



Physical, Hedonic, and Chemical of Crispy Brownies Substituted with Jack Bean Flour

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ABSTRACT - This study aims to analyze the effect of koro sword flour substitution (0–30%) on wheat flour on the sensory, physical, and chemical characteristics of crispy brownies and determine the best formulation. The study used a Complete Random Design with four treatments, including sensory analysis (trained panelists), hedonic tests (80 untrained panelists), and color, moisture content, and protein analysis. The results showed that substitutions of up to 30% had no significant effect on sensory quality and overall receptivity rates, although increased substitution tended to decrease preference for aroma and taste and increase texture hardness. Formulations without substitutions (0%) are the best overall, while 20% substitutions result in higher protein content and better physical characteristics. This study makes a scientific contribution by showing that koro sword flour can be used as a partial substitute for wheat flour without reducing consumer acceptance, while increasing the nutritional value of the product. Thus, this ingredient has the potential to be an alternative in supporting local food diversification. Practically, these findings are relevant for the development of bakery products based on local ingredients and open up opportunities for MSMEs to create innovative and value-added products.

Keywords: Crispy brownies, sword bean, jack bean, flour substitution, protein content.

INTRODUCTION

Koro sword beans (*Canavalia ensiformis*) are a local plant that is widely found and is easy to find in various regions in Indonesia. This plant is widely grown in the tropics and has undergone naturalization processes in various regions (Widiantara et al., 2021). This plant grows a lot in the tropics and has undergone a naturalization process, with one of the production centers being in Temanggung Regency, Central Java. Farmers who are members of the Damar Sindoro Sumbing community are able to produce around 4-8 tons per harvest season (Pertiwi, 2018). Because its use is still limited, its limited use causes this commodity to be less cultivated optimally, so efforts are needed to develop processing into products that are value-added, highly nutritious, and have better economic value (Widiantara et al., 2021).

Koro sword beans belong to the group of legumes with a relatively high protein content, which is around 27.4%, so they have the potential to be developed as *protein rich flour* (PRF) (Widiantara et al., 2021). In the form of flour, this ingredient can be used as an alternative to wheat flour and soybeans, with the advantages of a more economical price and competitive nutritional content (Kidul et al., 2021). In addition, the characteristics of koro sword flour, which has a fairly high amylose content, have the potential to support the formation of a crispy texture in processed products (Khafsah et al., 2024). However, its use needs to go through proper processing processes such as soaking, fermentation, and heating to reduce antinutrient compounds and increase safety consumption (Nursalma & Sitasari, 2021).

One of the product innovations that is developing is crispy brownies, which are brownies with a thin and crispy texture that have a longer shelf life than steamed or baked brownies (Aisyah et al., 2024). The use of koro sword flour

as a substitute for wheat flour in this product has the potential to increase nutritional value, especially protein content, without significantly reducing consumer acceptance. Previous research has shown that substitution of koro sword flour in baked brownies can increase protein levels, but high amounts of use tend to decrease sensory reception, such as the appearance of distinctive aromas, sandy textures, and changes in product characteristics (Nikawati et al., 2020). In addition, the addition of ingredients such as chocolate and margarine is known to help mask these distinctive characteristics so that the product remains acceptable to consumers.

Previous research is generally still limited to baked brownies or other processed products, and has not thoroughly studied the sensory, physical, and chemical aspects of crispy brownie products. Studies on the use of koro sword flour in crispy brownies with a thorough evaluation are still relatively limited, so further research is needed to determine the quality of the product holistically and determine the optimal formulation that can be accepted by consumers.

Based on this analysis, this study aims to analyze the effect of koro sword bean flour substitution of 0%, 10%, 20%, and 30% on sensory quality, level of preference, physical characteristics of color, and chemical content in the form of moisture and protein content in crispy brownies, as well as determine the best formulation that has optimal quality and is acceptable to consumers.

