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The effect of pumpkin (*Cucurbita moschata*) and red bean flour (*Phaseolus vulgaris* L.) substitution on organoleptic assessment and nutritional value of cactus cake

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Abstract

This study aims to determine the effect of pumpkin (*Cucurbita moschata*) and red bean flour (*Phaseolus vulgaris* L.) substitution on organoleptic assessment (color, aroma, crispiness and taste) and nutritional value (water content, ash content, fat, protein, carbohydrates and crude fiber) of cactus cake, determine the best treatment and determine the serving size and AKG of the best treatment cactus cake. This type of research is a quantitative True Experimental study using a Completely Randomized Design (CRD). The results showed color (ρ-value = 0.246), aroma (ρ-value = 0.865), crispiness (ρ-value = 0.000), taste (ρ-value = 0.000). The cactus cake with the best treatment was P3. Water content (ρ-value = 0.008), ash content (ρ-value = 0.000), protein (ρ-value = 0.410), fat (ρ-value = 0.021), carbohydrate (ρ-value = 0.095) and crude fiber (ρ-value = 0.161). Each serving size of P3 (30 g) has an energy content of 112 kcal, total fat 10 g (15% RDA), protein 2 g (2% RDA), carbohydrate 1 g (1% RDA) and crude fiber 2 g. There is no effect of pumpkin and red bean flour substitution on the organoleptic value (color and aroma) and nutritional value (protein, carbohydrate and crude fiber) of cactus cake. However, there is an effect of pumpkin and red bean flour substitution on the organoleptic value (crispyness and taste) and nutritional value (water content, ash content and fat) of cactus cake.

Keywords: Pumpkin; Red beans; Organoleptic value; Nutritional value; Cactus cake

1. Introduction

Snacks are foods consumed before main meal to temporarily delay hunger [1]. Snacks generally have a delicious taste and a practical form, so they are popular with almost all levels of society. However, packaged snacks are often high in calories, fat, salt, and sugar, and contain additives such as colorings, Monosodium Glutamate (MSG), and preservatives to make them last longer and more attractive. Excessive consumption of snacks with these contents can increase the risk of various diseases related to unhealthy eating patterns [2].

Diets with a composition that is too high in calories, lots of protein, fat, sugar, but low in fiber or consumption of foods that are not diverse can cause an imbalance in nutrient intake that has the potential to cause obesity. This condition can increase the risk factors for degenerative diseases such as hypertension, coronary heart disease, diabetes mellitus and others [3]. In the era of globalization which is marked by rapid trade, food processing industry, services and information that will affect the lifestyle and eating patterns of people who tend to prefer and like practical types of food [4].

One strategy that can be applied to this problem is to create a food product in the form of a healthy snack that is practical, delicious, has high nutritional value and can provide health benefits beyond its nutritional content function or what is known as functional food. Functional food is increasingly popular because it can provide health benefits in addition to being a source of energy. Functional food has been proven to have good physiological value, such as antioxidant, antihypertensive, and anti-cholesterol properties. The development of functional food in Indonesia can be well

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supported because it has an abundant diversity of local food ingredients, which can be processed into functional foods to improve public health [5]. In addition, the use of local food ingredients can also support the food diversification program. Food diversification (food diversification), namely the development of various food products based on local ingredients that are healthier and more nutritious [6].

Local food ingredients that have the potential to be used as functional food are pumpkin. Pumpkin contains beta-carotene, fiber, and antioxidants that can improve the immune system and help control blood sugar levels [7]. In addition to pumpkin, red beans also have high potential as functional food ingredients. Red beans are a source of vegetable protein with high fiber content that can help maintain digestive health and control blood sugar levels [8]. The combination of pumpkin and red beans in various food products has been shown to provide significant health benefits, such as reducing the risk of obesity and type 2 diabetes mellitus [9,10].

Various studies have developed pumpkin and red bean-based foods, such as snack bars [9], cookies [10], instant porridge [11], and cakes [12]. Therefore, researchers are interested in developing cactus cakes as a healthy snack innovation based on pumpkin and red beans. Cactus cake is a traditional food originating from Betawi, also known as "coconut root cake" because its shape resembles a coconut root [13]. In Southeast Sulawesi, this cake is called cactus cake because its shape resembles a cactus plant. This cake is made from glutinous rice flour and rice flour, has a savory taste and crunchy texture, so it is popular with almost all levels of society [14].

By combining pumpkin and red beans in making cactus cake, it is expected to produce healthy snacks that have the potential as functional foods with high protein and fiber content. The development of cactus cakes based on pumpkin and red beans not only supports food diversification, but can also be a solution to provide healthier snacks for the community, especially in efforts to prevent degenerative diseases. Functional foods should be consumed every day so it is very important to produce food products that are not only high in nutritional value and provide more benefits in terms of health but are also acceptable in terms of organoleptic color, aroma, crispiness and taste. As stated by Indrasari et al., 2020 [6], which states that in addition to health and nutritional content aspects, factors that determine food quality can be reviewed from the aspect of deliciousness or taste and also the aspect of the quality of natural food ingredients.

