

# Optimization of Cookies Formulation Based on Composite Flour of Sorghum (*Sorghum bicolor* L), Breadfruit (*Artocarpus communis*), and Peanut (*Arachis hypogaea* L.)

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Submission: 9 March 2022; Revision: 21 May 2022; Accepted: June 17, 2022; Published: May 31, 2023

## ABSTRACT

This study investigates the challenges associated with making cookies using wheat flour as the primary raw material. Due to the difficulty in cultivating wheat seeds in the region, alternative sources of flour, such as sorghum, breadfruit, and peanuts, need to be explored to diversify the food supply. Therefore, this study aims to assess the level of the desired characteristics achieved from the composite of sorghum, breadfruit, and peanut flour cookies using the Design-Expert program and the D-optimal Mixture method. To evaluate the responses, chemical, organoleptic, and physical properties are examined, including water content, protein content, fat content, carbohydrate content, color, aroma, texture, taste, and hardness. Furthermore, the optimal formula, generated by the program, contains 23.298% sorghum, 7.869% breadfruit, and 18.843% peanut flour, with an accuracy value of 0.653. The results show that the optimal formula for cookies based on the composite flour has the desired characteristics and complies with the SNI standards 2973-1992 and 2973-2011.

**Keywords:** Breadfruit; cookies; design expert; peanuts; sorghum

## INTRODUCTION

Contemporary society is characterized by a considerable degree of mobility, busyness, and a demanding work schedule. Consequently, individuals tend to opt for convenient and easily consumable food options that cater to their fast-paced lifestyle. Snack foods have emerged as a popular solution to meet these requirements. Among Indonesian consumers, cookies are consumed as the second most preferred snack after chips, holding a substantial market share of 66% (Snapcart, 2017). It has the potential to serve as a healthful and nourishing food that satisfies the

protein requirements of the body, thereby aiding in the prevention of Protein Energy Malnutrition (PEM).

The raw materials used to make cookies affect the end product quality, specifically the flour used. There is a constraint in the production of wheat in Indonesia, as evidenced by data from the Central Statistics Agency (BPS, 2020). In 2018, the import amounted to 10,096,299.2 kg but increased to 10,692,978 kg in 20219. Data from Kementerian Pertanian (2018) showed that in 2014, per capita wheat flour consumption was 1,364 in 2014, and it increased at an average growth rate of 19.92 per year until 2018. This high level of consumption has a negative impact on the foreign exchange reserves of the country.

Therefore, it is necessary to replace wheat flour, which is a raw material, with local ingredients. One potential alternative ingredient for making cookies is gluten-free flour produced using a minimum development baking process (Sitanggang, 2016).

Sorghum (*Sorghum bicolor* (L) Moench) is a promising candidate for flour production because it contains up to 73% carbohydrates (Rukmana & Oesman, 2005). It is one of the cereals that have the potential to be developed in Indonesia due to its wide adaptability, tolerance to drought or hot climates, and resistance to pests and diseases. The plant has been developed in six provinces with a development area reaching 23,141 hectares divided into several regions (Sirappa, 2003). Despite its relatively high productivity, ranging from 4,241 to 6,172 tons/ha, the utilization of sorghum in Indonesia is still suboptimal (Directorate General of Food Crops, 2010). Another potential food ingredient to be made into flour for cookies is breadfruit, acting as a local raw material and a source of carbohydrates. In 2017, the production was 104,962 tons but increased to 124,287 tons in 2018 (BPS, 2019). It contains 28.2% carbohydrates per 100 g of material, which increases to 78.9 g per 100 g of material when processed into flour (Widayati & Damayanti, 2000). Breadfruit flour is superior in terms of vitamin and mineral content and has low calories (Novrini, 2020) with 3.6% protein (Budijanto, 2009).

The minimum protein content in cookies according to the standard is 5% (BSN, 2011). Therefore, the addition of raw materials such as peanuts is necessary to produce cookies with high protein content. Peanut is a nutritious food that contains plant-based protein of up to 30.4 g per 100 g of edible material (Purnomo and Purnawati, 2007). According to FAOSTAT (2009), 85% of peanuts are used as food with an average consumption rate of 2.4 kg/capita/year in the form of boiled/roasted peanuts, pecel/gado-gado seasoning, biscuits, and flour. Peanut flour can be added in the process of making cookies to meet the protein content standard of the product.

Cookies can be produced using gluten-free flour because the baking process requires minimal expansion (Sitanggang, 2016). Furthermore, cookies made from composite flour of sorghum, breadfruit, and peanuts must be formulated to obtain the desired characteristics of the final product and comply with SNI 293-1992 and SNI 2973-20211 quality standards. The optimal formula can be obtained with the Design Expert software using the Mixture D-Optimal method. The advantage of this application is that the number of limited changing materials can be more than 2 responses with a high level of flexibility in minimizing problems (Ghozaly et al., 2018).