METHOD

Materials and Tools

This study uses the main ingredients in the form of white sword koro beans, wheat flour, sugar, eggs, margarine, dark chocolate compound, chocolate powder, salt, and water. For chemical analysis, reagents such as NaOH, HCl, H₃BO₃, as well as Kjeldahl indicators and tablets with 300 mL Kjeldahl tubes were used. The equipment used includes common kitchen utensils (basins, scales, stoves, ovens, baking sheets, strainers, whisks, spatulas) as well as laboratory equipment such as Kjeldahl flasks, distillation tools, burettes, pipettes, erlenmeyers, chemical cups, desiccant, and other supporting tools.

Research Methods

This study used a one-factor Complete Random Design (RAL) with four levels of substitution of koro sword flour for wheat flour, namely F1 (0%), F2 (10%), F3 (20%), and F4 (30%) with one repetition (Rahmawati et al., 2020). The selection of substitution levels of 0–30% is based on previous research showing that substitutions of up to 30% can still retain the sensory characteristics of the product, while use above that level has the potential to lower consumer acceptance due to the appearance of distinctive aromas and changes in texture. The sensory test was carried out by 3 trained panelists who have experience in evaluating food products, understand sensory attributes, and have gone through basic assessment exercises, to assess sensory quality including texture, aroma, and taste (1 indicator each). The hedonic test involved 80 untrained panelists (40 women and 40 men) aged 17–45 years to assess their level of liking based on five indicators, namely color, aroma, texture, taste, and overall, using a Likert scale of 1–9 (very dislike to strongly like). The chemical analysis carried out included water and protein content at the Saraswanti Indo Genetech Laboratory.

Preparation Stage

Modified Koro Sword Bean Flour Manufacturing

The manufacture of koro sword flour refers to (Rachmawati, D., 2016) starting from sorting and washing, followed by soaking for 3 days with water replacement every 6 hours to reduce cyanide levels. The seeds are then boiled at 100°C for 20 minutes, peeled, soaked in a 0.5% lactic acid solution, and then dried at 45°C for 60 minutes. Once dry, the ingredients are ground and sifted using an 80-mesh sieve until a fine flour is obtained.

Making crispy brownies

Crispy brownies are made with a substitution of koro sword flour of 0–30% of the total flour. Dry ingredients are mixed, while chocolate and margarine are melted by the *double boiler method*. The eggs and sugar are beaten, then mixed with other ingredients until homogeneous. The dough is thinly flattened on a baking sheet and baked at 170°C for 30 minutes until crispy. The product is then cooled, packaged, and labeled according to the treatment.

Data Analysis

The data was tabulated using Microsoft Excel 2019 and analyzed with IBM SPSS Statistics 26 at a confidence level of 95% ($\alpha \leq 0.05$). The normality test was performed with the Kolmogorov–Smirnov due to the number of samples >50 , as well as the homogeneity test to ensure similarity of variance as a prerequisite for parametric analysis (Ahadi et al., 2023). Normally-distributed and homogeneous data were analyzed using One Way ANOVA because this method was able to test the average difference between treatments parametrically. Conversely, if the data are not normally distributed, Kruskal–Wallis is used as a nonparametric alternative that does not require a normal distribution. If there is a significant difference, the analysis is followed by the DMRT (for ANOVA) or Mann–Whitney (for Kruskal–Wallis) assays. The results are presented in the form of average values. The moisture content was analyzed using the gravimetric method (SNI 01-2891-1991), while the protein content used the Kjeldahl method (Kisworo et al., 2024). The best formulation determination is made using the De Garmo method based on sensory parameters (color, aroma, texture, taste, and whole). Color analysis (L^* , a^* , b^*) was performed using Adobe Photoshop 2024.

RESULTS AND DISCUSSION

Sensory Test Results

The assessment of the sensory test was carried out with one repetition using 3 trained panelists to evaluate the sensory quality of *crispy brownies* with the substitution of koro sword peanut flour. The observed parameters include texture, aroma, and taste. The average value of the sensory test results is then presented in **TABLE 1**.

TABLE 1. Sensory test results.