2. Methods

This research employs a quantitative approach using the True Experimental method, specifically utilizing a Completely Randomized Design (CRD). The study includes four different formulations, consisting of one control group (P0) and three treatment groups (P1, P2, and P3). The details of these four formulations are as follows:

- P0 = 0% yellow pumpkin : 0% red bean flour (Control)
- P1 = 30% yellow pumpkin : 20% red bean flour (Treatment)
- P2 = 25% yellow pumpkin : 25% red bean flour (Treatment)
- P3 = 20% yellow pumpkin : 30% red bean flour (Treatment)

3. Results and discussion

3.1. The Effect of Pumpkin and Red Bean Flour Substitution on the Organoleptic Value of Cactus Cake

Table 1 Recapitulation of the results of the Kruskal-Wallis test and the Mann-Whitney further test for organoleptic assessment of cactus cake

Organoleptic attributes	ρ-value
Color	0.246*
Aroma	0.865*
Crispness	0,000**
Flavor	0,000**

Description: ** = there is a significant difference * = No significant difference

The results of the Kruskal-Wallis and Mann-Whitney statistical tests showed that the color and aroma attributes had a ρ-value > 0.05 so that there was no significant difference between the formulas P0, P1, P2 and P3 on the color and aroma

of cactus cake. Therefore, H0 is accepted and H1 is rejected, there is no effect of pumpkin and red bean flour substitution on the organoleptic value of the color and aroma of cactus cake.

On the other hand, the crispiness and taste attributes show a ρ-value <0.05 so that there is a real difference between the formulas P0, P1, P2 and P3 on the crispiness and taste of cactus cake. Therefore, H1 is accepted and H0 is rejected, there is an effect of pumpkin substitution and red bean flour on the organoleptic value of the crispiness and taste of cactus cake.

3.1.1. Color

The average organoleptic value of cactus cake color can be seen in table 2 below:

Table 2 Average organoleptic value of cactus cake color

Formula		**Average Color**	**Category**
P0	(0% : 0%)	3.888 ± 0.897a	Like
P1	(20% : 30%)	3,550 ± 0,780a	Like
P2	(25% : 25%)	3.667 ± 0.723a	Like
P3	(30% : 20%)	3.583 ± 0.777a	Like

Description: ab = similar letter notation means there is no real difference at the Mann Whitney test level.

The results of statistical tests on the table of the effect of pumpkin and red bean flour substitution on the organoleptic value of the color of cactus cake showed that there was no significant difference (ρ-value > 0.05) in color between formulas P0 (0% pumpkin: 0% red bean flour), P1 (30% pumpkin: 20% red bean flour), P2 (25% pumpkin: 25% red bean flour) and P3 (20% pumpkin: 30% red bean flour). The highest average organoleptic color value was in formula P0 (3.88) followed by formula P2 (3.66), and P3 (3.58). While the lowest average organoleptic color value was in formula P1 (3.55). Referring to this, the substitution of red bean flour or an excessive amout of pumpkin can reduce the organoleptic value of the color of cactus cake. This is reinforced by the results of the study that the color of cactus cake formula P2 is the most preferred color among the three treatments. Formula P2 is given a balanced concentration of pumpkin and red bean flour substitution, namely 25% each, so that the resulting color is not too striking reddish yellow or brown.

The color of cactus cake formula P0 (control) has the highest organoleptic value because P0 is yellowish white so that the color of the product looks brighter than the color of formulas P1, P2 and P3. Meanwhile, the color of cactus cake formula P1 gets the lowest organoleptic value because the color of P1 tends to be reddish yellow or orange which tends to brown so that the color of the product looks darker. The yellowish white color in formula P0 is produced from margarine. While the reddish yellow color tends to brown which tends to be dark in formula P1 is caused by the concentration of pumpkin substitution of 30% and red bean flour of 20% as well as the presence of other ingredients such as margarine and sugar.

The yellowish-white hue of the cactus cake formula P0 results from the use of margarine. This aligns with Pratomo's research (2023) [15], which indicates that replacing red palm oil with margarine significantly affects the color of cookies. This effect is attributed to the beta-carotene pigment in margarine, which imparts a yellowish tone to the final product. Meanwhile, the color of the cactus cake produced in formula P1, namely reddish yellow leading to brown, is supported by research by Putra et al., (2021) [16] which explains that, in pumpkin puree there is a carotenoid pigment, namely a natural reddish yellow pigment where if the addition of pumpkin puree increases with each treatment, the cookies will be reddish yellow or orange. In addition, the dark color of the cactus cake product formula P1 is also due to the addition of 20% red bean flour. Aulia et al., (2024) [17] stated that the higher the substitution of red bean flour, the lower the level of panelist preference due to the increasingly brownish color of the cookies. The darker color of the cookies is due to the increased intensity of the Maillard reaction which produces a brown compound called melanoidin. This increase in color occurs due to the increasing sugar and protein content in the dough.

