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Evaluasi Kadar Protein, Kadar Air, dan Penerimaan Sensoris Kerupuk dengan Penambahan Puree Daun Kelor

[Evaluation of Protein Content, Moisture Content, and Sensorial Acceptability of Crackers with the Addition of Moringa Leaf Puree]

Kristianus Elky Saputra Ladiba[1], Nelsy Dian Permatasari[1*], dan Jatmiko Eko Witoyo[2]

[1] Department of Food Technology, Politeknik Tonggak Equator, Jalan Fatimah No 1-2, Pontianak, Kalimantan Barat
[2] Department of Agro-industrial Technology, Faculty of Industrial Technology, Institut Teknologi Sumatera, Jalan Terusan Ryacudu, Desa Way Hui, Jati Agung, Lampung Selatan, Lampung

* Email korespondensi : nelsypolteq@gmail.com

ABSTRACT

Crackers are a popular traditional Indonesian snack that generally has a low protein content. Fortification with natural ingredients rich in nutrients, such as Moringa leaves puree, is an alternative to increase the nutritional value of crackers. Nevertheless, the utilization of moringa leaves in food systems, particularly in Kalimantan Barat, remains relatively underdeveloped. So, this study aims to evaluate the protein content, moisture content, and sensory acceptance of crackers with various additions of moringa leaf puree. Crackers were made by adding moringa leaf puree at concentrations of 0% (control), 3%, 5%, and 7% (w/w). Protein content was analyzed using the Kjeldahl method, and moisture content was analyzed using the thermogravimetric method. Sensory acceptability, including color, aroma, taste, and texture, was evaluated using a scoring test, and overall acceptability was assessed using a hedonic test with 20 semi-trained panelists. Data analysis for protein and moisture content employed linear regression, while sensory acceptability was evaluated using One-way ANOVA. Results indicated that the addition of Moringa leaf puree tends to increase the protein and moisture content of the uncooked raw crackers, achieving R^2 values of 0.9715 and 0.9018, respectively, as determined by linear regression analysis. The scoring test revealed that the addition of moringa leaf puree significantly influenced all observed attributes. According to hedonic testing, crackers containing 5% moringa leaf puree were the most preferred by-panelists. This study concludes that a concentration of 5% moringa leaf puree is the recommended formula for producing crackers with enough nutritional value and favorable sensory acceptance by panelists.

Keywords: crackers, moisture content, Moringa leaves puree, protein content, sensorial acceptability

ABSTRAK

Kerupuk merupakan makanan ringan tradisional Indonesia yang populer dan umumnya memiliki kandungan protein yang rendah. Fortifikasi dengan bahan alami kaya nutrisi seperti daun kelor (*Moringa oleifera*) merupakan alternatif untuk meningkatkan nilai gizi kerupuk. Meskipun demikian, pemanfaatan daun kelor dalam sistem pangan, khususnya di Kalimantan Barat, masih relatif terbatas. Penelitian ini bertujuan untuk mengevaluasi kadar protein, kadar air, dan penerimaan sensoris kerupuk dengan berbagai penambahan puree daun kelor. Kerupuk dibuat dengan penambahan puree daun kelor pada konsentrasi 0% (kontrol), 3%, 5%, dan 7% (w/w). Kadar protein dianalisis menggunakan metode Kjeldahl dan kadar air dianalisis menggunakan metode termogravimetri. Penerimaan sensoris, meliputi warna, aroma, rasa, dan tekstur, dievaluasi menggunakan uji skoring, sedangkan penerimaan secara keseluruhan dievaluasi menggunakan tes hedonik dengan 20 panelis semi terlatih. Analisis data untuk kadar protein dan kadar air menggunakan regresi linier, sedangkan penerimaan sensorik dievaluasi menggunakan ANOVA satu arah. Hasil penelitian menunjukkan bahwa penambahan puree daun kelor cenderung meningkatkan kadar protein dan kadar air pada kerupuk mentah, dengan nilai R^2 masing-masing sebesar 0,9715 dan 0,9018 berdasarkan analisis regresi linier. Uji skoring menunjukkan bahwa penambahan puree daun kelor berpengaruh signifikan terhadap semua parameter yang diamati. Berdasarkan uji hedonik, kerupuk yang mengandung 5% puree daun kelor merupakan kerupuk yang paling disukai oleh panelis. Penelitian ini menyimpulkan bahwa

penambahan 5% puree daun kelor merupakan formula yang disarankan untuk memproduksi kerupuk dengan nilai gizi yang cukup dan penerimaan sensoris yang baik oleh panelis.
Kata kunci: kadar protein, kadar air, kerupuk, penerimaan sensoris, puree daun kelor

