

Optimization of the use of sorghum flour, peanuts, and moringa leaves in the making of high-protein gluten-free biscuits

[Optimasi penggunaan tepung sorgum, kacang tanah dan daun kelor pada pembuatan biskuit non-gluten tinggi protein]

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ABSTRACT

Protein is one of the macronutrients that the body needs in large quantities in addition to carbohydrates and fats. Protein needs must be fulfilled to avoid health problems. Eating high-protein biscuits can be one way to meet daily protein needs. Biscuits made from sorghum composite flour of sorghum, peanuts, and moringa leaves can produce non-gluten high protein biscuits. This study aimed to determine the optimal balance of using sorghum flour, peanuts, and moringa leaves to produce high-protein biscuits with acceptable sensory values. The research method used was an experimental method with descriptive data analysis. The optimization method used the Response Surface Methodology (RSM) experimental design with a central composite design (CCD). The best biscuit formula as a result of the RSM experimental design optimization has a protein nutrient content of 8.71%, 2.60% moisture content, 2.60% ash content, 32.99% fat content, and 53.85% carbohydrate content. The combination of using flour significantly affects the texture of the biscuits, but does not significantly affect the color. The use of composite flour consisting of 60% sorghum flour, 37% peanuts, and 4% moringa leaves in the manufacture of non-gluten biscuits resulted biscuits that are high in protein and have physicochemical properties and good sensory acceptability.

Keywords: Non-gluten biscuits, optimization, protein, RSM

ABSTRAK

Protein merupakan salah satu makronutrien yang dibutuhkan tubuh dalam jumlah banyak di samping karbohidrat dan lemak. Kebutuhan protein harus tercukupi untuk menghindari masalah kesehatan karena defisiensi protein seperti penyakit kurang kalori dan protein, marasmus, kwashiorkor maupun *stunting*. Mengonsumsi biskuit tinggi protein dapat menjadi salah satu cara untuk memenuhi kebutuhan protein sehari-hari. Biskuit berbahan dasar tepung sorgum, kacang tanah, dan daun kelor dapat menghasilkan biskuit non-gluten yang tinggi protein. Penelitian ini bertujuan untuk mengetahui imbalan penggunaan tepung sorgum, kacang tanah, dan daun kelor secara optimal untuk menghasilkan biskuit tinggi protein dengan nilai sensori yang dapat diterima. Metode penelitian yang digunakan adalah eksperimental dengan analisis data yang bersifat deskriptif. Metode optimasi menggunakan rancangan percobaan *Response Surface Methodology* (RSM) dengan *central composite design* (CCD). Formula biskuit terbaik hasil optimasi rancangan percobaan RSM memiliki kandungan gizi protein 8,71%, kadar air 2,60%, kadar abu 2,60%, kadar lemak 32,99%, dan kadar karbohidrat 53,85%. Kombinasi penggunaan tepung berpengaruh nyata terhadap tekstur biskuit, namun tidak berpengaruh nyata terhadap warnanya. Penggunaan tepung komposit yang terdiri dari 60% tepung sorgum, 37% kacang tanah, dan 4% daun kelor pada pembuatan biskuit non gluten dapat menghasilkan biskuit yang tinggi protein karena diatas standar SNI protein biskuit yaitu 4,5% dan memiliki sifat fisikokimia serta penerimaan sensori yang baik.

Kata kunci: biskuit non-gluten, optimasi, protein, RSM

Introduction

Along with carbohydrates and lipids, protein is one of the macronutrients that the body need in large amounts. For children 1-3 years old, the daily requirement for protein is 20 g, while for children 4-5 years old, it is 25 g (Ministry of Health of the Republic of Indonesia, 2019). The need for protein in children who

need catch-up growth is 2.82 - 4.82 grams / kgBW / day so that if the normal weight of 1-2 year old girls is around 8.9 kilograms - 11.5 kilograms and boys are around 9.6 kilograms - 12.2 kilograms, then to catch up growth at least need to fulfil 25 grams of protein per day. According to BPS (2021) the protein consumption per capita per day of Indonesian people is still below the national protein consumption adequacy standard of 57 g where nationally the protein consumption per capita is only 46.95 g daily.