3.1.2. Aroma

The average organoleptic value of cactus cake aroma can be seen in table 3 below:

Table 3 Average organoleptic value of cactus cake aroma

Formula		Average aroma	Category
P0	(0% : 0%)	3,500 ± 0.798a	Like
P1	(20% : 30%)	3.367 ± 0.764a	Kinda like it
P2	(25% : 25%)	3.383 ± 0.715a	Kinda like it
P3	(30% : 20%)	3.467 ± 0.694a	Kinda like it

Description: ab = similar letter notation means there is no real difference at the Mann Whitney test level.

The results of statistical tests on the effect of pumpkin and red bean flour substitution on the organoleptic value of cactus cake aroma indicated that there was no significant difference (ρ-value > 0.05) between formulas P0 (0% pumpkin: 0% red bean flour), P1 (30% pumpkin: 20% red bean flour), P2 (25% pumpkin: 25% red bean flour) and P3 (20% pumpkin: 30% red bean flour). The highest average organoleptic aroma value was obtained in formula P0 (3.50), followed by formula P3 (3.46) and P2 (3.38), while the lowest organoleptic aroma value was found in formula P1 (3.36).

The aroma of cactus cake formula P0 (control) has the highest organoleptic value because the aroma in P0 is quite familiar to the panelists. Where P0 has a distinctive aroma of rice flour plus a fragrant and savory aroma from margarine. According to Zelly 2020, the aroma produced from coconut root cake comes from the raw materials used. The aroma of coconut root cake is typical of the rice flour used and the fragrance of margarine. Meanwhile, the P1 formula in cactus cake obtained the lowest average organoleptic value for the aroma attribute, which was caused by the intensity of the aroma which tended to be strong in the formulation. On the other hand, among the three treatments (P1, P2, and P3), the highest organoleptic aroma value was obtained by the P3 formula (20% pumpkin: 30% red bean flour), which has a more balanced and less dominant aroma character.

The intense aroma of the cactus cake formula P1 is caused by the high concentration of pumpkin substitution of 30%, combined with red bean flour of 20%. The interaction between the natural aroma of these ingredients with margarine and cooking oil produces dominant aroma characteristics, thus giving the impression of a strong aroma in cactus cakes. This conclusion matches Azizah et al., (2023) [18] who stated that the addition of more pumpkin puree and green bean flour made the aroma of cookies less liked by panelists because the aroma of each ingredient would be stronger. Meanwhile, the aroma in the P3 formula (20% pumpkin: 30% red bean flour) obtained a slightly higher organoleptic value compared to the other three treatments. This formula has a more balanced and less dominant aroma character. This is consistent with the outcomes of the study by Aulia et al. (2024) [17], which stated that the substitution of red bean flour did not significantly affect the aroma, because red bean flour produced a butter aroma.

3.1.3. Crispness

The average organoleptic value of cactus cake crispiness can be seen in table 4 below:

Table 4 Average organoleptic value of cactus cake crispiness

Formula		Average crispiness	Category
P0	(0% : 0%)	4.517 ± 0.622a	Really like
P1	(20% : 30%)	2.617 ± 0.739b	Kinda like it
P2	(25% : 25%)	2.417 ± 0.871b	Do not like
P3	(30% : 20%)	2.767 ± 0.848b	Kinda like it

Description: ab = similar letter notation means there is no real difference at the Mann Whitney test level.

The statistical test results on the impact of substituting pumpkin and red bean flour on the organoleptic assessment of cactus cake crispiness indicated a significant difference (ρ-value < 0.05) between the formulas P0 (0% pumpkin: 0% red bean flour), P1 (30% pumpkin: 20% red bean flour), P2 (25% pumpkin: 25% red bean flour) and P3 (20% pumpkin: 30% red bean flour). The cactus cake formula that indicated a significant distinction in the organoleptic value of crispiness was formula P0. The highest average organoleptic value of crispiness was formula P0 (4.51) followed by formulas P3 (2.76) and P1 (2.61) while the lowest organoleptic value of crispiness was found in formula P2 (2.41).

The organoleptic value of the crispiness attribute in the P0 formula showed much higher results compared to P1, P2, and P3. This is due to the characteristics of the P0 texture which is fragile, light, and crispier compared to other formula. In contrast, formulas P1, P2, and P3 obtained low average organoleptic values for the crispiness attribute. This is because the resulting texture shows uneven crispness in all parts of the cactus cake with the characteristics of a slightly crispy outer surface, while the middle tends to have a softer or softer consistency. This condition causes the organoleptic value of the cactus cake in this formulas to be lower.

