrast, the brightness level tended to decrease with the increasing percentage of local cornflakes added. According to Lembong and Utama (2021) and Ummah *et al.* (2021), positive a* sign results indicate red coordinates and negative values indicate green coordinates. The data has a* values that have positive and negative values for all samples and are small. Thus, the chromatic range produces red and green variants with less intensity and variation. This is thought to be the result of the combination of tomato and cornflakes treatment percentages, as well as uneven tomato treatment on the surface of some samples. While the b* values obtained for the symbols are all positive, indicating yellow coordinates, consistent with the color of moringa seed food bar products, with the addition of tomatoes and cornflakes. The results of the analysis of the level of texture hardness show that the value decreases with increasing percentage of tomato and cornflakes treatment in the product, so there is a tendency to decrease the strength of interaction (cohesion) in the product due to less liquid binder material as a binder, so that the food bar is easily broken. Therefore, if the percentage of ingredient components is increasing, the binder material also needs to be added. According to Rahmi *et al.* (2021), in research on soybean-based snack bars that the higher the water content in the sample, the smaller the fracture force.

Based on the data, a* value has positive and negative values for all samples and is of small value. Thus, the chromatic range produced red and green variants with fewer and more varied intensities. This was thought to be the result of a combination of the percentage of tomato and cornflake mixtures, as well as the uneven distribution of tomatoes on the surface of some samples. While the b* values obtained for the symbols are all positive, showing yellow coordinates, consistent with the color of the moringa seed food bar product, with the addition of tomatoes and local cornflakes. Analysis of the level of texture hardness showed a decreasing value with an increase in the percentage of tomato and cornflake mixture on the product. Thus, the strength of interaction (cohesion) in the product tended to decrease as a result of the binding material (binder) being less liquid, which made the food bar break easily. Therefore, if the percentage of the raw material increases, the binder material also needs to be increased. According to Rahmi

Table 1. Color intensity (chroma) and hardness level of moringa seed food bars with the addition of tomato and cornflakes.

Samples	L* (Lightness)	a* (Redness)	b* (Yellowness)	C (chroma)	Hardness (Newton)
T1J1	7.70±0.25	-0.15±0.02	13.85±0.63	13.85±0.63	36.64±2.41
T1J2	4.08±0.16	-0.27±0.01	14.46±0.16	14.46±0.16	25.07±3.22
T1J3	10.41±0.12	0.82±0.05	16.42±0.06	16.44±0.07	18.81±1.54
T2J1	9.19±0.17	0.39±0.08	13.91±0.21	13.92±0.21	17.79±5.28
T2J2	5.71±0.11	-0.93±0.05	28.37±0.59	28.39±0.59	20.63±6.99
T2J3	7.58±0.15	-0.16±0.01	17.31±0.30	17.31±0.30	16.43±4.84
T3J1	5.09±0.23	0.85±0.07	16.43±0.27	16.45±0.23	17.40±4.92
T3J2	6.92±0.18	1.34±0.08	15.48±0.78	15.54±0.77	15.41±4.56
T3J3	7.57±0.08	2.57±0.17	14.04±0.29	14.27±0.26	11.52±2.67

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et al. (2021), in soybean-based snack bars, the higher the water content, the smaller the fracture force.

3.2 Antioxidant activity analysis

Antioxidant activity analysis of moringa seeds with the addition of tomato and cornflakes 'Titi' can be seen in Table 2. Table 2 shows that, based on the antioxidant activity tested with the DPPH method, the trend of the highest value was found in the combination with an increasing percentage of tomato and cornflakes mixture, which was in the T3J2 sample treatment consisting of 70% tomato and 60% cornflakes. The combination of the right formulation of tomato seeds, cornflakes and moringa could increase the antioxidant activity function of the product to anticipate changes in bioactive compounds due to thermal processing. Tomatoes are rich in bioactive phytochemicals beneficial to health. Lycopene and β-carotene are the two main active ingredients in tomatoes, which have strong antioxidant properties apart from quercetin, kaempferol, naringenin, caffeic acid, and lutein, which also exhibit antiproliferative, antidiabetic, and anti-inflammatory activities (Ali *et al*., 2020). Corn also contains beneficial bioactive compounds such as vitamin A (carotenoids), vitamin E precursors, higher levels of phenolic acids, as well as xanthophyll, lutein and zeaxanthin, which act as antioxidants. In addition, these compounds could also form macular pigment as reported by Suarni (2010) and Prasanthi *et al*. (2017) that during different processing methods, phenolic profiles can form both in certain quality and quantity.