Children under five years old are a golden period that is very important in the growth and development of a child's physique. Food intake is an important factor in metabolising the growth process. One of the main factors for stunting is the lack of nutrient intake needed by the body. Children who are not given vitamin A and vitamin D supplementation, lack of protein, fat, and Fe intake have a risk of stunting (Aritonang et al., 2020; Ayuningtyas et al., 2018). Snack products in the form of high-protein biscuits can be an alternative to help the growth and repair of body tissues in children under five (Rohmawati et al., 2020).

The ingredients for making biscuits are generally made from wheat flour and gluten is a protein contained in flour. Gluten consumption can cause problems in autistic children or people with celiac disease. Autistic children have metabolic disorders, namely the lack of phenol sulphur transferase (PST) enzyme related to the digestion of gluten and casein. Gluten and casein have a combination of certain amino acids that the digestive system of autistic children has difficulty breaking down completely into single amino acids so that if they enter the bloodstream and enter the brain. will be captured by opioid receptors, this can cause brain growth failure and trigger autistic symptoms. Celiac disease is an autoimmune disease whose symptoms arise from eating foods containing gluten. In people with Celiac disease, the immune system overreacts to gluten. The reaction will cause inflammation that can eventually damage the lining of the small intestine and disrupt the absorption of nutrients (Ciacci et al., 2007).

Alternative raw materials for making biscuits, namely wheat flour, need to be replaced with non-gluten flour so that these high-protein biscuits can be consumed by toddlers who have stunting or autism problems and people with celiac disease. The raw material chosen to produce high-protein non-gluten biscuits certainly needs to have a high protein content.

Sorghum is a potential local food commodity from the range of cereals that is still rarely used. Sorghum does not contain gluten and contains about 11% protein, higher than other types of cereals such as rice and corn which contain 6.8% and 9.4% protein respectively (USDA, 2015; Wulandari et al., 2017). Peanut is a grain from a legume plant that contains high protein of 25-30% (Arya et al., 2016). The Moringa plant, known as the "Miracle Tree" because of its high nutritional content, has leaf parts that contain high protein, namely 22.2% - 34.4% (Benhammouche et al., 2021).

Sorghum flour can be an alternative ingredient to replace wheat flour as a base for biscuits (Haqiqi & Komariah, 2019), but as a composite flour in making high-protein biscuits, the protein content of sorghum is lower than peanut and moringa. The addition of peanut and moringa flour to biscuits can increase their protein content. The high fat content in peanut flour can also increase the texture of the biscuits to be softer and crisper and provide lubrication, mouthfeel, aeration, and biscuit flavour (Davidson, 2016), but because it contains high fat, the process of grinding peanut flour cannot be maximised because if the grinding is too long the peanuts will be oily and clumpy. As based on Chodur et al. (2018), moringa leaves have phytochemical compounds, especially glucosinolates, which can cause a bitter taste so that the addition cannot be too much so that the taste of the biscuits is acceptable.

Based on Irsak et al. (2023), biscuits from composite flour of sorghum and peanut with a ratio of 50%: 50% have a good acceptance value with high protein content, which is 12.18%. The addition of 3% moringa flour to biscuits produced biscuits with high protein content, reaching 10.12% (Augustyn et al., 2017). The addition of moringa flour above 5% did not get a good sensory assessment in terms of taste, aroma, colour, and texture, namely the biscuits became more bitter, had a languorous aroma, a greenish colour, and a less crunchy texture (Indriasari et al., 2019). There is still no research on the physicochemical and sensory properties of high-protein non-gluten biscuits using a combination of sorghum, peanut, and moringa

composite flour. The purpose of this study was to determine the optimum formula for the combination of sorghum, peanut and moringa flour use in making high-protein non-gluten biscuits with physicochemical and organoleptic characteristics that are acceptable to consumers.

Materials and methods

Materials and equipments

The ingredients used in the manufacture of non-gluten composite biscuits included sorghum seed flour from West Nusa Tenggara (NTB), peanut flour from Bandung, Safiya moringa leaf flour, margarine, brown sugar, full cream milk, egg yolk, baking soda, and salt. The tools used included KIRIN digital oven (32 L capacity, AC 250 V/15A), grinder (Fomac FCT-Z500), distillation unit (BUCHI K-350), TA.XTPlus texture analyser (Stable Micro System, Surrey, UK), and chromameter (CM-5, Konica-Minolta, Tokyo, Japan).

