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Optimization Of Formula Crackers Enhanced With Kelor (*Moringa Oleifera*) Leaves Using Mixture Design Method

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Abstract: The moringa leaves powder can be used as a supporting material for the enrichment of food products that are ready for consumption, one of which is in crackers. Formula optimization is needed in the process of making crackers enriched with kelor leaves powder. This study aimed to obtain the optimal formulation in the development of moringa crackers using the D-optimal Mixture method. The research stages were carried out divided into three stages, including (a) characterization of moringa leaves powder and crackers; (b) determining the raw material for crackers from cassava starch, mocaf, and wheat flour; (c) optimization of the formula crackers by adding moringa leaves powder using the Mixture Design method. A combination of flour (46.43 %) and moringa powder (4.57 %) resulted in an optimum moringa crackers formulation. This formulation could provide hardness 2470.65 g, fracturabillity 297 mm, moisture 3.58%, ash 3.48%, protein 12.45%, color 4.07, aroma 4.03, taste 3.73, and overall 3.97. The moringa crackers prepared using showed the best solution for this combination of variables with a desirability value of 0.554.

Keywords: Crackers, Kelor, Mixture Design Method, Moringa, Optimization

1. Introduction

The moringa (*Moringa oleifera*) plant has several nicknames, including the miracle tree, tree for life, and amazing tree, because the parts of the moringa plant, starting from the roots, stems, leaves, skin, flowers, fruit, and seeds, have health benefits. Moringa plants can live in various types of soil, are

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easy to breed, are resistant to dry seasons, and do not require intensive care [1]. The kelor leaves contain high antioxidants and can be used as a source of protein and minerals [2][3]. The nutrient content in 100 grams of dried kelor leaves is 7.5 g of water; 38.2 g carbohydrates; 27.1 g protein; 2.3 g fat; 19.2 g fiber, 2003 mg calcium; 368 mg magnesium; 204 mg phosphorus; 0.6 mg copper; 28.2 mg iron; 870 mg sulfur; 1324 potassium; and calories 205 kcal [4]. The kelor leaves can be processed into powder, in 100 grams of kelor leaves powder contains 28.25% protein [5].

The high content of nutrients found in moringa leaves powder can be used as a supporting material for the enrichment of food products that are ready for consumption, one of which is in crackers. According to the National Standardization Agency for Indonesia [6], crackers are a type of biscuit that requires a fermentation process or not, as well as through a lamination process to produce a flat shape and when broken, the cross-section looks multiple. The most important process stage in the manufacture of crackers is fermentation, which aims to ripen the dough so that the dough is easily processed, forms flavor, texture, and can produce good quality crackers products [7].

Formula optimization is needed in the process of making crackers enriched with moringa leaves powder. The mixing of ingredients in the formulation will affect the characteristics of the resulting crackers. Determination of formula optimization can be done using the Design-Expert application. According to Bas and Boyaci [8], Design-Expert is a program used for product or process optimization in the main response caused by several variables, and the goal is to optimize the response. The advantage of the Design-Expert program with the Mixture Design method is that it has numerical accuracy reaching 0.001 and can process data quickly and accurately as needed [9]. The objective of this study was to determine the optimization of the formula for crackers enriched with moringa leaves powder using the D-optimal Mixture method.

2. Materials and Methods

2.1 Materials

Materials used in the process of making crackers include: kelor (*Moringa oleifera*) leaves were bought from UMI Kelorina SME's Pagaden, Subang. West Java. Tapioca (casava starch), modified cassava flour (mocaf) and wheat flour, skim milk, butter, vegetable oil, yeast, baking powder, sugar, and salt were purchased from Subang Traditional market, Indonesia. Aquadest, selenium, H_2SO4, NaOH, H_3BO_3, Phenolphthalein indicators, and HCl were purchased at Sigma-Aldrich, Singapore.

2.2 Methods

2.2.1 Preparation of samples

The fresh moringa were washed, blanching at 80 °C for 3 minutes, and then dried using tray cabinet dryer at 45°C for 4 hour. Dried moringa leaves are ground to a powder. The raw materials are weighed according to the formula using a digital balance (Metler Toledo, Ohio, USA). The ingredients are mixed, then yeast is added. The dough is fermented at 27-30 °C for 20 minutes until the dough's texture is suitable. Flowing is done by adding flour (1.5%), salt (0.3%), and baking powder (0.4%) from the formulation as a dust-filling material. Dough printing with crackers size 6 cm, width 3 cm, and thickness 2 mm. The dough that has been printed is then baked at 110 °C for 40 minutes using the oven (DECK GAS Masema 2 Deck 4 Tray; Type: YXY-40AS). Cooked crackers are packaged and ready to be analyzed.