The uneven crispiness of cactus cookies substituted with pumpkin and red bean flour is influenced by the high water content in the dough, which is caused by the substitution of pumpkin puree. The moisture content of the final product is significantly affected by the original water content present in the raw ingredients [19]. Putra et al. (2021) [16] also explained that cookies tend to be less crispy due to the high water content in pumpkin puree, which reaches 89.86%. This statement is also supported by Azizah et al. (2023) [18], who reported that increasing the addition of pumpkin puree and green bean flour caused the texture of the cookies to be less crispy, so that the level of panelist acceptance decreased.

However, from the three treatments, the P3 formula (20% pumpkin and 30% red bean flour) obtained a higher organoleptic value compared to P1 and P2. This shows that increasing the concentration of red bean flour and decreasing the concentration of pumpkin in P3 provides a fairly good balance in crispiness between the treatment formulas. This is consistent with the research of Aditiya and Ismawati (2023) [20], which states that the higher the use of red bean flour, the denser the texture of the cookies becomes, which supports increased panelist acceptance of the product.

3.1.4. Flavor

The average organoleptic value of cactus cake taste can be seen in table 5 below:

Table 5 Average organoleptic value of cactus cake taste

Formula		**Average taste**	**Category**
P0	(0% : 0%)	4,000 ± 0.919a	Like
P1	(20% : 30%)	2.933 ± 0.944b	Kinda like it
P2	(25% : 25%)	2,867 ± 0,990b	Kinda like it
P3	(30% : 20%)	2.983 ± 0.782b	Kinda like it

Description: ab = similar letter notation means there is no real difference at the Mann Whitney test level.

The results of statistical tests on the effect of pumpkin and red bean flour substitution on the organoleptic value of cactus cake taste showed that there was a significant difference (ρ-value < 0.05) between formulas P0 (0% pumpkin: 0% red bean flour), P1 (30% pumpkin: 20% red bean flour), P2 (25% pumpkin: 25% red bean flour) and P3 (20% pumpkin: 30% red bean flour). The cactus cake formula that indicated a significant distinction in the organoleptic value of taste was formula P0. The highest average organoleptic value of taste was formula P0 (4) followed by formulas P3 (2.98) and P1 (2.93) while the lowest organoleptic value of taste was found in formula P2 (2.86).

The average organoleptic value of the cactus cake taste attribute shows the variation of organoleptic values of each formula. The average organoleptic value of the cactus cake taste without substitution (P0) is 4, which means that the panelists like the taste of the product. In contrast, cactus cake with pumpkin and red bean flour substitution (P1, P2, and P3) had a lower average value, which was around 2.93 to 2.98, indicating a lower level of preference, but still in the category of "quite like". The highest average organoleptic taste value was found in the P0 formulation, indicating that the taste of cactus cake without pumpkin and red bean flour substitution was preferred by the panelists. This could be due to the more familiar and balanced taste composition, which comes from basic ingredients such as rice flour, sugar, margarine, and salt. In contrast, the P2 formula, with a composition of 25% pumpkin and 25% red bean flour, recorded the lowest value for the taste attribute. This decrease in value could be due to the dominance of the pumpkin flavor which was less acceptable to the panelists or changes in the taste balance produced by the substitution of these ingredients.

However, formula P3 (with 20% pumpkin and 30% red bean flour) recorded the highest average taste value among the three treatment formulas. The dominant red bean flour mixture rather than pumpkin in the formula provided a more acceptable taste compared to the other treatment formulas (P1 and P2). Majido et al (2022) [12] explained that the less

pumpkin flour was added and the higher the addition of red bean flour in making cakes, the more the resulting taste was liked by the panelists. This is in line with Azizah et al (2023) [18] who stated that the higher the concentration of pumpkin substitution, the lower the level of panelist preference. The addition of pumpkin puree can affect the taste of cookies because pumpkin has a sweet taste, but if too much is added, the level of panelist acceptance decreases because of the very strong distinctive taste that comes from the flavonoid compound content in pumpkin.

3.2. Best Treatment Cactus Cake Substitution

The results of determining the best treatment of cactus cake using the De Garmo method showed the highest total productivity (NP) value, namely P3 (NP = 0.70) followed by P2 (NP = 0.46) and the lowest P1 (NP = 0.17). Therefore, based on the productivity value, the cactus cake that received the best treatment of the three treatments was P3 (20% pumpkin: 30% red bean flour). As for the average organoleptic value of P3 for each attribute, namely color (2.98), aroma (3.46), crispiness (2.76) and taste (2.98). P3 cactus cake is slightly brownish yellow, has a balanced and not too dominant aroma, is crispy on the outside and soft on the inside (uneven crispiness) and has a combination of pumpkin and red bean flavors.