The developed formulation can produce food products where the mixture of composite flour of sorghum,

breadfruit, and peanuts affects the characteristics of the resulting cookies. Meanwhile, formula optimization is the determination of the optimal formula based on the studied responses. Optimization can also be described as a set of mathematical and numerical methods to determine and identify the best formula.

Optimization formulas can be performed using the simplex method with linear programming, lindo software, solver facilities in Microsoft Excel, and Design Expert's Mixture D-Optimal method. The application used in this study is Design Expert's Mixture D-Optimal method, which displays optimization results based on each response. To determine the optimal formulation based on all the responses received, the program offers a solution feature to provide information about the selected formulation based on the overall responses. The results displayed by the solution feature can be customized according to the specific criteria of the user, ensuring that the solution aligns with the analysis response results (Nugroho, 2012).

The selected optimal formulation possesses a degree of precision or desirability, where a value closer to one indicates a higher precision level in the optimization. Design Expert's Mixture D-Optimal method can be used to obtain optimal formulations and to prove the creation of composite flour cookies made from sorghum, breadfruit, and peanut. Therefore, this study aims to determine the optimal formulation for making cookies using composite flour through Design Expert's Mixture D-Optimal method.

## Materials and Methods

### Sample Preparation

The materials used to make the cookies included a composite flour consisting of white sorghum flour (*Sorghum bicolor*) brand "Lingkar Organik", breadfruit flour (*Artocarpus communis*) brand "Lingkar Organik", and peanut flour (*Arachis hypogaea* L.) sourced from Bantul Regency, fine sugar brand "Ninaku", margarine brand "Forvita", chicken eggs, baking powder brand "Kupu-kupu", powdered milk brand "Dancow Forti Gro", salt and vanilla essence brand "Kupu-kupu".

Analysis Materials and Equipment: Analysis of raw materials and products required chemicals such as distilled water, concentrated  $H_2SO_4$ , catalyst tablets (3.5 g  $K_2SO_4$  and 0.4 g  $CuSO_4$  per tablet), boiling stones, 40% NaOH, 4% boric acid, Zinc granules,  $Na_2S_2O_3$ , 0.1 N HCL, methyl red indicator, n-hexane solution, 30% NaOH, concentrated HCL, pp indicator, KI, Luff School solution,  $Na_2S_2O_3$  0.1 N and 6 N  $H_2SO_4$ .

This study used several tools, such as an oven (Krisbow), a mixing machine, an analytical balance

(OHAUS, Shanghai, China), a gas stove (Rinnai, RI-602 BGX), clamps, stands, porcelain cups (Memmert made in German, type UNS55 230 V-50.60H), Kjeldahl flasks (Iwaki 300 mL), burettes (Pyrex 50 mL), Kjeldahl distillation equipment, heaters, distillation equipment and accessories, measuring flasks (Iwaki CTE33 100 mL), Erlenmeyer flasks (Pyrex Iwaki TE-32 250 mL), glass beakers (Pyrex IWAKI TE-32 250 ml), filter paper, complete Soxhlet equipment, fat flasks (Pyrex Iwaki 500 mL), electrothermal (230 volts 150 watts), Erlenmeyer flasks equipped with a reflux condenser, and desiccator.

### **Analysis 1: Analysis of Raw Materials and Products**

The analysis of raw materials and products involved chemical response, namely water, protein, fat, and carbohydrate content analysis using the gravimetric (AOAC, 2012), Kjeldahl (AOAC, 2005), Soxhlet method (AOAC, 2005), and Luff Schoorl methods (AOAC, 2005), as well as physical response in the form of cookies texture hardness using Texture Analyzer (Rosanna et al., 2015).

### **Analysis 2: Organoleptic Test**

The organoleptic response to the product was tested using a hedonic method on 30 panelists with evaluation attributes including color, aroma, and texture with parameters 1 (very dislike), 2 (dislike), 3 (slightly dislike), 4 (slightly like), 5 (like), and 6 (very like) (Soekarto, 1985).

### **Study Design**

In the planning stage, data input is required for independent variables, including their upper and lower limits for each ingredient. Additionally, the determination of the response to produce the necessary number of formulation runs that require analysis is a crucial step. During the optimization stage, the selected formula recommended by the program is subjected to testing, based on the initial response to refine and improve the formula. The response generated by the selected formula is then compared with the laboratory analysis results, as a means of evaluating the effectiveness.

To initiate the process, it is crucial to distinguish between fixed and variable factors. The variables include white sorghum, breadfruit, and peanut flour, while the fixed factors encompass powdered sugar, margarine, chicken eggs, baking powder, powdered milk, salt, and vanilla essence. The variable ingredients such as sorghum, breadfruit, and peanut flour have upper and lower limits determined and comprise 50% of the total ingredients. The upper and lower limits

are determined from the selected cookies formulation using the organoleptic test method, hedonic testing, with 30 panelists and the evaluation attributes include color, aroma, texture, and taste. Furthermore, the cookies formulation used in determining the limits is based on Hariadi et al. (2017) with modifications. The upper and lower limits are obtained by adding and subtracting 5% to and from the mean value of the variable, respectively.