Introduction

Crackers are a traditional Indonesian snack that is typically a favorite among children and adults, made from different types of flour as the primary ingredient, including rice flour, tapioca flour, etc. Crackers contain carbohydrates of 50 g/100 g, and fat of 20 g/100 g, but are low in protein at 2-5 g/100 g (Kusmartini et al., 2022). The low protein content of crackers is an important concern, so it is necessary to fortify innovations from local plant foods that contain high protein, one of which is moringa leaves. In fact, moringa leaves (Moringa oleifera Lam.) are a tropical plant that grows widely in Indonesia and is known to have a high nutritional content, including protein content (6.7-9.97%), fiber (11.23 g/100g), calcium, iron, magnesium, phosphorus, vitamin A, vitamin C, vitamin E, and vitamin B complex (Hodas et al., 2021; Leone et al., 2015; Witoyo et al., 2025). However, the utilization of the Moringa leaves in the food product system in Indonesia, including the Kalimantan Barat Region, is still limited and underutilized, even though the local community widely cultivates Moringa plants (Samsudrajat et al., 2020).

Some earlier studies reported on the addition of moringa leaves in the form of flour and extracts in different food products. Ruchdiansyah et al. (2016) reported that the addition of 10-20% moringa leaf flour to crackers could increase protein content to 5.21-5.97% and was sensorially acceptable to panelists. In addition, Juhana et al. (2023) also reported that the addition of moringa leaf extract of 10-30 ml can increase the nutritional content of snakehead fish crackers, especially protein content. However, research on the addition of moringa leaf puree in crackers is still limited. Advantages of adding moringa leaf puree compared to moringa leaf flour are retention of higher nutrient content and bioactive compounds (Hapsari et al., 2022). Furthermore, the addition of puree will affect elasticity because moringa leaf puree has a finer particle size, high moisture content, contains natural pectin, provides a fresher taste and aroma, thus affecting sensory acceptability (Mpalanzi et al., 2023; Shere et al., 2018). Based on the above facts, the purpose of this study is to evaluate the addition of moringa leaf puree at concentrations of 3%, 5%, and 7% (w/w) on the protein content, moisture content, and sensorial acceptability of crackers. This research is expected to contribute to the development of functional food products based on local ingredients that can increase nutritional value, especially protein content, and can be well-received by consumers.

Materials and Methods

Materials and tools

The ingredients used in this study are fresh moringa leaves (*Moringa oleifera*) obtained around the Politeknik Tonggak Equator, Pontianak, commercial tapioca flour (Rose brand), salt, garlic, and water purchased from pastry shops around Pontianak City. Chemicals for analysis include concentrated H2SO4, NaOH 40%, HgO, KSO, methyl red-methylene blue indicator, 4% boric acid, and HCl 0.01 N obtained from chemical suppliers around Pontianak City, Kalimantan Barat. The tools used include

blenders (Philips HR2115, Indonesia), analytical balances (Mettler Toledo AL204, Mettler Toledo, Switzerland), ovens (Memmert-UN55, Memmert GmbH, Germany), desiccant, porcelain cups, Kjeldahl flasks, Kjeldahl distillers, titration equipment, steamers, stoves, standard food processing equipment, and glassware.

Research methods

This study uses an experimental method using a Complete Random Design (CRD) with 1 factor, namely the addition of moringa leaf puree, which consists of 3 levels of treatment as follows:

D0 : Crackers without additions of moringa leaf puree
D1 : Crackers with the addition of 3% w/w of moringa leaf puree based on tapioca flour
D2 : Crackers with the addition of 5% w/w of moringa leaf puree based on tapioca flour
D3 : Crackers with the addition of 7% w/w of moringa leaf puree based on tapioca flour