2.2.2 Research stages

The research was divided into three stages, including (a) characterization of moringa leaves powder and crackers; (b) determining the main raw material of crackers (cassava starch (tapioca), modified cassava flour (mocaf), and wheat flour); (c) optimization of the formula crackers by adding moringa leaves powder using the Mixture Design method.

The Design-Expert application using the Mixture Design method aims to analyze adding kelor leaves powder to the crackers' characteristics by determining the fixed and independent variables. The formula optimization is obtained based on the specified response needs. The settings included in the Mixture Design method are lack of fit = 5 and replicate = 3 so that 11 treatment formulas are obtained[12].

2.2.3 Procedure analysis

Hardness and fracturability

The analysis used in this research is the physical response: hardness and fracturability (TA.XTPlus texture analyzer, Stable Micro System, Surrey, UK); The samples was cut using a three-point bending rig (type HDP/3PB). The conditions of compression strengths: target mode distance; distance, 5 mm; test speed, 3 mm/s.

Nutritional composition

Nutritional compositions viz., protein, moisture, ash, of kelor crackers were determined. Moisture and ash contents were determined by using the gravimetric method [10]. The Buchi-Dumaster equipment was used to measure the protein content [10].

Sensory characteristics

The sensory test was carried out by hedonic testing using the scoring method. Sensory response to color, aroma, taste, overall of 30 moderately trained panelists, with a scale of 1 (very dislike) - 5 (very like) [11].

Determination of minerals

Minerals concentrations determined by using flame atomic absorption spectroscopy system [10]. Sodium, potassium, magnesium, and calcium content were analyzed. The crackers crushed into powder. In a crucible, the crackers are weight until 3g for each formulation. The sample then charred until smoke ceases. Then place the crucible in the furnace for ashing process. Increase the temperature at maximum of 550 °C. Let the crucible stand for at least 8 hours or overnight. Take out crucible out of furnace and let cool. 6M HCl was added to crucible ensuring all ash has come into contact with acid then evaporate on water bath. Then another 2ml HCl was added and swirl. Finally dilute the ash with 100 ml of distilled water in conical flask. The blank was treated with the same method.

2.3 Statistical Analysis

Data were analyzed using the variance test (ANOVA). If there are significantly different data ($P<0.05$), the Duncan test aims to test for the presence of significant differences between samples. While the data of optimalization were analyzed using the Microsoft Excel program and the application of the Mixture Design method.

3. Results and Discussion

3.1 Characteristics of moringa powder and crackers

Making moringa leaves powder follows the method of Iwansyah et al. [13], with the following stages: sorting, weighing, washing, draining, blanching and drying using a cabinet dryer at 45 °C for 4 hours, milling, and packaging. Nutrition composition of moringa leaves powder and crackers are shown in Table 1.

Table 1: Moisture, ash and protein content of moringa leaves powder and commercial crackers

Constituent	Moisture (%)	Ash (%)	Protein (%)
Kelor leaves powder	6.58	12.28	26.93
Commercial crackers	4.49	2.80	8.19

Data are presented as mean

According to Setiaboma et al. [5] reported that the moisture content of moringa leaves powder was 4.80%, ash content 11.13%, and protein content of 30.16%. There are differences in the analysis results because, at the stage of making moringa leaves powder, blanchers are carried out using hot steam and 80 mesh size of sieving. The blanching process stages can increase the moisture content and reduce the protein content, but it does not affect the ash content. This influence can be caused by a variety of factors, such as temperature and blanching time. These result was agreement with Kumalasari et al. [14], which stated that temperature and processing time influenced bamboo shoots' physicochemical characteristics.

Table 1 also shows that crackers made from wheat flour as the main ingredient have moisture content by Indonesian National Standard (SNI) 01-2973-2011 (max. 5%), their ash content is relatively high, and their protein content is by SNI 01- 2973-2011 (min. 4.5%)[7]. The determination of raw materials to manufacture products is carried out by selection using the hedonic test. Figure 1 shows the organoleptic test results (color, aroma, taste, and texture) of crackers from mocaf and wheat flour.