### **Study Stage**

The main raw material preparation of composite flour is obtained by mixing sorghum, breadfruit, and peanut flour. The initial cookies formulation is determined using the Design Expert 13.0 program. The planning stage entails the input of data or ingredients, independent variables, and their respective upper and lower limits for each ingredient. Additionally, the determination of the response to produce the required number of formulation runs that need to be analyzed is a crucial aspect of this stage. To evaluate the responses, chemical, organoleptic, and physical properties are examined, including water content, protein content, fat content, carbohydrate content, color, aroma, texture, taste, and hardness. The Design Expert program processes the results of the measurement and calculation to produce an ANOVA table. Furthermore, the program recommends a polynomial model with the best order for each response. The next stage is optimization, which involves testing the selected formula recommended by the program based on the initial response.

## **RESULTS AND DISCUSSION**

The input data used in the Design Expert 13.0 program by entering the upper and lower limits of the variable, optimal setting (custom) design and the number of responses produced 14 formulation runs. The variable values used are sorghum (20%-30%), breadfruit (5%-15%), and peanut flour (10%-20%). The selected optimal design includes an additional model, lack-of-fit, replicate, and center points, each with a value of 2, resulting in a total of 14 formulation runs.

Composite flour is produced from a mixture of sorghum, breadfruit, and peanut flour to prepare the primary raw materials for making cookies. The chemical analysis of the water content of all composite flour formulations fulfills the quality requirements according to SNI wheat flour 3751-2009, which is a maximum of 14.50% (BSN, 2009). Furthermore, composite flour with a higher proportion of sorghum has a higher water content compared to breadfruit and peanut. According to Cahyadi et al. (2018), sorghum flour possesses a

Table 1. Initial cookies formulation

Run	Sorghum flour	Breadfruit flour	Peanut flour
1	25	5	20
2	30	5	15
3	25	10	15
4	21.5896	11.6704	16.7399
5	25	15	10
6	20	15	15
7	20	10	20
8	25	15	10
9	28.3154	8.26782	13.4168
10	30	10	10
11	25	5	20
12	30	5	15
13	30	10	10
14	25	10	15

Table 2. Results of composite flour analysis

Formulation	Water content	Starch content
1	5,97	48,59
2	6,44	57,04
3	5,97	60,66
4	5,94	58,09
5	6,47	71,02
6	5,94	62,75
7	5,47	51,24
8	6,47	72,12
9	6,50	60,94
10	7,00	69,22
11	5,50	47,06
12	6,47	57,34
13	7,46	67,47
14	6,50	60,66

water content of 10.37%. Similarly, breadfruit flour and peanut flour exhibit water contents of 8.66% and 7.1%, respectively (Wulandari et al., 2016 dan Siswanto & Wanito, 2017). The water content of raw materials affects the texture of the resulting snacks and can produce harder and more difficult-to-break cookies (Yasinta et al., 2017).

The starch content of composite flour of sorghum, breadfruit, and peanut ranges from 47.06% to 69.92%. The decrease in starch content is due to the addition of high levels of peanut flour. Based on Ratnaningsih and Marsono's study in 2013, legumes or beans exhibit a range of 18-49% total starch content. In contrast, Yulifianti et al., (2015) showed that peanut flour contains a starch content of 5.8%. Sorghum flour has a starch content of 65.85%, while breadfruit flour ranges from 78.9% (Avif & TD, 2020 Nurcahyo et al., 2014). Composite flour with high starch content produces cookies with high starch content.

**Water Content**

The ANOVA results showed that the linear model significantly affected the water content with a probability value of 0.0014 at a 5% significance level. Therefore, the response value of water content can be used for optimization in obtaining products with optimum characteristics. The lack of fit result with the linear model was not significant with a value of 0.1194. The result shows that the response data of water content is suitable for the model.