Parameter	P (value)	Mean $\pm$ SD			
		F1	F2	F3	F4
Texture	0.810	6.67 $\pm$ 2.082a	7.67 $\pm$ 1.528a	7.67 $\pm$ 1.528a	7.67 $\pm$ 5.77a
Aroma	0.463	7.67 $\pm$ 1.1732a	8.67 $\pm$ 0.577a	6.67 $\pm$ 2.309a	8.00 $\pm$ 1.000a
Taste	0.312	6.00 $\pm$ 2.000a	8.67 $\pm$ 0.577a	7.67 $\pm$ 0.577a	7.00 $\pm$ 1.000a

Description:

The same letter in the same column shows no real difference in $\alpha = 0.05$

Preference Test Results

The preference level test for *crispy brownies* with koro sword bean flour substitution was carried out in one test involving 80 untrained panelists. The assessment aims to determine the level of consumer acceptance based on sensory attributes which include taste, color, aroma, texture, and overall product assessment. The results of the evaluation of the hedonic test are presented in **TABEL 2**.

TABLE 2. Crispy brownies preference test results.

Parameter	Sample	Mean ($\pm$) Standard Deviation	P (value)	Favorite Levels
Color	F1	7.99 $\pm$ 0.771 ^a	0.362	Like
	F2	7.96 $\pm$ 0.770 ^a		Like
	F3	7.88 $\pm$ 0.832 ^a		Like
	F4	7.75 $\pm$ 0.907 ^a		Like

Parameter	Sample	Mean ($\pm$) Standard Deviation	P (value)	Favorite Levels
Texture	F1	7.90 $\pm$ 0.805 ^a	0.772	Like
	F2	7.93 $\pm$ 0.792 ^a		Like
	F3	7.93 $\pm$ 0.823 ^a		Like
	F4	7.80 $\pm$ 0.848 ^a		Like
Aroma	F1	7.88 $\pm$ 0.832 ^a	0.249	Like
	F2	7.80 $\pm$ 0.892 ^a		Like
	F3	7.65 $\pm$ 0.901 ^a		Like
	F4	7.64 $\pm$ 0.945 ^a		Like
Taste	F1	7.95 $\pm$ 0.778 ^a	0.749	Like
	F2	7.89 $\pm$ 0.857 ^a		Like
	F3	7.91 $\pm$ 0.845 ^a		Like
	F4	7.80 $\pm$ 0.877 ^a		Like
Overall	F1	7.96 $\pm$ 0.737 ^a	0.687	Like
	F2	7.95 $\pm$ 0.761 ^a		Like
	F3	7.85 $\pm$ 0.873 ^a		Like
	F4	7.84 $\pm$ 0.863 ^a		Like

Remarks **based on the results of the Kruskal Wallis test, there is a real difference if $p(\text{value}) < 0.05$ and no difference if $p(\text{value}) > 0.05$*
Preference test scale 1 = very very dislike to 9 = very very like: different letters in the same column show a real difference according to the Mann Whitney test

The substitution of koro sword bean flour over *crispy brownies*, had a significant impact on the sensory attributes assessed by the panelists. In this study, the substitution of koro bean flour was carried out in four formulations, namely 0%, 10%, 20%, and 30%. Based on the results of the test of the value of taste, color, texture, aroma, and overall it shows interesting variations, providing an overview of consumer preferences in determining the best formulation of the final product (Hasanah & Ismawati, 2025).

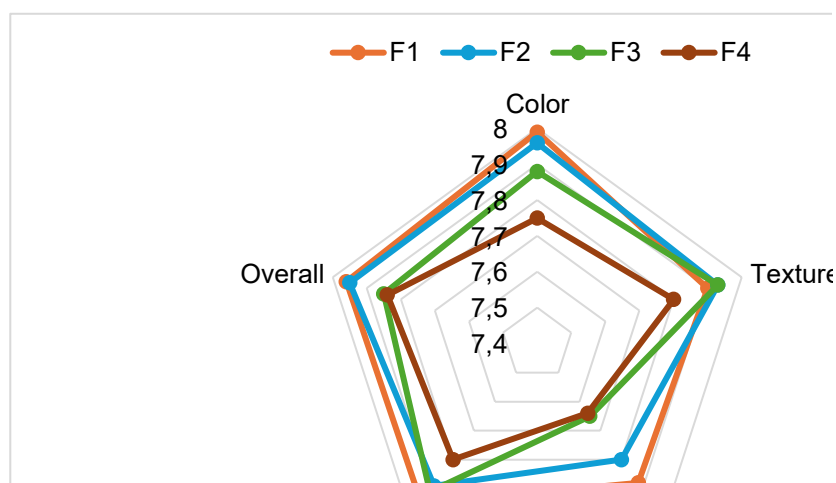


FIGURE 1. Preference test assessment radar.