Research implementation

a) Preparation of Moringa Leaf Puree

Manufacturing Moringa leaf puree refers to the method described by Ruchdiansyah et al. (2016) with modifications. Shortly, fresh moringa leaves are sorted and washed thoroughly with running water to remove dirt and contaminants. The leaves that have been cleaned are blanched by boiling water at 100 °C for 2 min. After that, moringa leaves are immediately cooled in ice water to room temperature (5 min), drained, and mashed using a blender for 4 min without adding water until it forms a puree with a smooth and homogeneous texture. Then, the moringa leaves puree is stored in a sealed container at 4°C before being used in the manufacture of crackers.

b) Manufacturing of Cracker

The procedure of making crackers refers to the method described by Ruchdiansyah et al. (2016) with modifications. Crackers are made with a basic formulation consisting of tapioca flour (100g), salt (7g), garlic powder (2.5g), water (50 ml), and moringa leaf puree are added at concentrations of 0% (control), 3%, 5%, and 7% based on the weight of tapioca flour (w/w). All ingredients are mixed and stirred until they form a homogeneous and smooth dough. The dough is then shaped into a cylinder with a diameter of about 3 cm, wrapped in a clean cloth, and steamed at 100°C for 60 minutes until fully cooked. Cooked cracker dough is cooled at room temperature, thinly sliced to a thickness of ±2 mm using a knife, and dried in the sun for 2-3 days until dry. Then, the uncooked raw crackers are stored in airtight containers for further testing.

c) Chemical and Sensorial Acceptability Analysis

The protein content and moisture content of uncooked raw crackers were analyzed using the standard method described by AOAC (2012). The moisture content was analyzed using the thermogravimetric method, and the protein content using the Kjeldahl method. The sensorial acceptability test (color, aroma, taste, and texture) was carried out using cooked crackers, using 20 semi-trained panelists through a scoring test (Marhama et al., 2022), with a description of the test scale shown in **Table 1**. In addition, the overall acceptability of cooked crackers was analyzed using a hedonic test (Anjani et al., 2022; Marhama et al., 2022; Sari et al., 2023) with 7 scales (Rahmadini et al., 2023), namely 1: strongly dislike, 2: dislike, 3: slightly dislike, 4: neutral, 5: slightly like, 6: like, and 7: strongly like. The sensory testing procedure was carried out by presenting 4 cracker samples (control, addition of moringa leaf puree of 3%, 5%, and 7% w/w), which were randomly coded with a random three-digit number to avoid bias during the testing process.

Table 1. Description of the scoring test scale used for the evaluation of the sensory acceptability of crackers

Scale	Description			
	Color	Aroma	Taste	Texture
1	Very green	Very unscented moringa leaves	Very tasteless of moringa leaves	Very non-crunchy
2	Slightly green	Slightly scented moringa leaves	Slightly tasty moringa leaves	Slightly crunchy
3	Simply green	Quite aromatic moringa leaves	Quite tasty moringa leaves	Quite crunchy
4	Colored green	Aromatic moringa leaves	Moringa leaf taste	crunchy
5	Very green	Very aromatic moringa leaves	Very tasty of moringa leaves	Very crunchy

Data Analysis

Protein content and water content were analyzed using linear regression analysis (Anggraeny et al., 2016). Sensory acceptability data were analyzed using one-way ANOVA using Mini Tab 17 at a 95% confidence level, and continued using the Tukey test to determine the difference between treatments at a 95% confidence level (Ahsin et al., 2019; Prabowo et al., 2024).

Results and Discussion

Protein Content

Protein content of uncooked raw crackers with the addition of moringa leaf puree ranges from 0.33-0.73% (**Figure 1**). The value of this protein content is higher compared to crackers without additions of moringa leaf puree (control) by 0.15%. This result was lower than the protein content of crackers with the addition of 10% moringa leaf flour of 5.21%, and crackers with the addition of 5% moringa leaf extract of 5.97% (Ruchdiansyah et al., 2016). The lower value of protein content in this study is due to differences in concentration and the type of raw material used. In this study, the concentration added was lower (3-7%) than that of the previous study, which added moringa leaf flour of 10%. This is due to the insignificant increase in the protein content in raw crackers. Figure 1 explains the positive correlation between the addition of moringa leaf puree and protein content of uncooked raw crackers, with the equation $y = 0.1003x+0.0461$, with an R2 value of 0.9715. This suggests that the addition of moringa leaf puree by x% into the cracker formula, the protein content will increase by $0.1003x + 0.0461$. An R2 value of 0.9715 indicates that the increase in protein content in uncooked raw crackers is influenced by the addition of moringa leaf puree by 97.15%. The tendency of increased protein content in raw crackers is due to the protein content contained in the moringa leaf puree, which is 9.97% (Hapsari et al., 2022). These results are in line with research reported by Maulida & Ismawati (2016), who also found that increased concentration of moringa leaf puree from 25-45% increases the moisture content of mocaf dry noodles. Hapsari et al. (2022) also reported that the addition of moringa leaf puree by 10-50% can increase protein content in mackerel nuggets. Juhana et al. (2023). In his study, it was also reported that the addition of moringa leaf extract of 10-30 ml was able to increase the protein content of snakehead fish crackers. According to the , there is no minimum requirement of protein content for rice crackers. Moreover, the requirement of the protein content for fish crackers was in the range of 5-12%, and for shrimp and shellfish crackers was in the range of 2-18%, depending on grades (Badan Standardisasi Nasional, 2016).