Research method

Optimisation of the use of sorghum flour, peanut flour, and moringa flour was conducted using Response Surface Methodology (RSM) experiments. The experimental design to obtain optimum data was carried out with the help of Design Expert 13 (DX13). This study used three independent variables, namely sorghum flour (X₁), peanut flour (X₂), and moringa leaf flour (X₃). The total number of treatment variations was determined by Central Composite Design (CCD). The main response (Y) analysed was the protein content of the biscuits, then the texture and colour of the biscuits were also analysed to determine the relationship between protein content and the texture and colour of the biscuits produced.

Experimental design

Plackett-Burman on Design Expert software is used to create experimental designs and screening variables. Plackett-Burman parameter optimization was used to identify the parameters—namely, protein content—that have the greatest impact on the response outcomes. The addition of sorghum flour (X₁), peanut flour (X₂), and moringa flour (X₃) has the most significant influence in the protein content response, with a p-value close to 0.05, according to the Analysis of Variance (ANOVA) test and Pareto Chart. The three major factors derived the upper and lower limit concentration ranges that were employed, and these are shown in Table 1 based on analysis utilizing curvature check.

Table 1. Range of upper and lower limits of RSM design

Variable	Upper limits	Lower limits
Sorghum Flour (X ₁)	30.18 %	20.96 %
Peanut Flour (X ₂)	20.96 %	12.57 %
Moringa Leaf Flour (X ₃)	2.10 %	1.26 %

Based on the range of upper and lower limits of each variable, then processed by software and produce 19 results of treatment variations. In each treatment variation, the response (Y) was analysed, namely protein content (%) as the main response. The protein content response of the biscuit treatment variations was calculated based on the protein mass balance, by summing the total protein of the ingredients in the biscuit formulation. The RSM-CCD experimental design can be seen in Table 2.

Table 2. RSM-CCD design of combination of sorghum flour, peanut flour, and moringa leaf flour

Run	Variable Sorghum flour (%)	Peanut flour (%)	Moringa leaf flour (%)	Response Protein level (%)
1	25.57	16.77	1.68	11.93
2	25.57	16.77	1.68	11.93
3	28.41	13.58	2.00	11.38
4	25.57	16.77	1.68	11.93
5	22.07	19.92	2.00	12.60
6	29.07	13.55	1.36	11.25

Run	Variable			Response
	Sorghum flour (%)	Peanut flour (%)	Moringa leaf flour (%)	Protein level (%)
7	22.07	20.56	1.36	12.59
8	25.57	16.32	2.10	11.92
9	30.16	12.57	1.26	11.04
10	25.57	16.77	1.68	11.93
11	22.68	19.95	1.36	12.48
12	25.64	16.67	1.68	11.91
13	23.57	18.96	1.46	12.31
14	29.07	13.56	1.36	11.25
15	29.07	12.92	2.00	11.26
16	25.57	16.77	1.68	11.93
17	25.57	17.16	1.26	11.92
18	26.42	15.58	2.00	11.76
19	27.57	14.74	1.68	11.54

The response data will be analysed with Design Expert 13 software to obtain the optimum formula that produces the highest biscuit protein content. The model that best fits the response conditions will produce an optimal point, namely high protein levels, as shown in Table 3.

Table 3. The optimum formula for high protein non-gluten biscuits

Sorghum flour	Peanut flour	Moringa leaf flour	Protein content (prediction)
22.07 %	13.58 %	1.36 %	12.57%

Flour preparation

Sorghum flour was made from sorghum seeds from West Nusa Tenggara (NTB). The process of making sorghum flour included washing the sorghum seeds with clean water. The sorghum seeds were then dried on a baking tray and put into an oven at 50°C for 8 hours. The dried sorghum seeds were then ground using a grinder (Fomac FCT-Z500). Peanut flour from Bandung was also ground using a grinder (Fomac FCT-Z500). The main ingredients of sorghum flour, peanut flour, and Moringa leaf flour were sieved with a 100-mesh sieve to be used as composite flour for non-gluten biscuits according to the RSM-CCD design.

Biscuit preparation

Biscuits were prepared by mixing cream margarine, brown sugar, eggs, and salt for five minutes. The same amounts of each component were used for all optimization treatment conditions: full cream milk 10.48%, egg yolk 3.35%, baking soda 0.13%, and salt 0.13%. Using a mixer, the components were thoroughly combined. After the dough has been thoroughly combined, it was taken with a spoon and placed on a baking dish, weighing approximately 15 grams. After flattening the dough to a thickness of ± 0.5 cm, it was shaped into the required shape. Next, the biscuit dough was baked at 150°C for 25 minutes. After cooked, the biscuits were cooled down and then placed into a container. The biscuit receptacles were labeled to differentiate between the 19 utilized formulas.