Color

Color is one of the main sensory attributes that plays an important role in giving an initial impression of a food product, because it is the first indicator observed by consumers before assessing other attributes such as aroma, texture, and taste. (Tarwendah, 2017). The results of the analysis using the Kruskal–Wallis test in Table 2 show that the p -

value is >0.05 , so that the null hypothesis (H_0) is accepted. Thus, it can be concluded that the substitution of koro sword bean flour does not have a significant difference in the taste parameters of *crispy brownies*. Based on the sensory results of the preference test in **TABLE 2** and **FIGURE 1**, the preference test assessment radar showed that *the brownies crispy* peanuts koro sword in the F1 sample had the highest average of 7.99 while the lowest value was in the F4 sample, which was 7.75. Thus, the treatment of the F1 sample was the preferred color of the panelists. The manufacture of *brownies* is dominated by basic ingredients such as chocolate, as well as the method and level of heating that triggers the *Maillard reaction*. In line with previous research (Setyani, Sri., 2017) explained that *the Maillard reaction* is a nonenzymatic browning process that occurs due to the interaction between carbohydrates and proteins. Thus, the substitution of koro sword bean flour did not show a significant difference in the level of panelists' acceptance of the color attributes of *crispy brownies*.

Texture

Texture plays a role in assessing various physical properties of foodstuffs, such as chewiness, softness, viscosity, and other textural characteristics. Texture is a quality parameter that plays an important role in the panelists' assessment, because inappropriate texture changes, even if they occur on a small scale, can affect the level of acceptance and perception of the quality of a food product. (Tarwendah, 2017) The results of the analysis using the Kruskal–Wallis test showed that *the p-value* in the texture parameter was greater than 0.05, so the null (H_0) hypothesis was accepted. There is no significant difference in the texture of *crispy brownies*. Furthermore, based on the results of the sensory test of the level of preference presented in **TABLE 2** and **FIGURE 1**, it is known that *crispy brownies* with F2 and F3 treatments obtained the highest and same average preference score, which was 7.93. Meanwhile, the lowest preference score was obtained in the F4 treatment with an average score of 7.80. The addition of koro sword bean flour has been shown to significantly affect the texture characteristics of *crispy brownies*.

The higher the substitution rate of koro sword bean flour in the formulation, the higher the hardness value of the *crispy brownies* produced will increase. The flour fineness generally refers to the standard wheat flour, so the difference in particle size between koro sword bean flour and wheat flour contributes to changes in the structure and texture of *crispy brownies*. (Setyani, Sri., 2017) The increase in the proportion of koro sword bean flour in brownie formulation affects the texture characteristics of the product, which is characterized by a higher level of crispiness. Relatively larger flour particle sizes have a smaller surface area so that the rate of water absorption is slower, while finer particles tend to speed up the hydration process. These conditions affect the formation of the dough structure during baking and contribute to the final texture of the brownies. This finding is in line with a study (Maulida, Putri., 2024) which states that the increase in the addition of mocaf flour and komak bean flour can increase the crispiness of brownies, because the starch and protein content in both types of flour have the ability to bind water which affects the textural properties of the product.