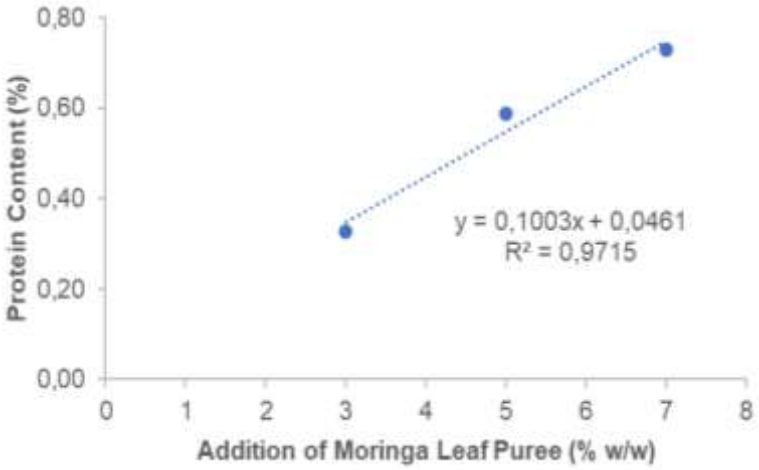

Figure 1. Protein content of uncooked raw crackers with the addition of moringa leaf puree

Moisture Content

Moisture content of uncooked raw crackers with the addition of moringa leaf puree ranges from 8.02-9.56% (**Figure 2**). This moisture content value is higher than that of crackers without the addition of moringa leaf puree (control) by 7.78%. This result is higher than the moisture content of crackers with the addition of 10% moringa leaf flour of 2.56%, and crackers with the addition of 5% moringa leaf extract of 3.68% (Ruchdiansyah et al., 2016). **Figure 2** shows that the positive correlation between the addition of moringa leaf puree and the moisture content of uncooked raw crackers with the equation y = 0.385x +7.0117, with an R^2 value of 0.9018. This suggests that the addition of moringa leaf puree by x% into the cracker formula, the moisture content will increase by 0.385x+7.0117. An R^2 value of 0.9018 indicates that the increase in moisture content in uncooked raw crackers is influenced by the addition of moringa leaf puree by 90.18%. The tendency of increased moisture content in uncooked raw crackers is due to the moisture content contained in the moringa leaf puree, which is 88.28% (Hapsari et al., 2022). These results are in line with the research reported by Putri et al. (2024), which stated that increased concentration of moringa leaf puree from 5-25% increases the moisture content of tahu walik. Hapsari et al. (2022) also reported that the addition of moringa leaf puree by 10-50% can increase moisture content in mackerel nuggets. According to Badan Standardisasi Nasional (1996), the maximum requirement for moisture content for uncooked and cooked rice crackers was 12% and 8%, respectively. Moreover, the requirement of the protein content for fish crackers, and shrimp and shellfish crackers was a maximum of 12% (Badan Standardisasi Nasional, 2016). In general, the moisture content of all crackers produced in this study meets the Indonesian cracker standards for uncooked rice crackers.