Component Coding: Actual

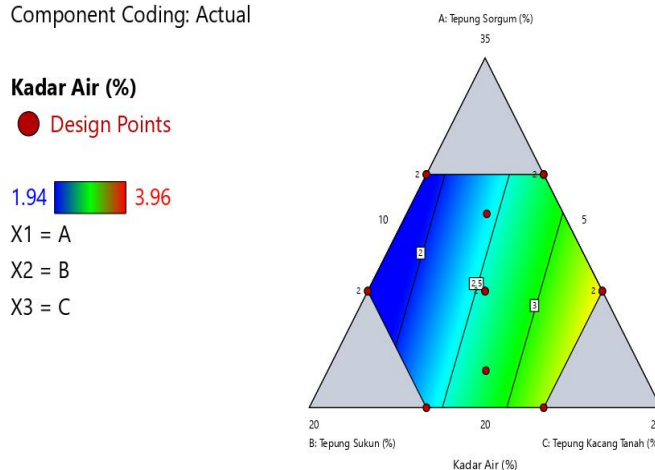


Figure 1. Contour plot graph of water content response

In Figure 1, there is a red color that indicates the highest response value located in the right corner, which is variable C for peanut flour. Therefore, the increase in water content of cookies is influenced by the proportion of peanuts in the composite flour. Cookies made from composite flour with a higher proportion of peanuts have an increased water content but a lower total dry weight. Furthermore, formulations 1 and 2 have a water content of 3.96% and 2.91% with a total dry weight of protein, carbohydrates, and fats of 87.36% and 93%, respectively. The higher the total dry weight (protein, fat, and carbohydrates), the lower the water content of food



material. According to Hutuely et al. (1991), when the water content decreases, compounds such as protein, starch, fat, and minerals have a higher concentration, while vitamins and color compounds decrease. Cookies that experience a decrease in this variable will result in an increase in protein, fat, and starch content in the material. The use of heat in food processing can decrease the percentage of water content, hence, there is an increase in the protein, fat, and starch percentage.

### Protein Content

The ANOVA analysis showed that the linear model was accepted at a 5% significance level, with a p-value of "Prob> F" equal to or less than 0.005. Therefore, the three variables, A (sorghum flour), B (breadfruit flour), and C (peanut flour), have a significant effect on the response to protein content. The significant protein response value can be optimized to produce products with desired characteristics. The lack of fit value in the ANOVA table showed an insignificant result with a value of 0.0573. Furthermore, the response data of protein content is suitable for the model, and a good result has an insignificant lack of fit value.

Based on Figure 2, the highest value is represented by the red color located in the upper right corner, which is variable C as peanut flour. Therefore, the protein content of cookies increases due to the proportion of peanuts in the composite flour. The content in composite flour cookies increases with the proportion of peanuts. The raw materials used are peanut flour, which accounts for 34.58% and affects the protein content (Sompie et al., 2021). Meanwhile, sorghum and jackfruit flour contain

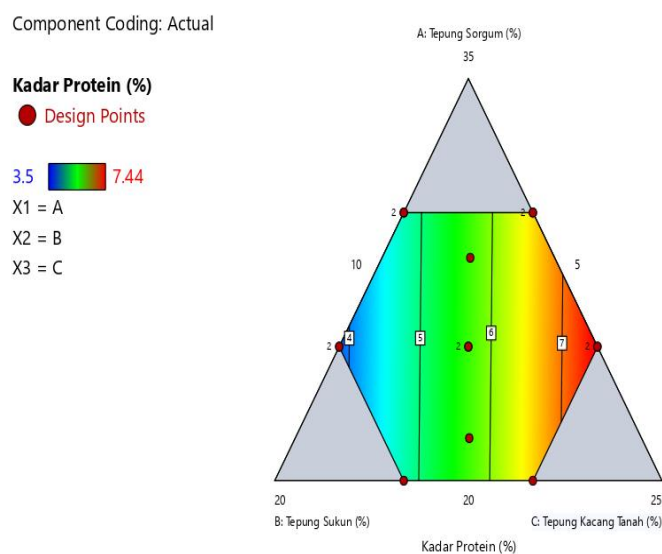


Figure 2. Contour plot graph of protein content response

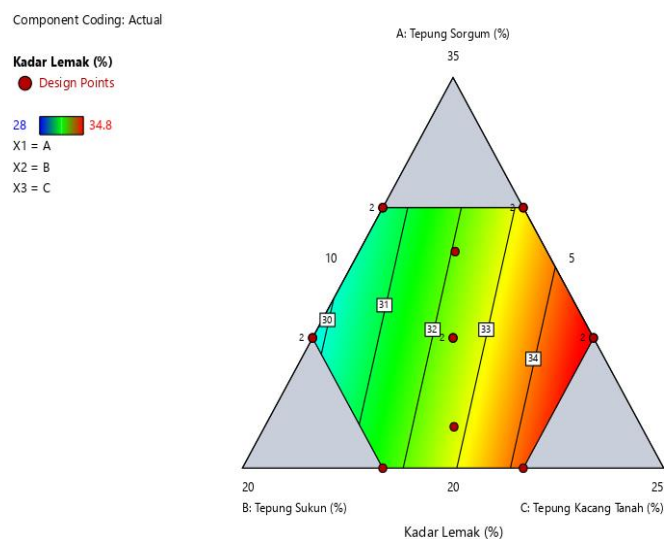


Figure 3. Contour plot graph of fat content response

only 9.49% and 3.6% proteins, respectively (Avif & TD, 2020 Murni et al., 2014). According to Fairus et al. (2021), peanut flour affects the increase in the protein content of cookies, where the addition of 40% and 30% resulted in a protein content of 9.13% and 6.25%.