The hedonic of color, taste and texture attribute, it can be seen that the average value of the panelists' preference is 3.80-4.47, 3.27-4.07, 3.23-4.17, respectively (Figure.1). Analysis of variance with a confidence level of 95% ($\alpha = 0.05$) shows that differences type of flour have a significant effect on the color, taste and texture of the crackers (*P<0.05*). Crackers from wheat flour had the highest preferences of color. Meanwhile, the hedonic test results on the aroma quality attribute showed that the average value of the panelists' preferred level was 3.80-3.97. The results of the analysis of variance (ANOVA) with a confidence level of 95% ($\alpha = 0.05$) shows that differences in type flour do not significantly affect the aroma of crackers (*P>0.05*).

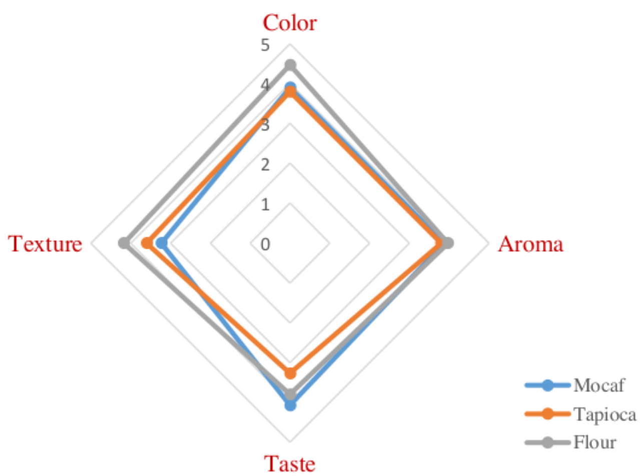

Figure 1: Hedonic test of crakers based on type of flour used

3.2 Optimized formula and nutritional properties of crackers

Optimization of the formula for crackers with supplementaion of moringa leaves powder using the Mixture Design method with a physical response to hardness and fracturability; chemical response to moisture content, ash content, protein content; sensory characteristics of color, aroma, taste, and overall. The formulation of crackers based on the Mixture Design method is shown in Table 2.

Table 2: Crackers formulation with supplementation of moringa

Formulation	Flour (%)	Kelor Leaves Powder (%)
P1	46	5
P2	48	3
P3	48	3
P4	48	3
P5	45	6
P6	47	4
P7	44	7
P8	46	5
P9	48	3
P10	44	7
P11	44	7

Hardness and fracturability are an essential indicator of food texture, especially on baked products such as bread and biscuits [15]. The fracturability is measured by calculating the force and distance needed to press the material until it cracks [16]. Figure 2A shows that the crackers hardness value of the 11 formulas was not affected by the addition of moringa leaf flour ($P>0.05$). The highest response value is indicated by the highest red dot's position at the angle of variables A and B (components of wheat flour and moringa powder) (Figure. 2A and Figure. 2B). The hardness value is not affected by moringa powder, presumably because the concentration of addition is relatively small. While, the crackers fracturability value of the 11 formulas was affected by the addition of moringa leaves powder ($P< 0.05$). Crackers with the addition of moringa flour where the higher concentration, the moisture content of crackers is getting lower so that the level of violence is higher. Hardness and fracturability level is affected by composition and processing related to dough structure, water solubility index and water absorption index [17]. If the water absorption index is high, the level of hardness and fracturability will decrease because more water is absorbed so the crackers will be softer [17].

Moisture content can serve as an indicator of the shelf life. Moisture content can affect food quality degradation chemically and microbiologically [18]. Moisture content 3-7% can reduce the possibility of microorganism growth and damaging chemical reactions such as hydrolysis and fat oxidation [19]. Fig. 2C shows that moisture content of the 11 formula crackers was affected by the addition of moringa leaves powder ($P<0.05$). Moisture content is influenced by the addition of moringa leaves powder, where the more moringa leaves powder is added, the less moisture content of the product will be. Besides, the product's moisture content is also influenced by the temperature stability during the roasting process, where the water content decreases a lot [19].