Research parameters

The parameters observed in this study were the formulation of the RSM-CCD design results, the protein mass balance was calculated and then tested for physical characteristics (colour and texture) to obtain response data. The best formulation was determined from the highest protein content. The best formulation with the highest protein content was then tested for other proximate characteristics (water, fat, ash, and carbohydrate) and the level of liking with the duo-trio discrimination test. The following were the details of the observations made: protein content of the best biscuits resulting from the optimisation of the RSM-CCD experimental design (AOAC, 2005), texture using TA.XTPlus texture analyser (Stable Micro System, Surrey, UK) (Indriarti et al, 2021), colour using a spectrophotometer (CM-5, Konica-Minolta, Tokyo, Japan) (Kaemba & Edy, 2017), chemical characteristics, including moisture content, ash content, fat

content, and carbohydrate content by difference (AOAC, 2005), sensory using the duo-trio discrimination test (Meilgaard et al, 2016).

Results and discussion

Protein content of biscuits

Protein content of biscuits was the main response studied. The protein content response of 19 variations of the biscuit formula suggested by Design Expert 13 has been calculated using a mass balance. The results of the protein content data were then analysed using software and resulted in a linear model as the selected model. The linear model has the best p value of all models analysed by the software, which is 0.0001. The p value of 0.0001 means that this linear model has a chance of error of only 0.01%, making the linear model the model suggested by the DX13 software.

Based on the DX13 software analysis, the optimal response value of protein content of the sorghum, peanut, and moringa composite flour biscuits showed a value in the range of 11.9% protein. The software also shows a 3D surface graph. The optimal response values are indicated by nodes. The contour plot and 3D graph are presented in Figure 1 and Figure 2.

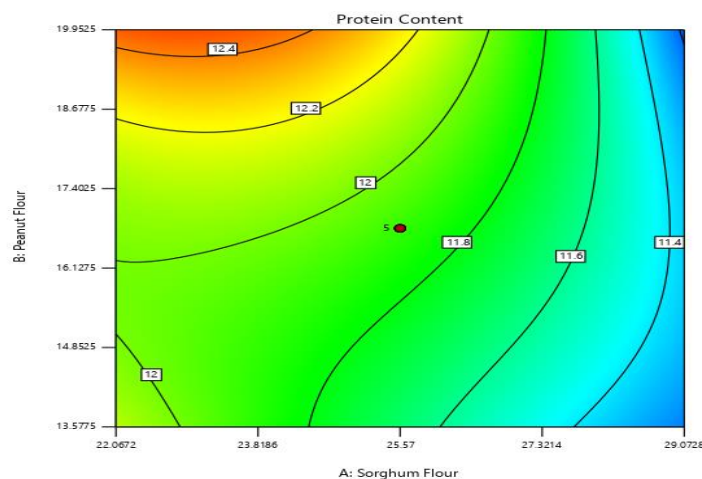


Figure 1. Contour plot of optimal response of protein content

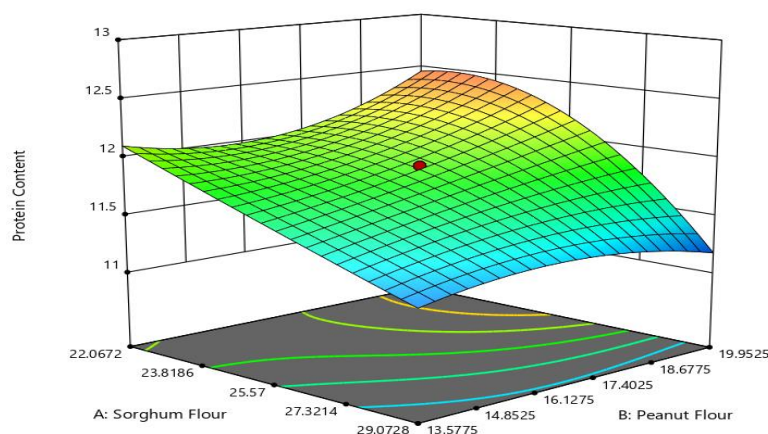


Figure 2. 3D graph of optimal response to protein levels kadar protein

Based on Figures 1 and 2, it can be seen that the higher the addition of sorghum flour and peanut flour, the higher the protein content of the biscuits produced.