3.3. The Effect of Pumpkin and Red Bean Flour Substitution on the Nutritional Value of Cactus Cake

The results of the analysis of the nutritional value of cactus cakes consisting of water content, ash content, protein content, fat content, carbohydrate content and crude fiber in the control cactus cake (P0) and cactus cake with the best treatment (P3) are presented in table 6 below:

Table 6 Results of nutritional value analysis of cactus cakes P0 and P3

Components (%)	**Sample code**			
	P0 (1)	**P0 (2)**	**P3(1)**	**P3(2)**
Water content	0.84	0.87	7.08	8.33
Ash Content	0.97	0.96	1.76	1.75
Protein Content	2.44	3.16	2.66	1.69
Fat Content	42.63	42.24	33.62	35.86
Carbohydrate Content	14.43	12.06	14.93	11.79
Crude Fiber	6.77	4.21	8.11	8.51

Table 7 Summary of the results of the One Way Anova test of cactus cake P0 and P3

Components (%)	**Average nutritional value**		**ρ-value**
	P0	**P3**	
Water content	0.85 ± 0.02	7.70 ± 0.88	0.008**
Ash Content	0.96 ± 0.00	1.75 ± 0.00	0,000**
Protein Content	2.80 ± 0.50	2.17 ± 0.68	0.410*
Fat Content	42.43 ± 0.27	34.74 ± 1.58	0.021**
Carbohydrate Content	13.24 ± 1.67	13.36 ± 2.22	0.095*
Crude Fiber	5.49 ± 1.81	8.31 ± 0.28	0.161*

Description: ** = there is a significant difference * = No significant difference

The results of the One Way Anova statistical test of the effect of pumpkin and red bean flour substitution on the nutritional value (water content, ash content, protein content, carbohydrate fat content and crude fiber content) of cactus cakes P0 and P3 can be seen in table 7 above.

The results of the ANOVA statistical test showed that the components of protein content, carbohydrate content and crude fiber have a ρ-value > 0.05 so that there is no real difference between P0 and P3 on the value of protein content, carbohydrate content and crude fiber of cactus cake. Therefore, H0 is accepted and H1 is rejected there is no effect of

pumpkin and red bean flour substitution on the nutritional value (protein content, carbohydrate content and crude fiber) of cactus cake.

On the other hand, the components of water content, ash content and fat content had a ρ-value < 0.05 so that there was a real difference between P0 and P3 on the values of water content, ash content, and fat content of cactus cake. Therefore, H1 is accepted and H0 is rejected, there is an effect of pumpkin substitution and red bean flour on the nutritional value (water content, ash content and fat content) of cactus cake.

3.3.1. Water content

The results of the cactus cake water content test showed that the water content in P0 (0% pumpkin: 0% red bean flour) had an average of 0.85% lower than the P3 treatment (20% pumpkin: 30% red beans) with an average water content of 7.7%. Therefore, the study found that the substitution of pumpkin and red bean flour for cactus cakes significantly increased the water content value of cactus cakes without substitution. Based on SNI: 01.2973-1992 Cookies, the maximum allowable water content is 5%. Therefore, P0 meets the SNI water content requirements while P3 does not meet the SNI water content requirements.

Substitution of pumpkin and red bean flour in cactus cake increases the water content of cactus cake compared to the water content of cactus cake without pumpkin and red bean flour substitution. The increase in water content in the P3 treatment (20% pumpkin: 30% red bean flour) is due to the substitution of pumpkin puree into the cactus cake. This is in line with the research of Loelianda (2017) [21] which states that the more pumpkin flour is added, the higher the water content will be, this is because pumpkin contains pectin which can bind water. In addition, the increase in water content in the P3 treatment is also due to the chemical properties of the raw materials, the length of the processing process and the storage applied can affect the water content of a product. Maulid et al. (2023) [19] stated that the product's water content is affected by the initial moisture level present in the raw materials. Another factor that influences is the hydrophilic nature of the protein, especially that contained in red bean flour. Hydrophilic properties arise due to the presence of polar side chains along the peptide chain, namely carboxyl groups and amino acids. Protein molecules have several organic groups such as N and O atoms that do not have a pair. The N atom in the peptide chain has a negative charge so it will attract the H atom from water which has a positive charge [22].

The ANOVA statistical analysis resulted in a ρ-value < 0.05, indicating that substituting pumpkin and red bean flour significantly influences the water content of cactus cake. This effect occurs because the inclusion of pumpkin and red bean flour increases the water content in the final product, attributed to their pectin content and hydrophilic properties, which enable them to retain water effectively.

3.3.2. Ash content

The results of the cactus cake ash content test showed that the ash content in P0 (0% pumpkin: 0% red bean flour) had an average of 0.96% lower than the P3 treatment (20% pumpkin: 30% red beans) with an average ash content of 1.75%. Therefore, in this study it was found that the substitution of pumpkin and red bean flour for cactus cakes increased the ash content significantly compared to cactus cakes without substitution. Based on SNI: 01.2973-1992 Cookies, the maximum allowable ash content is 1.5%. Therefore, P0 meets the SNI ash content requirements because the average ash content is below the maximum ash content while P3 does not meet the SNI water content requirements because the average ash content exceeds the maximum amount.