### Fat Content

The ANOVA results for the chemical response value of fat content against the 14 formulations show a significant linear model, with a p-value "Prob> F" equal to or less than 0.005, which is <0.0001. Based on this data, it can be concluded that the three variables, namely sorghum flour, jackfruit flour, and peanut flour in the ingredients, have a significant effect on the response value. Therefore, the fat content response value can be optimized to obtain the desired cookies characteristics.

The lack of fit value shows an insignificant result, indicated by the p-value of the lack of fit being 0.1377. The value indicates the suitability of the fat content response data with the model, and a good result has an insignificant lack of fit.

According to Figure 3, the red color represents the highest fat content response value located in the upper right corner, which is variable C as the peanut flour. Based on this graph, the increase in cookies fat content is influenced by the proportion of peanuts in the composite flour. Cookies produced from composite flour with a higher proportion of peanuts have an increased fat content. This is because the fat content of peanut flour is 33.63% higher than sorghum and jackfruit flour at 3.54% and 1.02%, respectively (Sompie et al., 2021, Avif & TD, 2020, and Komala et al., 2017).

Component Coding: Actual

Kadar Karbohidrat (%)

● Design Points

40.14 65.31

X1 = A

X2 = B

X3 = C

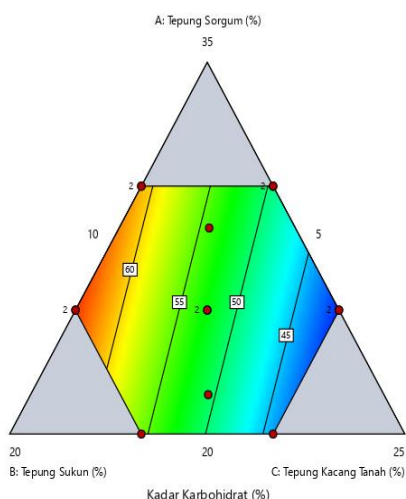


Figure 4. Contour plot graph of carbohydrate content response

### Starch content (carbohydrates)

The ANOVA table results at a significance level of 5% recommend a linear model that affects the carbohydrate content with a 95% confidence interval and a probability value of <math><0.0001</math>. A significant model has a p-value "Prob> F" equal to or less than 0.005, meaning the combination of sorghum, jackfruit, and peanut flour significantly affects the cookies model. Therefore, the results can be used to obtain products with optimal characteristics in the optimization process.

The lack of fit value from the recommended linear model is insignificant. This can be seen from the p-value of the lack of fit, which is greater than 0.05, namely 0.9549. The results show the suitability of the starch content response data with the model, and a good result has an insignificant lack of fit value.

Figure 4 shows the highest response value in the 14th formulation marked with red color around variables A and B as sorghum and breadfruit flour. The results indicate that the fat content of cookies increases due to the proportion of breadfruit and sorghum in the composite flour.

The carbohydrate content of cookies increases with a decreasing amount of peanuts and an increasing proportion of breadfruit and sorghum. It can be concluded that the starch content of composite flour affects the cookies. Composite flour with a higher proportion of breadfruit and sorghum flour than peanuts produces an increased starch content of 71.02% with 25%, 15%, and 10% of sorghum, breadfruit, and peanut flour. Meanwhile, a proportion of 25% sorghum, 5% breadfruit, and 20% peanut flour contain starch at 47.06%.

Composite flour with a high starch content is produced from a higher proportion of breadfruit and sorghum than peanuts. Based on Sumarno et al. (2013), the use of breadfruit in flakes will increase the carbohydrate content of the resulting cookies. This is because the flour is one of the carbohydrate sources with a content of 83.62%. Similarly, the addition of sorghum to low-fat soybean biscuit products at a ratio of 70:30 and 90:10 produces a starch content of 58.2% and 66.9%, respectively (Omoba & Omogbemile, 2013).

### Organoleptic Color Attributes

The ANOVA table shows that at a significance level of 5%, the Quadratic model is significant with a p-value "Prob > F" less than 0.05 at 0.0262. The combination of sorghum, breadfruit, and peanuts in the proportion of the composite flour significantly affects the color response value in the cookies model.

Furthermore, the lack of fit of the Quadratic model is insignificant, and the obtained result showed that the value is greater than 0.05 at 0.4438. A model with good conformity of color attribute response data should have an insignificant lack of fit value.

The contour plot in Figure 5, showing the response of color against the 14 formulations, indicates that the highest response value is marked by the red color near variable A as Sorghum flour. Therefore, an increase in the proportion of sorghum in the composite flour influences the color attribute of cookies.