Ash content indicates the mineral content in food products. While, protein is one of the macronutrient groups besides fats and carbohydrates. Protein plays a role in forming biomolecules rather than as a source of energy [20]. The ash and protein content of the 11 formula crackers was affected by the addition of moringa leaves powder ($P<0.05$) (Figure. 2D and 2E). The highest response value is indicated by the highest red dot's position at the angle of variables A and B (components of wheat flour and moringa powder as in Figure. 2). The ash content of crackers increased with the increasing amount of moringa powder in the crackers formulation. The increase in the amount of ash content of crackers was caused by the addition of minerals originating from the moringa powder which was added to the formulation, as well as the protein content of crackers. According to Sebranek [21], protein content depends on the number of ingredients added and is largely influenced by moisture content. These results are in accordance with those shown in table 1.

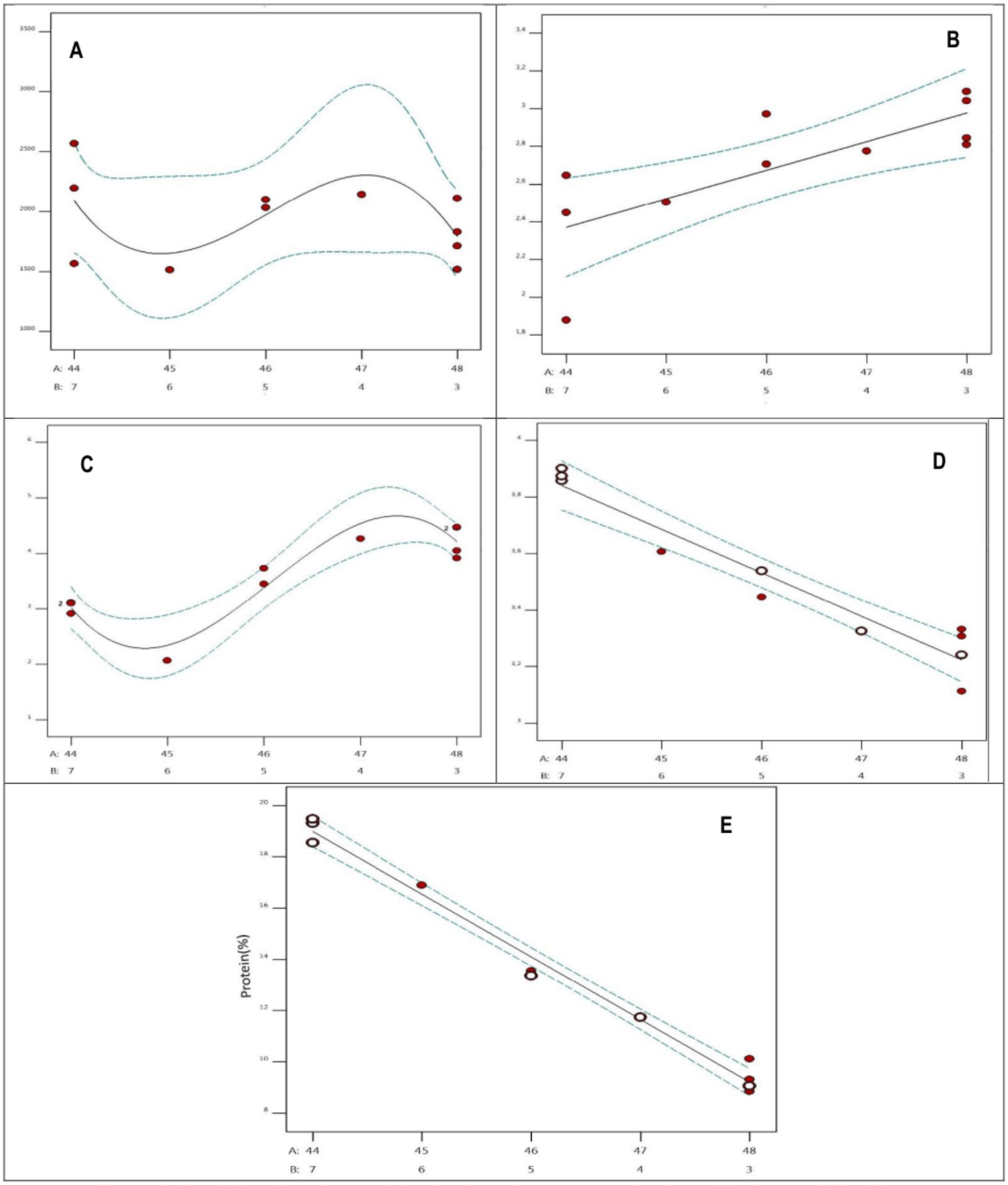

Figure 2: Graph based cracker optimization formula response to hardness (A), fracturability (B) moisture (C), ash (D) and protein (E) content. The blue dotted line shows the 95% confidence interval. The red circle shows the design points.