Sorghum flour and peanut flour were the 2 variables that had the most significant effect on the protein response level ($p < 0.05$). The stage was continued with the optimisation process to determine the formula that produced the highest protein levels. Optimisation of the response data formula found that the minimise formula produced the best biscuit protein levels, reaching 12.567% with a desirability of 0.995.

The solution chosen was the one with the highest desirability value, which was 0.995 (close to 1). The desirability value was used to determine the accuracy of the optimal solution results with a value range of 0 to 1. A desirability value of 1 indicates that the response is perfect while a desirability value of 0 indicates the response is not good and must be discarded (Laluce et al., 2009). The best formula for the use of composite flour to produce high-protein biscuits was chosen as the first solution, namely the addition of 22.07 g of sorghum flour, 13.58 g of peanut flour and 1.36 g of moringa flour or if the substitution is changed in the addition of 100 g of composite flour, the percentage becomes 59.63% or rounded up 60% of sorghum flour, 36.69% or rounded up 37% of peanut flour, and 3.67% or rounded up 4% of moringa flour.

The next stage was validation between predicted and actual biscuit protein levels. Validation is needed to test the accuracy of the model. Validation was carried out by comparing the prediction of the best treatment formula based on the model with the research results. Comparison of research results and predictions can be seen in Table 4.

Table 4. Comparison of predicted and actual protein content

Variable	Optimum Model	Protein Content (%)	
		Predicted	Actual
Sorghum Flour	22.07 %		
Peanut Flour	13.58 %	12.57	8.71
Moringa Leaf Flour	1.36 %		

Based on Table 4, the protein level of the optimised biscuits has not reached the protein level predicted by DX 13 software. This can be due to the R² (coefficient of determination) value of the ANOVA model was 0.7437, indicating that 74.37% was influenced by the composite flour factor of sorghum, peanut, and moringa leaves, while the remaining 25.63% was influenced by other factors not included in the model. The heating or baking procedure of the biscuits may be one of the factors causing the protein levels to fall short of the intended aim. This supports the claim made by Sundari et al. (2015) that food ingredients experience more protein degradation the higher the temperature employed and the longer the processing time.

This study employed a temperature of 150°C for 25 minutes when making biscuits. The amount of protein decreased due to the higher oven temperature. This is in accordance with Novia et al. (2011) in which eggs baked at 70 degrees produced protein levels of 37.6%, at 80°C protein decreased to 28.4%, at 90°C protein content dropped to 25.0% and the lowest protein levels were found in the 100°C treatment which was 22.4%. Research (Siskawardani et al., 2021) also showed that the increase in temperature in the baking process reduced the protein content of sweet bread where successively the baking temperatures at 170 ° C, 180 ° C, 185 ° C produced protein levels of 1.39%, 1.27%, and 1.17% with the same baking time, namely 8 minutes. Another research by Patel et al. (2019) showed a decrease in protein levels in pumpkin seed fortified biscuits where the roasting temperature of 180°C produced biscuits with protein levels of 19.41% and the roasting temperature of 220°C produced biscuits with protein levels of 16.09%.

The ingredients of the research biscuits also actually had a fairly high protein content, such as sorghum flour which contains 10.09% protein, peanut flour 29.26% protein, moringa leaf flour 29.53% protein, as well as additional ingredients, namely egg yolk and protein ,and full cream milk which have protein contents of 31.85% and 27.53%, respectively, however, the protein content of the optimised biscuits is still below the target predicted by DX13 software (12.57%).

Sorghum flour that does not contain gluten can still bind the biscuit dough. Based on Adedara & Taylor (2021) the presence of sucrose sugar in the sorghum biscuit formulation is responsible for the texture of the biscuits similar to wheat biscuits. During baking, the sucrose melts and permeates into the dough. When cooled, the sugar forms a glass that envelops the flour particles. It is this glassy sugar matrix that is responsible for the strength and cohesiveness of the biscuits. In addition, based on (Yustina et al., 2021) sorghum flour has the ability to bind water which is not much different from wheat flour, where the yield test results of muffins using sorghum flour (non-gluten flour) were 95.90% while wheat flour (gluten flour) was 95.86%, therefore, even though sorghum flour is non-gluten flour, it can function as a binder that easily blends with other flours if mixed well.