Baking composite flour cookies at a temperature of 130°C induces browning, a process influenced by the Maillard reaction. It is noteworthy that the Maillard reaction takes place at temperatures exceeding 115°C

Component Coding: Actual

Warna

● Design Points

3.4 4.4

X1 = A

X2 = B

X3 = C

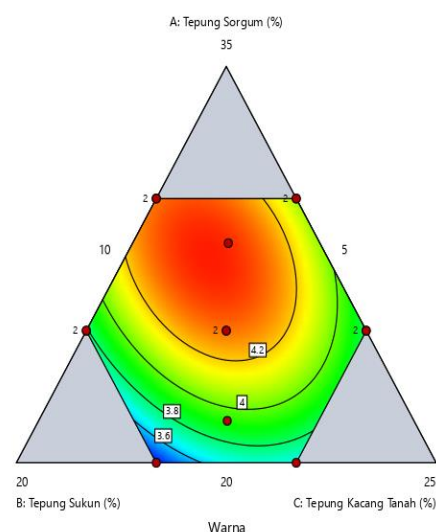


Figure 5. Contour plot graph of color response.

(Cauvain, 2003). The browning of food materials is caused by the Maillard reaction, which is a non-enzymatic browning between free amino acids reacting with reducing sugar groups such as fructose, lactose, and maltose at high temperatures. Glycosylamine is formed during baking when the carboxyl reacts with amino or peptide groups. These components are then subjected to polymerization to form dark-colored components, namely melanoidins, which produce brown-colored products (Gobel et al., 2016). Therefore, cookies baked at higher temperatures will produce a darker color (Muflihati et al., 2015).

The largest coefficient value in the polynomial model for color response is variable A, and the contour plot indicating red is located in the area. The sorghum is directly proportional to the evaluation of the composite flour-based cookies products made from breadfruit, and peanuts. This is because a higher addition of sorghum flour produces brown cookies that are preferred by the panelists. This flour contains a fairly high tannin content of around 0.4-3.6%, which makes the color of the food product dark (Harijono et al., 2012).

### Organoleptic Aroma Attribute

The ANOVA table at the 5% level shows that the linear model is significant with a p-value "Prob > F" smaller than 0.05 at <0.00001. Therefore, the combined proportion of sorghum, breadfruit, and peanut flour significantly affects the aroma response value in the cookies model.

The lack of fit value of the recommended model is insignificant, as indicated by a result greater than 0.05, at 0.7730. Therefore, there is a good fit between the aroma attribute response data and the model.

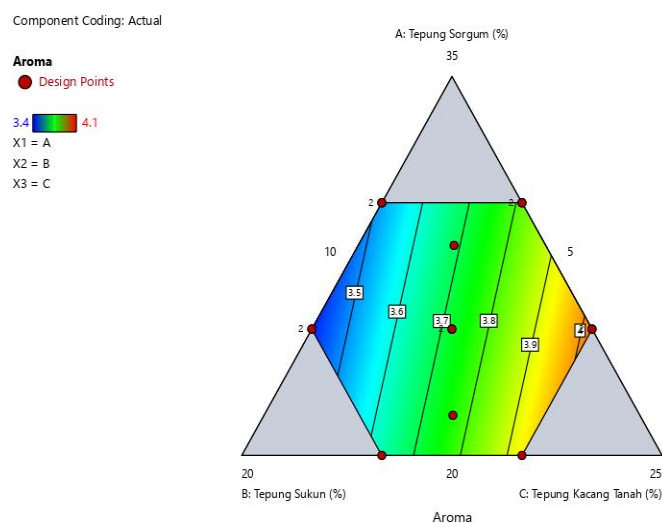


Figure 6. Contour plot graph of aroma response.

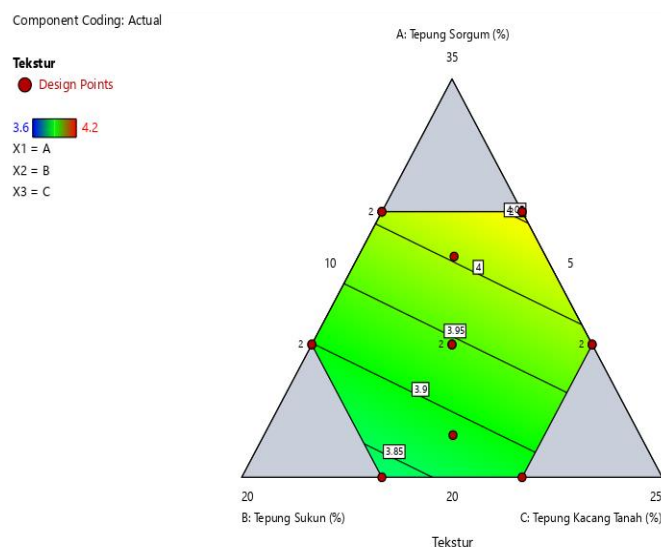


Figure 7. Contour plot graph of texture response.

The contour plot in Figure 6 indicates that the highest response value is marked by the red area near variable C as peanut flour. Therefore, the increase in the color attribute value of cookies is influenced by the proportion of peanuts in the composite flour.