3.3 Sensory characteristics

The hedonic test of the crackers' color response with the addition of moringa powder are shown in Fig. 3A. The results showed that the color response of the 11 formulations has a significant effect by ratio combination of flour and moringa powder (p=0.0001 <0.05). The Design Expert graphic with the highest response value is shown by the highest red dot's position at the angles of variables A and B (components of wheat flour and moringa powder) (Figure 3A). The green color of the crackers comes from the added moringa powder.

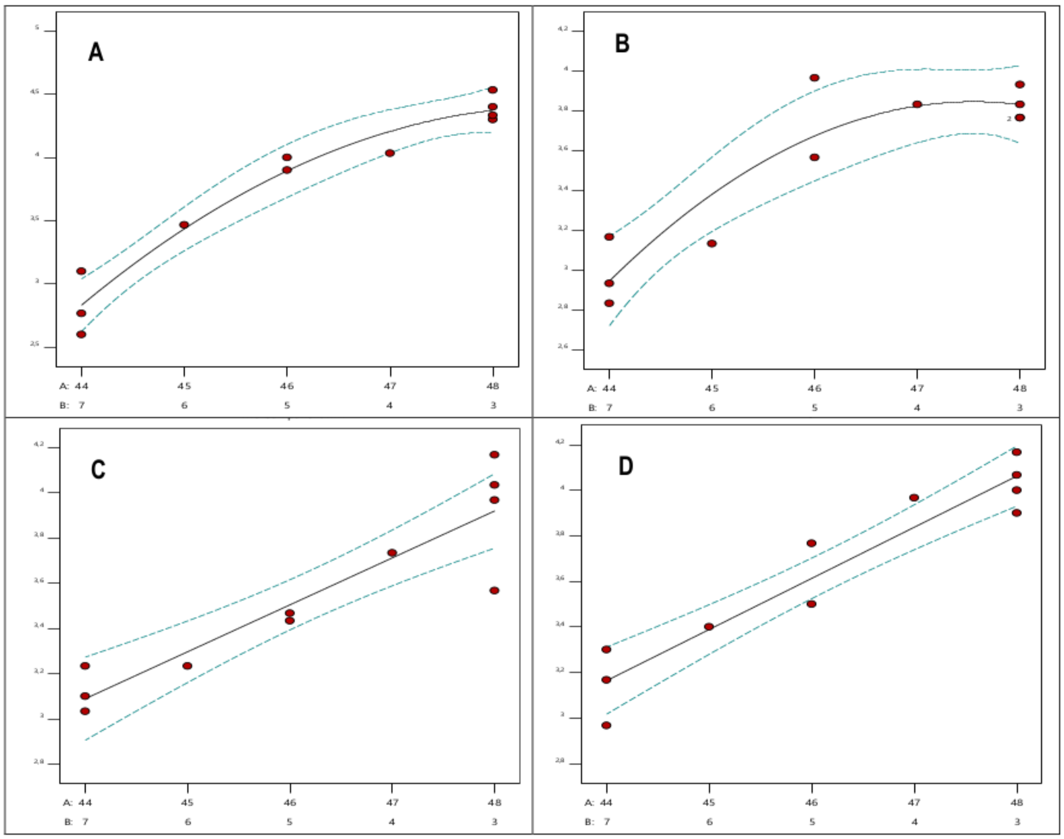

Figure 3: Graph based cracker optimization formula response to hedonic test of color (A), aroma (B) taste (C), and overall (D). The blue dotted line shows the 95% confidence interval. The red circle shows the design points.

Furthermore, the results showed that the aroma response of the 11 formulations has a significant effect by ratio combination of flour and moringa powder (*p*=0.0003 <0.05). The Design Expert graphic with the highest response value is shown by the highest red dot's position at the angles of variables A and B (components of wheat flour and moringa powder) (Figure 3B). The value of liking for the aroma showed that the panelists rated them from disliking to liking the crackers' aroma with the addition of moringa leaves powder. The unpleasant aroma of the crackers comes from the added moringa powder.

Figure 3C showed that the taste response of the 11 formulations affects by ratio combination of flour and moringa powder (*p*=0.0001 <0.05). The highest response value is shown by the highest red dot position at the angle of variables A and B (components of wheat flour and moringa leaf powder) (Fig. 3C). The value of liking for taste showed that the panelists gave ratings from slightly dislike to like the taste of crackers with Moringa leaf flour. The slightly bitter taste of the crackers comes from the added moringa flour.