The protein content of the optimised biscuits was 8.71%, which means it met the minimum standard of SNI 2973:2011, which is 5% protein. The standard for supplementary food for toddlers 6-59 months with a thin category is to contain a minimum of 8% protein (Permenkes, 2016). Optimised biscuits that have a protein content of 8.71% can be used as additional food or PMT biscuits for toddlers to fulfil nutritional intake and prevent diseases due to malnutrition, especially protein. PMT biscuits for toddlers need to contain at least a minimum of 160 calories, 3.2 - 4.8 g protein, and 4 - 7.2 g fat per 40 g biscuit (Putri & Mahmudiono, 2020).

Analysis of biscuit texture response

The RSM-CCD experimental biscuits and optimised biscuits were tested for their texture profile, namely hardness and fracturability using a texture analyser. Hardness and fracturability are important physical characteristics to analyse as they are directly related to the sensory acceptability of the biscuits. The results of the RSM-CCD experimental design formulation showed that the hardness and fracturability of the biscuits were significantly different. The texture profile of the RSM experimental design biscuits is presented in Figure 3.

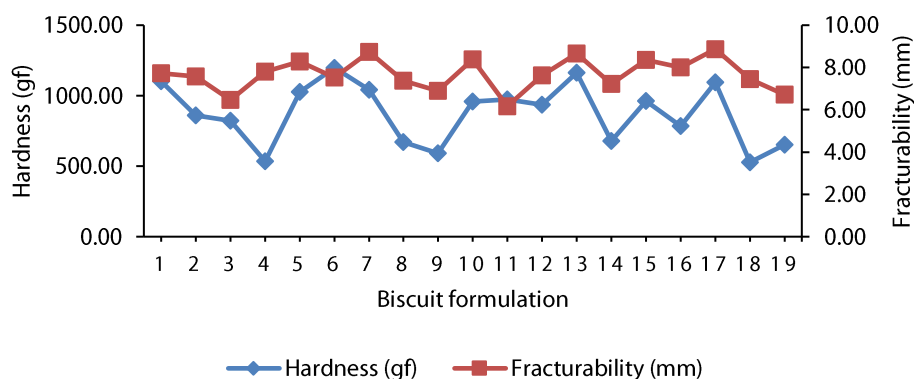


Figure 3. Texture profile of RSM-CCD trial biscuits

Based on the texture test of 19 biscuit treatment variations, the highest biscuit texture profile value was owned by run 13 with a hardness of 1162.42 gf and fracturability of 8.66 mm, while the lowest texture profile value was in run 18 with a hardness of 527.62 gf and fracturability of 7.46 mm. There are several factors that can affect the texture of biscuits, such as the ingredients used, the amount of addition, and chemical content such as protein and water content, as well as the baking process.

Based on the statistical model analysis, sorghum flour and peanut flour were the two factors that could significantly influence the texture profile of the biscuits. Peanut flour had a greater significance value than sorghum flour where based on ANOVA the p value of peanut flour was 0.0081 ($p < 0.05$). In the run 13 biscuit treatment, the addition of peanut flour was quite high, at 18.96% where the upper limit was 20.96%. The high addition of peanut flour was in line with the increase in protein content of the biscuits, resulting in high hardness and breakability values. Conversely, the low addition of sorghum flour and peanut flour

in the run 18 biscuit treatment resulted in a biscuit texture profile with low hardness and breakability. The optimisation process was intended for a good biscuit texture profile with hardness and breakability that was neither too high nor too low.

The optimised biscuit formula chosen as the best treatment was with the addition of 22.07g sorghum flour, 13.58g peanut flour, and 1.36g moringa flour. This optimised biscuit formulation was predicted by DX13 software with the hardness and fracturability texture profiles presented in Table 5.

Table 5. Predicted biscuit texture profile

Sorghum Flour (g)	Peanut Flour (g)	Moringa Leaf Flour (g)	Hardness (gf)	Fracturability (mm)
22.67	13.77	1.361	847.303	8.716

The optimised biscuits were tested for texture using a texture analyser to validate whether the texture of the biscuits matched the prediction results of the DX13 software. In Table 6, a comparison of biscuit texture is presented where it turns out that the optimised biscuits had hardness and breakability that were not much different from the predictions and the conformity was above 95%.