The assessment of the aroma increases with the proportion of peanut flour because of the distinctive aroma preferred by the panelists. This is in line with Gultom & Raya (2019), where the addition of 40% and 20% peanut flour resulted in food bars with an evaluation of 46.7% and 10%, respectively.

The aroma of breadfruit and sorghum flour, which are generally less liked by panelists, is related to Novrini (2020). In this study, the higher percentage of breadfruit flour caused a less-liked aroma due to the taste, which is off-flavored, bitter, and chalky, causing panelists to dislike the cookies. This is similar to Riyanto et al., (2020), where the addition of sorghum flour to fig bars reduced the evaluation of the aroma response because of the distinctive dusty, woody, and green aroma.

### Organoleptic Texture Attribute

The ANOVA table at the 5% significance level recommended a linear model that is insignificant, with a "Prob > F" value greater than 0.05 at 0.2917. Therefore, the proportion of the combination of sorghum, breadfruit, and peanut flour in the value response of texture attributes does not significantly affect the cookies model.

The lack of fit of the recommended linear model is insignificant, with a value greater than 0.05 at 0.9566. A model with good response data of texture attributes should have an insignificant lack of fit value.

The contour plot in Figure 7 indicates that the highest response value is marked by the yellow color in variable A as sorghum flour. Therefore, the improvement of cookies color attribute value is influenced by the proportion of sorghum in the composite.

According to (Anggraeni 2019), crispiness when broken is the most preferred texture. Ease of breaking, hardness, and consistency on the first bite is part of the texture (Fellows, 2002). Factors affecting cookies texture include fat content, which captures air during mixing and can develop from the starch (Zoulias et al., 2002 and Singh et al., 2003). The texture is affected by the ratio of amylose to amylopectin. A more brittle or firmer texture is formed with higher amylopectin or amylose, respectively (Widiantara et al., 2018). Furthermore, high water content also affects the texture of food products. It makes cookies harder and difficult to break, causing the texture to be less desirable (Yasinta et al., 2017).

The texture evaluation increases with the addition of sorghum flour proportion. Meanwhile, sorghum flour has an amylose and amylopectin fraction content of 29.74% and 70.26%, respectively (Avif & TD, 2020).

### Organoleptic Taste Attribute

The ANOVA table with a 5% significance level for the linear model is insignificant with a p-value "Prob > F" less than 0.05 at <0.00001. Therefore, the combination proportion formulation of sorghum, breadfruit, and peanut significantly affects the response value of taste attributes in the cookies model.

The lack of fit value of the recommended model is insignificant, with a result greater than 0.05, which is 0.5910. A good model that shows the suitability of

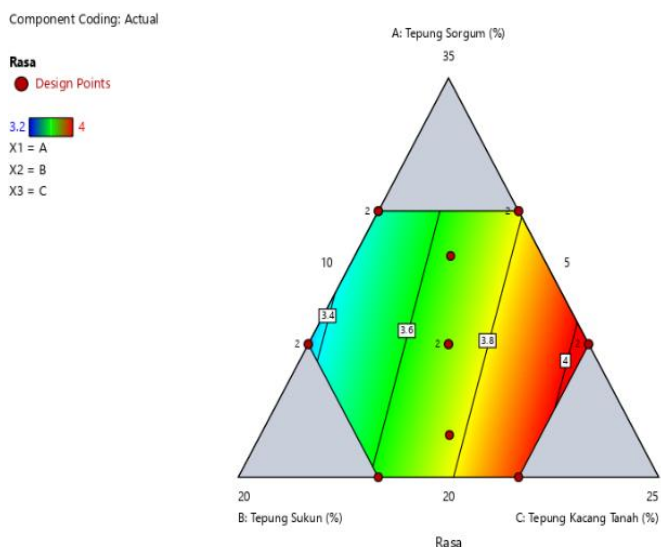


Figure 8. Contour plot graph of taste response.

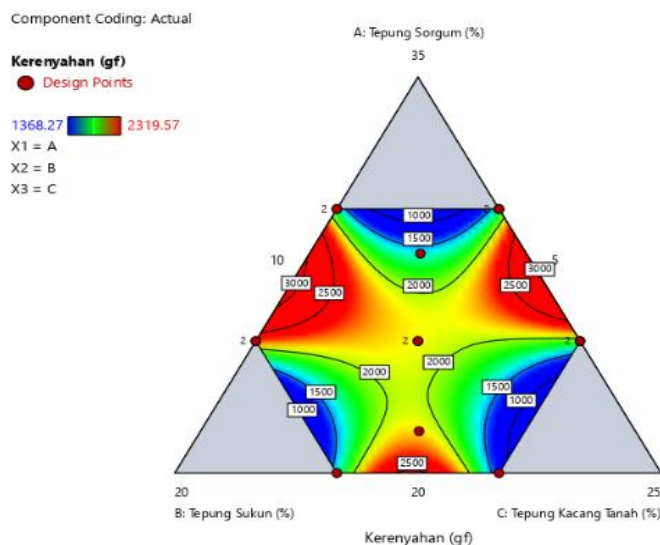


Figure 9. Contour plot graph of hardness response

response data with taste attributes has an insignificant lack of fit value.