Aroma

Aroma is a sensory attribute in the form of odor characters in food products that are formed due to the release of volatile compounds. These compounds enter the nasal cavity during the olfactory process and are subsequently received and interpreted by the olfactory system as odor stimuli (Rozi & Maulidiya, 2022) The results of the Kruskal–Wallis test in **TABLE 2** show a p value of > 0.05 , so that H_0 is accepted and there is no significant difference in the aroma of *crispy brownies* due to the substitution of koro sword bean flour. Based on the preference test (**TABLE 2** and **FIGURE 1**), the F1 treatment had the highest average score (7.88), while F4 had the lowest (7.64), so F1 was most preferred by the panelists. Increasing the substitution rate of koro sword bean flour tends to reduce the acceptance of the aroma of *crispy brownies*, in line with previous research (Setyadjid & Setiyaningrum, 2022) the abundance of koro sword beans has an effect on the aroma because the flour has a distinctive aroma from fermentation. However, if the use of chocolate bars and chocolate powder in equal proportions in each treatment causes a high intensity of chocolate aroma during the heating process, so the distinctive aroma derived from koro sword bean flour tends to be covered.

Taste

Taste or taste is a sensory response felt by the taste buds during food consumption, which is formed from the interaction between taste, aroma, and other supporting factors such as consistency and sensory perception (Apriyantono, 2022) The results of the analysis using the Kruskal–Wallis test as presented in **TABLE 2** and **FIGURE 1** show that the *p-value* is greater than 0.05, so the null (H_0) hypothesis is accepted. This indicates that koro sword bean flour does not provide a significant difference in the flavor attributes of *crispy brownies*. Based on the preference test, the F1 sample obtained the highest taste preference value of 7.95, while the F4 sample had the lowest value of 7.80, which shows a tendency to decrease the level of preference of the panelists as the percentage of koro sword bean flour substitution increased.

The taste of brownies is determined by the formulation of the constituent ingredients, especially the type and proportion of flour, sugar, and chocolate used, as each of these components contributes to the formation of the final taste of the product (Setyani, Sri., 2017) Because the use of other additives is made the same, the differences in flavor that appear are suspected to come from the formulation of koro sword bean flour. Koro bean flour has a distinctive aroma that is somewhat faint, so the fermentation process and aromatic content contribute to the formation of the taste of *crispy brownies*. Thus, the substitution of koro bean flour in *crispy brownies* does not provide a statistically significant difference in taste, but the increase in the number of substitutions tends to decrease the level of preference of the panelists due to the appearance of the distinctive taste character of koro beans in the final product.

Overall

The results of statistical analysis of overall liking using the *Kruskal wallis* test presented in Table 2, namely $p \text{ (value)} > 0.05$, which means that there is no real difference in the overall parameters, namely in the form of taste, color, aroma, and texture of *crispy brownies* substituted for koro sword beans. Based on the results of the preference test analysis presented in **TABLE 2** and **FIGURE 1**, overall, the average value of the preference test in the F1 sample treatment had the highest average of 7.96 while the lowest value was in the treatment with the F4 sample, which was 7.84. Thus, the F1 sample code treatment is the overall parameter that the panelists prefer.

Determining the Best Formula

The determination of the best formulation of *crispy brownies* with koro beans is carried out through the calculation of the effectiveness value using the weighting test method, comprehensively considering all parameters and characteristics of the products that have been analyzed presented in **TABLE 3** AND **TABLE 4**.

TABLE 3. The result of determining the difference value of the highest average and the lowest value.

Parameter	Rank	Treatment				Highest score	Lowest value	Difference
		F1	F2	F3	F4			
Color	1	7.99	7.96	7.88	7.75	7.99	7.75	0.24
Texture	4	7.90	7.93	7.93	7.80	7.93	7.80	0.13
Aroma	5	7.88	7.80	7.65	7.64	7.88	7.64	0.24
Taste	3	7.95	7.89	7.91	7.80	7.95	7.80	0.15
Overall	2	7.96	7.95	7.85	7.84	7.96	7.84	0.12

TABLE 4. Results of Determining the Best Product with the De Garmo Method

Parameter	Weight	Treatment							
		F1		F2		F3		F4	
		NE	NP	NE	NP	NE	NP	NE	NP
Color		1						0	0
Texture	0.07	0.77	0.07	0.87	0.06	0.54	0.04	0	0
	0.27		0.21	1	0.27	1	0.27		
Aroma	0.33	1	0.33	0.67	0.22	0.04	0.01	0	0
	0.20		0.20	0.6	0.12	0.73	0.15		
Taste	0.13	1	0.13	0.92	0.12	0.08	0.01	0	0
Overall		1						0	0
Total	1	4.77	0.94	4.06	0.79	2.40	0.47	0	0