The high ash content in treatment P3 (20% pumpkin: 30% red bean flour) was due to the substitution of pumpkin and red bean flour. This increase in ash content is related to the high mineral content in food ingredients, which affects the increase in ash content [23]. This finding is in line with the research of Majido et al. (2022) [12] which revealed that in making cakes with pumpkin flour and red bean flour substitution, the more red bean flour used, the higher the ash content, due to the high mineral content in red beans. In addition, other studies also state that the higher the substitution of pumpkin flour, the higher the ash content in steamed pumpkin brownies. This increase in ash content is due to the high mineral and vitamin content in pumpkin flour [24].

Based on the statistical analysis of ANOVA, the ρ-value <0.05 was obtained, so it can be concluded that the substitution of pumpkin and red bean flour has a significant effect on the ash content of cactus cake. Where, this is due to the substitution of pumpkin and red bean flour which have high mineral content.

3.3.3. Protein Content

The results of the protein content test of cactus cake showed that the protein content in P0 (0% pumpkin: 0% red bean flour) had an average of 2.8% higher than the P3 treatment (20% pumpkin: 30% red beans) with an average protein content of 2.17%. Therefore, in this study it was found that the substitution of pumpkin and red bean flour for cactus cake reduced the protein content value compared to cactus cake without substitution. Based on SNI: 01.2973-1992 Cookies, the minimum protein content allowed is 5.9%. Therefore, both P0 and P3 did not meet the SNI water content requirements because the protein content of both samples did not reach the minimum protein content.

Substitution of pumpkin and red bean flour decreased the protein content of cactus cake from cactus cake without substitution. The decrease in protein content in P3 is thought to be due to the high water content in the P3 material due to pumpkin substitution. Substitution of water-rich materials such as pumpkin has been shown to increase the water content of the final product but decrease the protein and fat content due to relative dilution [23]. This is in line with research by Normilawati et al. (2019) [25] which examines the link between water content and protein content in biscuits, explaining that Sample 1: Has a water content of 4.43% and a protein content of 5.31%. Sample 2: Has a water content of 3.84% and a protein content of 6.89%. These results indicate that samples with higher water content have lower protein content, and vice versa. This indicates an inverse relationship between water percentage and protein amount in biscuits.

The low protein content in both samples (P0 and P3) so that it does not reach the minimum SNI limit is due to the main ingredients of the product which are gluten-free ingredients. The specialty of wheat flour compared to other cereal flours lies in the gluten content which is not found in other flours. Gluten consists of gliadin and glutenin which are components of protein that are only found in wheat flour [12]. Gluten has hydrophobic properties in water [26]. Protein is a compound that has hydrophilic and hydrophobic groups. Hydrophilic groups can bind water, while hydrophobic groups do not bind water [27].

The results of the ANOVA statistical test showed that there was no significant difference (ρ-value > 0.05) in protein content between P0 and P3. This can be explained by the use of gluten-free ingredients, such as red bean and pumpkin flour, which have relatively low protein content compared to ingredients containing gluten. Gluten-free ingredients tend not to be able to maintain a stable protein structure in processed products, which contributes to the uniformity of protein content between the P0 (control) and P3 formulations, although in P3 substitutions were made with red bean and pumpkin flour.

The decrease in protein content in gluten-free products was also reported by Alhassan et al. (2020) [29], which explained that gluten-free ingredient-based products, such as bean flour, tend to have lower protein content compared to wheat-based products. Thus, although the substitution with red bean and pumpkin flour in P3 changes the composition of the ingredients, factors such as the type of ingredients used (gluten-free) and high water content cause no significant difference in protein content between P0 and P3. In addition, the high water content in the P3 dough can also affect the protein content in the final product. The high water content in the dough causes the ingredients to dilute and has the potential to reduce the protein concentration in the final product. This is in line with research conducted by Prasetyo et al. (2021) [28], which states that high water content in dough can reduce the concentration of other nutrients, including protein, because most of the components will dissolve in water.

3.3.4. Fat Content

The results of the cactus cake fat content test showed that the fat content in P0 (0% pumpkin: 0% red bean flour) had an average of 42.43% higher than the P3 treatment (20% pumpkin: 30% red beans) with an average fat content of 34.74%. Therefore, in this study it was found that the substitution of pumpkin and red bean flour for cactus cakes significantly reduced the fat content value compared to cactus cakes without substitution. Based on SNI: 01.2973-1992 Cookies, the minimum allowable fat content is 5.9%. Therefore, both P0 and P3 meet the SNI water content requirements because the fat content of both samples exceeds the minimum allowable fat content.