The contour plot in Figure 8 shows that the highest response value for the taste attribute is marked by the red color near variable C as peanut flour. Therefore, an increase in the proportion of peanuts in the composite flour affects the color attribute of cookies positively.

The evaluation of the taste attribute made with composite flour of sorghum, breadfruit, and peanut is highly affected by the addition of peanuts. The higher the proportion of peanut flour in the composite, the more preferred the taste attribute of the cookies by the panelists. According to Fairus et al. (2021), cookies with a distinctive sweet taste and a peanut flavor are preferred by panelists because of the addition of the highest proportion, which resulted in an improved rating for the taste attribute.

### Hardness

The significance of the 5% level for the Special Cubic model indicates that the hardness response is insignificant with a p-value of "Prob > F" greater than 0.05, at 0.1187. Therefore, the combined proportion of sorghum, breadfruit, and peanut flour formulations does not affect the hardness response in the cookies model.

The lack of fit value for the recommended model is also insignificant, and the result obtained is greater than 0.05, at 0.2286, with an f-value of 2.01. Therefore, there is a good fit between the hardness response data and the model.

In Figure 9, the contour plot of the fourteen formulations against the hardness response shows that the highest response value is marked by the red color



Table 3. Comparison of actual and predicted values of composite flour cookies

Response	Result	
	Prediction	Laboratory
Water content (%)	3,20428	3,4653
Protein content (%)	6,77428	6,751
Fat content (%)	34,1387	34,2
Carbohydrate content (%)	44,7847	44,8378
Color	4,02326	4,1
Aroma	3,9219	3,9
Texture	3,94181	4,03
Taste	3,93407	3,9667
Hardness	1368,36	1389,37

in the largest, medium, and smallest point between variables A (sorghum flour) and B (breadfruit flour), A (sorghum flour) and C (peanut flour), and B (breadfruit flour) and C (peanut flour). Furthermore, the high content of polysaccharides, such as pectin, starch, cellulose, and hemicellulose, and the gelatinization process during heating affect the hardness of food products. Free hydroxyl groups absorb water molecules, causing the swelling of starch granules due to the gelatinization process that weakens the hydrogen bonds regulating the integrity of the starch granule structure. The water molecules evaporate when the starch is heated, causing a decrease in the water content and forming pores in the food material (Harahap et al., 2018).

### Formula Optimization and Verification

The optimization process involves setting target criteria for each component and response based on desired outcomes, which serve as a reference for optimization. Furthermore, a scale of importance is assigned to each component and response to achieve the desired objectives. This scale is called "importance", with the lowest and highest options being 1 and 5, depending on the associated response variable.

The optimal formula solution, generated using Design Expert 13.0 software during the optimization phase, produces a desirability value of 0.653 with a composition of 23.298% sorghum, 7.859% breadfruit, and 18.843% peanut flour. Meanwhile, formula 1 is predicted to have a water content of 3.204%, protein content of 6.775%, fat content of 34.139%, carbohydrate content of 44.784%, color of 4.023, aroma of 3.922, texture of 3.942, taste of 3.934, and hardness of 1368.271. Analysis of the optimal formula response

is carried out according to the initial formula, and the actual values obtained from the analysis are compared with the predicted values generated by Design Expert 13.0 software.

The results indicate a correlation between the actual and predicted data. The response variables of water content, protein content, fat content, carbohydrate content, color, aroma, texture, taste, and hardness still fulfill the 95% confidence and prediction interval.

### CONCLUSION

The results concluded that Design Expert 13.0 software produced an optimal formula for composite flour cookies with an accuracy value of 0.653. Therefore, formula 1 resulted in characteristics at a rate of 65.3% optimization target, comprising 23.298% sorghum, 7.859% breadfruit, and 18.843% peanut flour. The verification yielded chemical responses of 3.4653% water content, 6.7851% protein content, 34.2% fat content, and 44.8373% carbohydrate content. Organoleptic responses included 4.1 color, 3.9 aromas, 4.03 texture, and 3.9667 taste, while the physical response was 1389.37 hardness. Similarly, the equation for Formula 1 predicted by the software matched the test results based on the comparison of predicted data with verification generated by Design Expert 13.0 software.

### ACKNOWLEDGMENTS

The authors are grateful to the parties who have assisted in the study and publication, specifically the Food Technology Study Program and the Faculty of Engineering at Pasundan University.

### CONFLICT OF INTEREST

The authors declare that the results are original and have not been published before, hence, no conflicts of interest to report.

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