Remarks: NE = Effectiveness Value, NP = Productivity Value

In this study, the determination of the best formulation of *koro sword crispy brownies* was carried out based on a quality evaluation that included chemical, physical, and sensory characteristics through a preference test. Each rating parameter is scored using a scale of 1–9, where higher values indicate better quality. The entire score of each parameter is then accumulated to obtain a total score. The formulation with the highest total score is determined as the best formulation, because it shows the most optimal quality characteristics of *modified koro sword crispy nut brownies*.

Based on the results of the score evaluation on each characteristic parameter of *the sword koro peanut crispy brownies*, it is known that the highest score was obtained in the F1 formulation. This formulation shows that the *crispy brown beans koro sword* in the F1 formulation is able to produce the best quality characteristics and has the highest acceptance rate by the panelists compared to other formulations. This is not in line with the research (Rachmawati, D., 2016) that the best formulation of baked brownies with the addition of modified koro sword flour was obtained in the F3 treatment. This treatment uses a 50% substitution rate of koro sword flour, which shows the most optimal balance between nutritional quality, physical properties of the product, and sensory acceptance rate compared to other treatments.

Color Physical Parameter Test Results

Color is a sensory attribute that is first observed by consumers before the product is consumed. Color characteristics are determined by the light absorbed and reflected back by an object (Idrus, 2023) In this study, color testing was carried out using an Oppo A31 mobile camera with a resolution of 4096 x 3072 pixels. The results of the photos are then analyzed using the Adobe Photoshop 2024 application to obtain L*, a* results. and b*, then the results are analyzed. The histogram image and the average of the color test are shown in **FIGURE 2** and **TABLE 5** below:

**FIGURE 2.** Brownies crispy.

TABLE 5. Average results of color testing.

Sampel Brownies Crispy	Mean $\pm$ SD
	L*, a*, dan b*
F1	189.70 $\pm$ 57.47 ^a
F2	171.57 $\pm$ 54.15 ^a
F3	158.15 $\pm$ 62.55 ^a
F4	165.25 $\pm$ 54.86 ^a

Based on the histogram results, it was obtained that the average brightness (*mean*) and standard deviation of the F3 treatment sample had the lowest L* value of 158.15 $\pm$ 62.55, resulting in the darkest *crispy brownie* color compared to other samples. This dark color is an expected characteristic of *crispy brownie products* because it reflects the optimal baking process and the formation of a non-enzymatic browning reaction (Maillard reaction). The overall sample of *crispy brownies* showed a predominance of reddish-brown color, which indicated a positive a* value. Reddish intensity tends to increase in samples with lower L* values. This suggests that the formation of reddish-brown pigment as a result of the Maillard reaction is more intense in brownies with lower brightness levels, especially in F3 treatment samples. The brown color of *crispy brownies* also indicates a contribution of a positive b* value (yellow direction). However, in the treatment sample with darker colors, the b* value was visually lower due to the predominance of dark brown to blackish brown colors. This condition is in accordance with the characteristics of *perfectly cooked crispy brownies*. Based on the results of color analysis, the F3 treatment sample was considered to have the color that best matched the characteristics of *crispy brownie products*. This is indicated by the lowest L* value, the predominance of an even dark brown color, as well as an indication of the optimal intensity of the browning reaction. The color visually resembles the typical color of *crispy brownies* that consumers like, which is not pale and not too dark to burn.

Chemical Content Test Results

Chemical content testing was carried out to determine the effect of koro sword bean flour as a substitute ingredient on the quality of *crispy brownies*. The chemical parameters analyzed include moisture content and protein content. Data from the chemical analysis of *crispy brownies* flour koro sword beans is presented in **TABLE 6**.