The fat content of cactus cake substituted with pumpkin and red bean flour decreased significantly due to the high water content in P3 compared to P1. This aligns with the opinion of Maulidya et al., (2023) [23] who stated that the decrease in protein and fat content of the final product was due to relative dilution due to water content. In addition, the decrease in fat content in P3 was also due to the high fiber content in P3. This is in line with research by Fitria and Prameswari (2022) [30] who stated that the addition of fiber-rich ingredients such as lentil flour can reduce the fat content in cookies. Research shows that the fat content in cookies decreases with the increasing substitution of lentil flour given.

The results of statistical analysis using the ANOVA method showed a significant difference in fat content between the formula without substitution (P0) and the formula with substitution (P3) with a ρ-value <0.05. This study revealed that the substitution of pumpkin and red bean flour in cactus cake significantly reduced fat content. This decrease was caused by the high water content in the substitute ingredients which caused relative dilution, as well as the high fiber content in pumpkin and red bean flour, which played a role in reducing the proportion of fat in the final product.

3.3.5. Carbohydrate Content

The results from the carbohydrate composition analysis of cactus cake showed that the carbohydrate content in P0 (0% pumpkin: 0% red bean flour) had an average of 13.24% slightly lower than the P3 treatment (20% pumpkin: 30% red beans) with an average carbohydrate content of 13.36%. Therefore, in this study it was found that the substitution of pumpkin and red bean flour for cactus cake slightly increased the carbohydrate content of cactus cake without substitution. Based on SNI: 01.2973-1992 Cookies, the minimum permitted carbohydrate content is 7%. Therefore, both P0 and P3 meet the SNI carbohydrate content requirements because the carbohydrate content of both samples exceeds the minimum permitted content.

Determination of carbohydrates is based on the Phenol-Sulfuric Acid method. This method has advantages in its implementation which has high efficiency in determining total sugars, both reducing sugars and non-reducing sugars. All monosaccharides (glucose, fructose, galactose) and disaccharides (lactose and maltose) except sucrose and starch (polysaccharides) are types of reducing sugars, while sucrose is a type of non-reducing sugar. The application of the phenol-sulfuric acid method is widely used to determine carbohydrates in samples directly which is expressed as a percentage of glucose. The principle of this method is that polysaccharides, oligosaccharides and disaccharides contained in a substance are broken down into monosaccharides by concentrated sulfuric acid and hydrate them to form furfural compounds that react with phenol to produce a stable yellowish orange color which is measured using a UV-Vis spectrophotometer at a wavelength of 490 nm [31,32].

Referring to the above, the low carbohydrate content in P0 and P3 is influenced by the test method used in the carbohydrate test. The phenol sulfuric acid method only measures total sugar (excluding crude fiber) in the sample and is not influenced by the measurement of other nutritional components (water content, ash content, protein content and fat content). Based on the results of the ANOVA statistical test, it shows that there is no significant difference in carbohydrate content between the cactus cake formula without substitution (P0) and the formula with substitution (P3) with a ρ-value> 0.05.

3.3.6. Crude Fiber

The results of the crude fiber content test of cactus cake showed that the crude fiber content in P0 (0% pumpkin: 0% red bean flour) had an average of 5.49% lower than the P3 treatment (20% pumpkin: 30% red beans) with an average crude fiber content of 8.31%. Therefore, in this study it is known that the substitution of pumpkin and red bean flour for cactus cake increases the crude fiber content of cactus cake without substitution.

Dietary fiber is a complex carbohydrate component that cannot be digested by digestive enzymes, but can be digested by digestive micro bacteria. Dietary fiber contained in vegetable plants is divided into 2 types, namely water-insoluble fiber and water-soluble fiber. Water-insoluble fiber consists of cellulose, hemilose, and lignin. While water-soluble fiber consists of pectin, gum, and mucilage [33].

Based on the results of the proximate test carried out only on the P0 treatment (0% pumpkin: 0% red bean flour) and the product with the best organoleptic value, namely the P3 treatment (30% pumpkin: 20% red bean flour). Where, from the two products that have been tested for nutritional content, the highest crude fiber content is in the P3 treatment. This shows that with the substitution of pumpkin and red bean flour in cactus cakes, the crude fiber content of cactus cakes is higher compared to the crude fiber content of cactus cakes without pumpkin and red bean flour substitution. The increase in crude fiber levels in the P3 treatment (30% pumpkin: 20% red bean flour) is due to the high fiber content in the pumpkin and red bean flour substitution cactus cake which is a high-fiber food ingredient. According to (Aprilia et al., 2022) [10] in pumpkin, the high fiber content in the form of pectin and red beans is also a good source of fiber, where every 100 grams of dried red beans provides about 4 grams of fiber consisting of soluble fiber and insoluble fiber. In addition, the increased fiber content in the P3 treatment was also caused by the pumpkin ingredient used in making cactus cake having the highest fiber content compared to other flour ingredients.