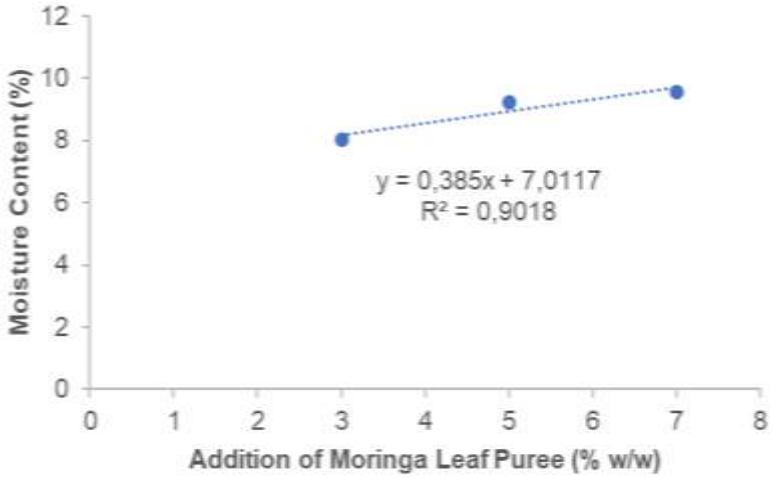

Figure 2. Moisture content of uncooked raw crackers with the addition of moringa leaf puree

Sensory Acceptability

Sensorial acceptability of control crackers (without the addition of moringa leaf puree) and crackers with the addition of moringa leaf puree are shown in **Table 2**. Sensorial acceptability, including color, aroma, taste, and texture, was carried out using a scoring test, and overall acceptability using a hedonic test. The average value of sensorial acceptability of cracker color ranged from 1.49 to 4.19. The most liked crackers by the panelists were crackers with the addition of 7% w/w of moringa leaf puree, and the most disliked crackers were control crackers (without the addition of moringa leaf puree). The ANOVA analysis showed that the addition of moringa leaf puree had a significant effect on the sensorial acceptability of color by panelists. In general, more additions of moringa leaf puree increase the panelists' sensory perception of color. This is because the color of the crackers becomes green. The results of color sensorial acceptability showed that the panelists preferred crackers with the addition of 7% w/w of moringa leaf puree. The green color on crackers is due to the presence of the chlorophyll pigment contained in moringa leaves. The total chlorophyll content in fresh moringa leaves ranges from 23.08-30.60 mg/L (Rasyidi et al., 2024). These results are in accordance with the results reported by Tapun et al. (2021) states that the sensorial acceptability of colors from crackers increased with the addition of moringa leaf flour from 4-8%, and decreased thereafter. Purwanti (2024) also reported that the sensorial acceptability of noodle color has increased with the addition of moringa leaf puree, which is 25-50% w/w compared to control noodles.

The average value of aroma sensorial acceptability of the cracker ranged from 1.38 to 3.71. The most liked crackers by the panelists were crackers with the addition of 7% w/w of moringa leaf puree, and the most disliked crackers were control crackers (without the addition of moringa leaf puree). The ANOVA analysis showed that the addition of moringa leaf puree had a significant effect on the sensorial acceptability of aroma by panelists. In general, more additions of moringa leaf puree increase the sensorial acceptability of the panelists' aromas. However, the addition of moringa leaf puree of 5% w/w and 7% w/w had insignificant differences in sensorial acceptability of aroma by the panelists. Crackers with additions of moringa leaf puree at a concentration of 3-5% have a minimal scent aroma, so it is still acceptable to the panelists, compared to crackers with the addition of moringa leaf puree at a concentration of 7% (Rasyidi et al., 2024). These results are also in accordance with the results reported by Tapun et al. (2021), which stated that the sensorial acceptability of the scent

of the crackers increased with the addition of moringa leaf flour from 4-8%, and decreased thereafter. Purwanti (2024) also reported that the sensorial acceptability of the aroma of noodles has increased with the addition of moringa leaf puree, which is 25-50% w/w compared to control noodles. Decrease/increase in aroma acceptance by the panelists was not significant due to the unpleasant aroma of moringa leaf puree caused by essential oils and enzyme lipoxidase activity (Hapsari et al., 2022; Putri et al., 2024).