Table 4. Validation of biscuit texture

Biscuit Texture	Hardness (gf)	Fracturability (mm)
Actual	867.86	8.45
Predicted	847.30	8.72
Percentage	98%	97%

The texture of the optimised biscuits has a crispy texture with good hardness and fracturability where the values are neither too high nor too low. This is influenced by the use of sorghum flour and peanut flour which is not too high which has been shown based on the texture profile of Table 6, the higher the treatment of the addition of sorghum flour and peanut flour, the higher the level of hardness and breakability of the biscuits.

The increase in the amount of flour is related to the increase in protein content of the biscuits produced. Protein levels can affect the level of hardness of biscuits, the higher the protein content, the higher the hardness of the biscuit texture (Irsak et al., 2023). The higher the addition of sorghum flour and peanut flour, the higher the protein content of the biscuits produced. In this study, the temperature and baking time were sufficient to evaporate the water in the biscuits so that the optimised biscuits had a crunchy texture and moisture content according to SNI, which is below 5%.

Color response analysis of biscuits

The RSM-CCD designed biscuits were also tested for color using a spectrophotometer. The color parameter expressed in L* value indicates lightness or brightness level with range of values 0-100 (dark-light), the a* value indicates red-green and the b* value indicates yellow-blue (Ratnawati et al., 2019). The L*a*b* value of the biscuits was then converted into Hue degrees to determine the color interpretation. Hue is a measure of the wavelength found in the dominant color received by sight (Larosa et al., 2015).

Based on the hue degree value, all treatments of the RSM-CCD biscuit formula variations fell into the Yellow Red (YR) color criteria. Based on the ANOVA results, the variation in the addition of sorghum flour, peanut flour, and moringa leaf flour did not have a significant effect on the color of the biscuits where the p model value was > 0.05 (not significant). This result can be caused by the color data, the difference in hue values was only slightly different from each other.

The color of biscuits can vary depending on the raw materials and their processing, protein sources, and baking process conditions (cooking time and temperature) (Dakhili et al., 2019). Related to protein, the addition of protein sources to biscuits will produce a darker crust color (lower Luminosity value) and a darker crumb color. This darker color is related to the interaction of amino groups with reducing sugars in the Maillard reaction when melanoidins are formed (Irsak et al., 2023). The color of biscuits is also

influenced by the ingredients. The biscuits from the optimization formula were also tested for color. The software predicted that the biscuits with the optimization formula would have a hue color of 66.299. The optimized biscuit samples were actually tested using a chromameter as validation. The results of the comparison of the predicted and actual colors of the biscuits can be seen in Table 8.

Table 5. Validation of color (°Hue) optimizing biscuits

Predicted	Actual	Percentage	Image of optimizing biscuits
69.61	66.42	95.42%	

Based on the test results, the optimized biscuits showed a hue of 69.61 indicating that the hue value obtained has the Yellow Red (YR) color criteria. This shown that moringa leaf flour does not significantly affect the color of the biscuits so that it does not interfere with the acceptability of the color quality.

Chemical characteristics of optimized biscuit

Biscuits produced from the optimum formulation were subjected to chemical characteristic analysis which can be seen in Table 9. Water content testing is one of the important chemical tests carried out in the food industry because it can determine the quality and resistance of food to possible damage. The high water content in food ingredients will increase the possibility of deterioration, either due to internal biological activity (metabolism) or invasion of destructive bacteria (Agus et al., 2023). The water content of the optimum formula biscuits has met the SNI standard with a water content of 2.60% (wb). Water content that is too high can cause the texture of the biscuits to become less crispy and accelerate changes in flavor during storage (Agus et al., 2023).

Table 9. Chemical properties of biscuits made using the optimum recipe

Parameter	Content (%)
Moisture	2.60 ± 0.05
Ash	2.26 ± 0.07
Fat	32.99 ± 0.03
Carbohydrate <i>by difference</i>	53.85 ± 0.02

The ash content of biscuits is used to determine the amount of minerals contained in the biscuits. The ash content of a food ingredient indicates the presence of inorganic material residue after burning, during burning at high temperatures, organic materials will burn and leave inorganic materials that roughly describe the mineral content of the food ingredient (Agus et al., 2023). The results of the ash content of the optimized biscuits can be seen in Table 9.