The tendency to increase fiber content in the P3 treatment is due to several factors, one of which is raw materials. This is in line with research (Astawan et al., 2019) [34] which states that the fiber content of the ingredients used in the formulation of white sweet potato analog rice with the addition of pumpkin flour can affect the fiber content in the final

product. High crude fiber content in a food product can indicate that the dietary fiber content contained therein is also high. This can be caused because crude fiber can generally be hydrolyzed by acids and bases indirectly related to dietary fiber content, where dietary fiber is a component that cannot be hydrolyzed by human digestive enzymes. This is in line with research studies (Ranonto et al., 2019) [35] that the effect of adding fruit such as pumpkin has the potential to increase fiber levels and active substances such as β carotene and carotenoids.

The resulting pumpkin and red bean flour substitute cactus cake can be said to be a source of fiber, because the crude fiber produced by the P0-P3 treatment is 5.49% -8.31%, so it can be said to be a source of fiber. This is in accordance with the opinion of (Hidayat et al., 2019) [36] which states that a food product can be called a source of fiber if it contains at least 3% dietary fiber, and is called high in fiber if it contains at least 6% dietary fiber. The high content of crude fiber in a food product can facilitate the digestive metabolism process in the body, so that it has a better health effect compared to food products that have low crude fiber [37].

Based on the statistical analysis of the ANOVA test, the ρ-value = 0.161> 0.05 was obtained, so it can be concluded that the substitution of pumpkin and red bean flour does not have a significant effect on the crude fiber content of cactus cakes. Where, this is because pumpkin and red bean flour have a crude fiber content that is not much different from ordinary rice flour or white glutinous rice flour which is usually used in making cactus cakes. According to research (Maulidya et al., 2023) [23], the substitution of white glutinous rice flour with pumpkin flour increases the crude fiber content of the resulting product. However, this increase may not be significant if the difference in fiber content between the substituted flour and the original flour is not too large.

3.4. Serving Size and Recommended Daily Intake (RDA) of Cactus Cake Best Treatment

Based on BPOM Regulation Number 1 of 2022 concerning Supervision of Claims on Processed Food Labels and Advertisements [38], processed foods can be claimed as high/rich in dietary fiber if they contain dietary fiber of not less than 6 g per 100 g (in solid form).

Cactus cake with a serving size of 30 g can be a snack option that has the advantage of its fiber content, although the contribution of protein and carbohydrates is relatively low and the fat content is quite high. The fairly high fat content needs to be considered to maintain the balance of daily consumption. Consumption of fiber-rich foods like this should be complemented with other foods containing protein and complex carbohydrates to create a balanced diet.

The serving size of cactus cake P3 (best treatment) is determined as 30 g. Each serving size has an energy content of 112 kcal, total fat 10 g, protein 2 g, carbohydrate 1 g and crude fiber 2 g. Every 30 g of cactus cake (substitution of 20% pumpkin and 30% red bean flour) meets 15% of fat needs, 2% of protein needs, 1% of carbohydrate needs. The nutritional information label of cactus cake P3 (best treatment) with a substitution concentration of 20% pumpkin and 30% red bean flour (P3) is presented as follows:

Table 8 Nutritional value information

Nutritional value information		
Serving Size 30 g		
4 Servings per Pack		
AMOUNT PER SERVING		
Total Energy		112 kcal
		%AKG*
Total Fat	10 g	15%
Protein	1 g	2%
Carbohydrate	4 g	1%
Crude Fiber	2 g	
*RDA percentage is based on 2150 kcal energy requirement. Your energy requirement may be higher or lower.		

4. Conclusion

- There is no effect of pumpkin and red bean flour substitution on the organoleptic value of color and aroma of cactus cake. However, there is an effect of pumpkin and red bean flour substitution on the organoleptic value of crispiness and taste of cactus cake.
- The best treatment of the three treatments was P3 (20% pumpkin: 30% red bean flour).
- There is no effect of pumpkin and red bean flour substitution on the nutritional value (protein content, carbohydrate content and crude fiber) of cactus cake. However, there is an effect of pumpkin and red bean flour substitution on the nutritional value (water content, ash content and fat content) of cactus cake.
- The serving size of P3 cactus cake is determined as 30 g. Each serving size has an energy content of 112 kcal, total fat 10 g, protein 2 g, carbohydrate 1 g and crude fiber 2 g. Every 30 g of cactus cake (substituted with 20% pumpkin and 30% red bean flour) meets 15% of fat needs, 2% of protein needs, 1% of carbohydrate needs.

Compliance with ethical standards

Disclosure of conflict of interest

The author has no conflict of interest in this research.

Statement of ethical approval

This study used humans as research subjects and has been approved by the Health Research Ethics Commission of the Institute for Research and Community Service, Halu Oleo University (KEPK-LPPM UHO) with Number: 2415/UN29.20.1.2/PG/2024.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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