The average taste sensorial acceptability value of the cracker ranged from 1.43 to 3.76. The most liked crackers by the panelists were crackers with the addition of 7% w/w of moringa leaf puree, and the most disliked crackers were control crackers (without the addition of moringa leaf puree). The ANOVA analysis showed that the addition of moringa leaf puree had a significant effect on the sensorial acceptability of taste by the panelists. In general, the additions of moringa leaf puree until 5 % w/w increase the sensory acceptance of the taste of panellists to crackers, and thereafter decrease. This is caused by the addition 7% w/w of moringa leaf puree, which will produce crackers with a bitter taste (Prayitno et al., 2021), due to the presence of flavonoids, alkaloids, steroids, tannins, saponins, anthraquinones, and terpenoids in moringa leaves (Misbah et al., 2025). These results are in accordance with the results reported by Ruchdiansyah et al. (2016), which stated that the sensorial acceptability of taste from crackers increases with the addition of moringa leaf flour from 10-20% and decreases with the addition of moringa leaves at a concentration of 30%. Purwanti (2024) also reported that the sensorial acceptability of noodle taste has increased with the addition of moringa leaf puree of 25-50% w/w compared to control noodles. Increased acceptance of taste by panelists with additions of moringa leaf puree or flour to a certain concentration due to the distinctive taste of moringa leaves (Ruchdiansyah et al., 2016; Tapun et al., 2021).

Table 2. The Scoring and hedonic test of crackers without and with the addition of moringa leaf puree

Parameter	Addition of moringa leaf puree (% w/w)			
	0	3	5	7
Color	1.48±0.68^{c}	2.48±1.21^{b}	2.95±1.07^{b}	4.19±0.93^{a}
Aroma	1.38±0.74^{c}	2.48±1.21^{b}	3.29±1.19^{ab}	3.71±0.98^{a}
Taste	1.43±0.60^{c}	2.62±1.32^{b}	2.76±1.09^{b}	3.76±1.18^{a}
Texture	2.10±0.83^{c}	3.24±1.14^{ab}	3.48±1.25^{a}	2.48±1.12^{bc}
Overall acceptability*	4.24±1.41^{b}	4.52±1.36^{b}	5.76±1.34^{a}	4.71±1.59^{ab}

Remarks:* evaluated by hedonic test. Different letters on the same line show a significant difference in the 95% confidence level based on tukey-test

The average sensorial acceptability value of cracker texture ranged from 2.10 to 3.48. The most liked crackers by the panelists were crackers with the addition of 5% w/w of moringa leaf puree, and the most disliked crackers were control crackers (without the addition of moringa leaf puree). The ANOVA analysis showed that the addition of moringa leaf puree had a significant effect on the sensorial acceptability of texture by panelists. In general, more additions of moringa leaf puree increase the sensorial acceptability of the panelists' texture to crackers. This is cause more moringa leaf puree added will produce crackers with a crispy texture. These results are in accordance with the results reported by Purwanti (2024), who reported that the sensorial acceptability of noodle texture improved with the addition of moringa leaf puree of 25-50% w/w compared to control noodles.

Increased sensorial acceptability of texture by panelists with the addition of moringa leaf puree to a certain concentration is caused by the high fiber content in the raw material, namely, moringa leaves. The fiber content in fresh moringa leaves ranges from 11.23 g/100g (Hodas et al., 2021). According to Tapun et al. (2021), the texture is influenced by the use of high-fiber raw materials in the product. formulation. Fiber will interact with and bind to the water contained in food ingredients during processing, which can result in a tough texture. Furthermore, the average value of the overall acceptability of the cracker was in the range of 4.24 – 5.76. The most liked crackers by the panelists were crackers with the addition of 5% w/w moringa leaf puree, with a score of 5.76 (like), with the following description: simply green, quite aromatic moringa leaves, quite tasty moringa leaves, and crunchy, with a protein content of 0.58% and a moisture content of 9.23%. Overall, the recommended incorporation of moringa leaf puree in crackers was 5% with enough nutritional content and high favorable sensory acceptability by panelists.

Conclusion

The evaluation of protein content, moisture content, and sensory acceptance of crackers with the addition of moringa leaf puree at a concentration of 3-7% w/w has been successfully carried out. The linear regression trend showed that the addition of moringa leaf puree was able to increase the protein content and moisture content of uncooked raw crackers with R^2 values of 0.9715 and 0.9018, respectively. The scoring test showed that the addition of moringa leaf puree significantly improved the sensorial acceptability of the color, aroma, taste, and texture of the crackers by the panelists. Based on the hedonic test on overall acceptability, the panelists chose crackers with the addition of 5% moringa leaf puree as the best treatment.

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