TABLE 6. Value of *crispy brownies* chemical content.

Chemical Properties	Mean $\pm$ SD <i>Brownies Crispy</i>			
	F1	F2	F3	F4
Moisture content (%)	1.29 $\pm$ 0.021 ^a	1.300 $\pm$ 0.028 ^a	1.170 $\pm$ 0.028 ^a	6.325 $\pm$ 2.566 ^a
Protein (% db)	7.70 $\pm$ 0.098 ^a	8.185 $\pm$ 0.075 ^a	8.680 $\pm$ 0.060 ^a	8.250 $\pm$ 0.110 ^a

Description:

The same letter in the same column shows no real difference in $\alpha = 0.05$

Moisture Content

Moisture content reflects the amount of water content in an ingredient and is one of the main parameters in the assessment of the quality of food products. The presence of water has an important role because it affects the physical and sensory properties of the product, including its appearance, texture, and taste characteristics. In *crispy brownies*, the moisture content has a significant influence on the level of crispiness, durability, and shelf life of the product (Pertiwi, 2018) Referring to the provisions of UNICEF (2017), the maximum permissible moisture content for high-energy biscuits is 4.5%. Therefore, the moisture content contained in *crispy brownies* of the F4 formulation is declared to exceed the maximum limit that has been set,

The increased proportion of modified flour use has the potential to increase the moisture content of *crispy brownies*, which is thought to be influenced by the physical and chemical properties of the raw materials used. In addition, the results of the chemical analysis showed that the variation in formulation had a significant influence on the moisture content of *crispy brownies*. These findings are in line with the results of previous studies that reported that differences in ingredient composition can affect the moisture content characteristics of food products (Anandito, 2020) which states that increasing the proportion of koro sword bean composite flour in cookie formulations tends to

increase the moisture content in the products produced. F1, F2, and F3 formulations still meet the SNI 01-2891-1991 standard for cookies or pastries, which have a moisture content of no more than 5%.

Protein

Protein has an important role as a structural element and regulator in the body. This nutrient is involved in the process of forming new tissues while maintaining the continuity and function of previously formed tissues (Setyawati, E., 2021) Based on the results presented in **TABLE 6**, the variation in the formulation of koro sword bean flour has been proven to have an influence on the protein content of crispy brownies. The F3 formulation showed the highest protein content, which was 8.680% per 100 grams, while the F1 formulation produced the lowest protein content with a value of 7.70% per 100 grams.

Based on SNI 01-2973-2011 on cookies, which is at least 5%. So that *crispy brownies* with koro sword bean flour substitution are declared to meet the applicable quality standards. The increase in protein content in *crispy brownies* is influenced by the increasing proportion of koro sword bean flour in the formulation. In line with research (Frinita, 2023) which states that the increased use of kidney bean flour in *crispy dry brownies* based on peanut flour and brown rice flour is able to increase protein levels between 8.46% and 8.83%. So the substitution of koro sword bean flour effectively increases the protein content of *crispy brownies*.

CONCLUSION

The substitution of koro sword bean flour up to 30% in *crispy brownies* did not significantly affect sensory quality, preference level, and physical characteristics ($p > 0.05$), with all formulations remaining in the “liked” category. However, higher substitution levels tended to decrease aroma and taste acceptance while increasing texture hardness. The F1 formulation (0%) was identified as the best overall based on preference tests and the De Garmo method, while the F3 formulation (20%) showed advantages in protein content and physical characteristics.

This study demonstrates that koro sword bean flour can be utilized as a partial substitute for wheat flour without reducing consumer acceptance, while improving the nutritional value of the product, particularly protein content. Practically, these findings highlight the potential application of koro sword bean flour in developing bakery products based on local resources, as well as opportunities for small and medium enterprises (SMEs) to diversify innovative and value-added products.

However, this study has several limitations, including the limited number of trained panelists, the focus on a single product (*crispy brownies*), and the absence of shelf-life analysis. Therefore, further research is recommended to include instrumental texture analysis, shelf-life evaluation, broader consumer preference testing, and exploration of higher substitution levels to optimize product development.

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