The overall response of the 11 formulations affects by ratio combination of flour and moringa powder (p=0.0001 <0.05). The overall quality's liking value showed that the panelists assessed they dislike to like the crackers' overall quality with moringa leaf powder addition. The added moringa flour influenced panelists' acceptance of the crackers.

3.4 Optimization of the basic formulation and verification of the model

The final objective of this study was to develop moringa crackers formulation. Hence, during the numerical optimization, the moisture, ash, and protein content responses were maximized, whereas other responses and material components were fixed in a range. The responses of moisture, ash, and protein content values were assigned in the high relative importance of '5.' This was due to the fact that moisture, ash, and protein content of moringa crackers are the most important attributes that influence in improving the quality of product. The relative importance given to hardness, fracturability, and hedonic of color, taste and aroma of the moringa crackers was '3.' Results of the optimization suggested that the moringa crackers prepared using flour (46.43 %) and moringa powder (4.57 %) showed the best solution for this combination of variables with a desirability value of 0.554 (Figure 4).

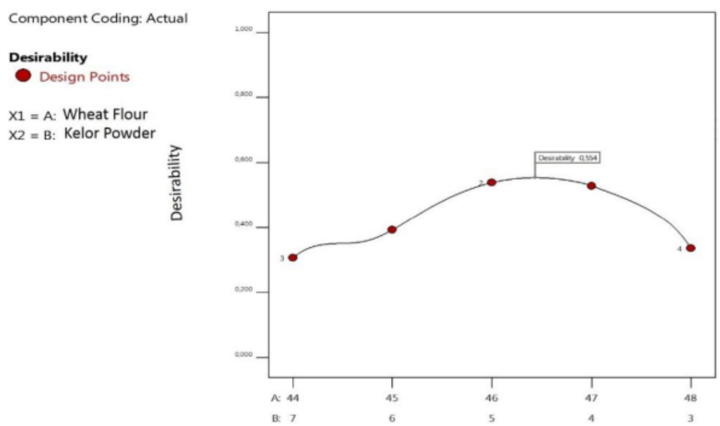

Figure 4. Desirability graph of optimization of formula crackers

This recipe was used to produce moringa crackers, and all the response variables of the final product were analyzed. The predicted response values were compared with the experimental values of each response using the equations of the model. The predicted response values were hardness 2188.32 g, fracturabillity 2.75 mm, moisture 4.09%, ash 3.45%, protein 12.79%, color 4.08, aroma 3.77, taste 3.62, and overall 3.73. The experimental response values were hardness 2470.65 g, fracturabillity 297 mm, moisture 3.58%, ash 3.48%, protein 12.45%, color 4.07, aroma 4.03, taste 3.73, and overall 3.97. The response values of the experimental and predicted data were within the range of confidence interval and prediction interval. This indicated that the model can be used to optimize the basic formulation of moringa crackers.

The results of the analysis of mineral content of the optimization formula were sodium levels (97.12 mg/100 g); potassium (40.01 mg/100 g); magnesium (5.95 mg/100 g); and calcium (2.96 mg/100 g). Moringa leaves powder contains the mineral zinc (1.51 mg/100g); iron (37.08 mg/100g); potassium (1631.03 mg/100 g); and magnesium (874.19 mg/100g). The difference in mineral content can be caused by various factors, such as processing, geographical factors, and environmental factors. This study was in agreement with Iwansyah and Yusoff [22] that reported geographic origins influenced the physicochemical and phyto-chemical content of the *Labisia pumila* var. *alata* leaves.

4. Conclusion

The Mixture D-optimal design approach was successfully to obtain combination flour and moringa leaves powder. A combination of flour (46.43 %) and moringa powder (4.57 %) resulted in an optimum moringa crackers formulation. The moringa crackers prepared using showed the best solution for this combination of variables with a desirability value of 0.554. This formulation could provide hardness 2470.65 g, fracturabillity 297 mm, moisture 3.58%, ash 3.48%, protein 12.45%, color 4.07, aroma 4.03, taste 3.73, and overall 3.97. Furthermore, we recommended for further research to be done, especially in the selection of optimization targets and a specific level of importance so that the desirability value is expected to be closer to one.

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