Table 2. Results of antioxidant activity analysis of moringa seeds with tomato and cornflakes 'Titi' addition.

Samples	Antioxidant activity (%)
T1J1	45.62±0.09
T1J2	50.13±0.46
T1J3	57.07±0.56
T2J1	76.30±0.19
T2J2	81.81±0.28
T2J3	86.13±5.65
T3J1	76.05±0.19
T3J2	84.95±0.46
T3J3	88.42±1.48

3.3 Hedonic analysis

Analysis of panelists' level of liking for the attributes of moringa seed food bars with the addition of tomato and cornflakes 'Titi' can be seen in Figure 1. Hedonic profile test on 9 samples of moringa seed foodbar formulation with the addition of tomato and cornflakes 'Titi' on the degree of panelist preference for each attribute presented, including color, aroma, taste and texture attributes. Figure 1 also shows that the scale of values received for the color attribute of the samples ranged from neutral to very fond of the attractiveness of the appearance of brown color in the product, caused by the percentage of the composition of the foodbar formula. At higher percentages, the color produced becomes lighter and seems paler, so the panelists gave lower scores than samples with lower percentages of ingredient composition. The best preference value was found in sample T2J3, in which the moringa seed-based food bar was added with 60% of tomato and 70% of cornflakes from the total moringa seeds, while the lowest value was from the mixture of 50% tomato and 50% cornflakes.

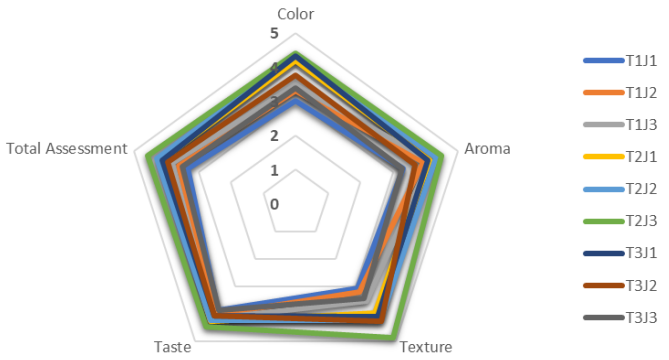

Figure 1. Hedonic analysis of moringa seed foodbar with tomato and cornflakes 'Titi' added.

Assessment of aroma and taste attributes by the panelists tended to give similar results. The highest preference value was found in the mixture of 60% tomato and 70% cornflake combined with honey and yogurt as binders that could develop the best aroma and taste during the roasting process. According to Anggraeni and Kristina (2019), the heating process in food more or less turns the sugar in honey into a caramelization, and starts from the Maillard reaction between reducing sugars and lysine amino groups in nuts. Caramelization results in discoloration and the formation of sugar degradation products, which contribute to the caramel flavor and aroma of honey. The overall taste of the food bar, even until the aftertaste, was not bitter at all. This was due to the compounds in the moringa seeds and did not affect the final evaluation of the taste attributes of the samples. The texture of the food bar is affected by the large percentage of the mixture combination, as seen from the low panelist assessment of the highest percentage of mixture compared to other samples. This was caused by the percentage of honey as the binder, which remained the same even though the percentage of the raw materials was increased.

4. Conclusion

Based on the results, it can be concluded that the mixture combinations of tomatoes and local cornflakes

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('jagung titi') in moringa seed-based food bar have a significant effect on the hedonic analysis, with the highest preference for the attributes found in the mixture of 60% tomato and 80% local cornflakes. For physical properties, results also showed a significant effect, with the best mixture being found in the combination of 60% tomato and 60% local cornflakes. However, the higher the percentage of tomatoes and local cornflakes ("Jagung Titi") added to the food bar, the weaker the bond and the easier the final product tended to break. The highest antioxidant activity was found in a combination of 70% tomato and 60% local cornflakes.

Conflict of interest

The authors declare no conflict of interest.

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