The ash content of the optimized biscuits was 2.26%, this is not in accordance with the SNI biscuit standard 2973-1992, where the maximum ash content in biscuits is 1.5%. This can be caused by the accumulation of ash content of the ingredients, such as sorghum flour which has an ash content of 1.39% (Wibowo, 2016), peanut flour which has an ash content of 1.9% (Sari et al., 2019). Moringa leaf flour has an ash content of 10.53% (Yunita et al., 2022) and other additional ingredients, such as margarine, brown sugar, milk, baking soda, and salt.

Fat is an important food substance for the human body besides carbohydrates and proteins as macronutrients. In making biscuits, hard biscuits are a type of biscuit that contains more or less fat. Based on BSN (2011) the minimum or maximum fat content in biscuits is not discussed, while the fat content of biscuits meets the biscuit quality standards according to BSN (1992), which is a minimum of 9.5%. The optimal biscuit fat content was 32.99%, the high fat content can be influenced by the addition of peanuts which have a high fat content of 46.88 g / 100 g (Dharsenda & Dabhi, 2020). Sorghum flour also contains 3.3 g of fat (Mustika et al., 2019; Wulandari et al., 2017) and moringa leaf flour contains 2.52% fat (Augustyn

et al., 2017). The addition of fat can also come from other supporting ingredients such as margarine and egg yolks (Widyastuti et al., 2015).

Fat is the main ingredient that contributes to the overall appearance of the product by improving the quality of the biscuit from creating a mouthfeel and improving the quality of the biscuit texture. Fat in biscuits plays a role in increasing volume and texture so that a soft taste is created in the mouth, fat can also extend shelf life because fat forms a crust that slows down the transfer of water vapor into the biscuit (Klunklin & Savage, 2018). Differences in the composition and type of fat used will affect the characteristics of the biscuit texture, reducing the fat content will produce harder biscuits (increased breaking strength) so that this will certainly affect the acceptability of the biscuit (Devi & Khatkar, 2016, 2017).

The carbohydrate content of biscuits was calculated based on by difference, which is the remainder of 100% minus the water content, ash content, protein content, and fat content that have been tested previously. The carbohydrate content of the optimized biscuits can be seen in Table 9. The carbohydrate content of the optimized biscuits calculated by difference was 53.85%. The minimum carbohydrate standard in biscuits is contained in the 1992 SNI regulation, where the minimum carbohydrate content for biscuits is 70% so that optimized biscuits are still below the minimum standard (BSN, 1992). The source of carbohydrates in biscuits can come from the accumulation of additional ingredients, where the main ingredient for making biscuits, namely sorghum flour contains 73 grams of carbohydrates (Mustika et al., 2019), peanut flour contains about 21 grams of carbohydrates (Agus et al., 2023) and moringa leaf flour contains 51.91 grams of carbohydrates.

Biscuit sensory evaluation

The sensory evaluation of optimized formula biscuits with the addition of sorghum flour, peanuts, and moringa leaves was tested using the duo-trio test which aims to see the effect of adding moringa leaf flour on the sensory properties of biscuits. In the sensory test, 2 test samples were presented to the panelists, namely biscuits without the addition of moringa leaf flour as a control and 1 sample of optimized formula biscuits as a reference sample. The sensory parameters assessed were color, aroma, taste, texture, and overall appearance. Based on the duo-trio test binomial table with a level of 0.05, from a total of 21 panelists, a minimum total value of 15 was required for each parameter so that the addition of moringa leaf flour was considered to have a significant effect on the sensory properties of biscuits.

Based on the duo-trio test, it was found that the optimum formula biscuits had sensory characteristics that were preferred and better than the control biscuits. From the form results, no sensory parameters reached a value of 15, so it can be concluded that the panelists felt the same or did not feel any changes when consuming biscuits with the addition of moringa leaf flour. Moringa leaf flour has disadvantages such as producing a rancid odor, greenish color, and bitter taste in biscuits (Augustyn et al., 2017). The addition of 1.36 g or 4% moringa leaf flour in the addition of 100 g of composite flour did not cause significant changes in the sensory characteristics of biscuits so that they can be liked by consumers.

Conclusion

The use of composite flour consisting of 60% sorghum flour, 37% peanuts, and 4% moringa leaves in making non-gluten biscuits produced biscuits with a protein content of 8.71% higher than the protein content standard of SNI 2973: 2011, brownish in color, had a crunchy texture with good hardness and breaking strength of 867.86 gf and 8.45 mm and had good sensory acceptance.

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