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Sensory Preference, Nutrients Content of Sorghum Substitute Bread with Strawberry Dadih Vla

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Abstract: Sorghum (Sorghum bicolor (L) Moench), is a cereal crop ranked the world's fifth most important cereal grain after wheat, maize, rice and barley. sorghum grain protein varies from 4.4 to 21.1% with a mean value of 11.4%. Sorghum grain is known for its hardness compared to other food grains. The hardness of the grain is due to higher content of protein prolamin (3.6 to 5.1%). Dadih is a fermented buffalo milk with various lactic acid bacteria (LAB). Dadih could be developed into other products such as vla. This study aimed to analyze physicochemical, sensory preference, and nutrients content of dadih vla. Dadih collected from Agam District, West Sumatera. The development of sorghum and curd substitute bread products was carried out by dividing them into 3 product formulations, namely 0%, 5% and 10% sorghum substitute bread and vla with the addition of 0%, 15% and 20% strawberry. Based on the physicochemical and sensory tests that have been carried out, it was found that the best formulation was a bread formula with 5% sorghum substitution and 15% strawberry VLA. The selected formula contains 39.24% water, 48.51% carbohydrates, 0.76% ash, 5.85% carbohydrates, 5.74% fat, 1.81% crude fiber, and 43.89% vitamin C. The pH value is 4.89 with brightness 56.87, redness 5.60 and yellowness 16.97. For future research, it is recommended that product testing be carried out in accredited laboratories and testing other nutritional variables so that the resulting product is more optimal and complete

Keywords: sorghum; bread; dadih; vla; sensory; nutrient

1. Introduction

Sorghum (Sorghum bicolor (L) Moench), is a cereal crop ranked the world's fifth most important cereal grain after wheat, maize, rice and barley (Akram et al., 2007; FAO, 1999; Rashwan et al., 2021). The composition of sorghum grain and its parts is generally similar to that of corn, except for lower oil content. The grain contains 8 to 12% protein, 65 to 76% starch with approximately 2% fibre. The germ, a rich source of oil (28% of the germ) also has high levels of protein (19%) and ash (10%) (Gyan-Chand K et al., 2017).

(Mohamed et al., 2009) found that sorghum grain protein varies from 4.4 to 21.1% with a mean value of 11.4%. Sorghum grain is known for its hardness compared to other food grains. The hardness of the grain is due to higher content of protein prolamin (3.6 to 5.1%) (T Rathore, 2019). The lysine content ranges from 1.06 to 3.64% (T Rathore, 2019). The protein fractionation studies in sorghum indicated that the distribution of albumin-globulin, prolamin and glutelin is about 15, 26 and 44% respectively of total nitrogen (T Rathore, 2019). Starch is the major constituent of grain accounting for 56-75% of the total dry matter in the grain (Gyan-Chand K et al., 2017). The total content of soluble sugars of sorghum grain ranged from 0.7 to 4.2% and the reducing sugars from 0.05 to 0.53% (Sreeramulu et al., 2009). Fat content in sorghum grain varies from 2.1 to 7.6%, crude fibre from 1.0 to 3.4% and ash from 1.3 to 3.3% (T Rathore, 2019). Another study on the physico-chemical characterization of sorghum accessions showed a wide variation in protein (7.99 to 17.8%), lipids (2.52

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to 4.76%), starch (51.88 to 85%), and amylose (12.30 to 28.38%) content (Hegde & Chandra, 2005). Linoleic acid (18:2) and oleic acid (18:1) were the major fatty acid constituents of sorghum lipids (Hegde & Chandra, 2005). The grain is commonly eaten with the testa which retains the majority of the nutrients. The wide range in composition of mineral and trace elements indicated that sorghum is a good source of minerals. The mineral composition however is influenced by the environmental conditions (Kumari et al., 2007). Therefore, sorghum can be used as a substitute for wheat flour in bread dough which is expected to increase the nutritional content of the bread.

Fermented food of dadih produced from buffalo milk fermented by a various of lactic acid bacteria (LAB). LAB isolates of dadih consist of three genera, namely Lactococcus, Lactobacillus, and Pediococcus [10]. LAB can be useful as a probiotic if it can survive to the human cecum and has the ability to adhesion in the intestine (Collado et al., 2007). The total colony of LAB from dadih up to 108 cfu/ml (Aritonang et al., 2022). LAB has been shown to have anti-diabetic, anti-obesity, anti-hypertensive, and immunostimulatory effects (Buziau et al., 2019), (Gizachew et al., 2023). The large number of species isolated from dadih were promoted more acidic product. LAB also produces bioactive compounds that give the product its nutrition and flavor.

Dadih can be processed into a range of products, including raw material, or fortified to improve product quality. However, traditionally, dadih had been consumed in fresh product with addition of onion and chili. Consumer perception on traditional products were more preferred, including dadih (Fibri & Frøst, 2019). The sensory of dadih should be slightly sour, white to light cream color, and texture like a tofu. Dadih processing effects of consumer preference and can change carbohydrate into lactic acid or other metabolites (Yang & Yoon, 2022). Just like yoghurt, dadih contains complete nutritional components. Yoghurt was higher vitamin A, riboflavin, calcium, magnesium, iron, zinc, iodine and selenium recommended intake for children (Hobbs et al., 2019). Besides, yoghurt contain protein, lipids, and LAB (Fernandez et al., 2017). Therefore, dadih's sensory preference and nutrients for other products should be analyzed.

Dadih vla is a dairy products like sauce. Cheese sauce has been made (Kůrová et al., 2022) that polysaccharide addition and homogenize can result different of sauce characteristics. However, characteristics of dadih vla is not analyzed in previous studies. Thus, this study aimed to identify the LAB produced by dadih and analyze sensory preference, and nutrients content of dadih vla.

2. Materials and Method

2.1. Materials

2.1.1. Sorghum Substitute Bread

The ingredient of bread was sorghum flour with high nutrient especially protein and other micronutrients with ratio 0% (FO), 5% (F1) and 10% (F2) concentrations. Others ingredient composite flour (red beans, soybeans, corn), sugar, margarine, yeast and UHT milk.

2.1.2. Stawberry dadih vla

The ingredient was dadih collected from Agam District, West Sumatera. Buffalo milk pasteurized in bamboo at room temperature for 48 hours. The ingredients used to make strawberry dadih vla are milk, corn powder, sugar, eggs, butter, dadih and strawberry to increase antioxidant. The factor was ratio of strawberry with three variations: 0% (F0), 15% (F1) and 20% (F2) concentrations. All samples were then tested with hedonic and hedonic quality test to get the best treatment in the sensory parameters. Afterwards, the best sample was analyzed proximate tests. Identification of LAB dadih analysis used 16S rRNA gene.

2.2. Method

2.2.1. Physicochemical Properties

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The physicochemical analysis carried out includes testing water, ash, fat, protein, carbohydrate, vitamin C, pH, and color content (using the Hunter Lab and CIE Lab systems). This test aims to determine the nutritional composition and quality of the sample. All analyses were carried out in triplicate at the Department of Food Technology and Agricultural Products, Faculty of Agricultural Technology, Andalas University.

2.2.1.1. Proximate Analysis

Proximate analysis is carried out to measure the main components in the sample, namely water, ash, protein, fat, and carbohydrate. This testing was carried out using procedures by SNI standards. Water content is measured using the gravimetric method based on the SNI 01-2891-1992 standard, namely by drying the sample at a certain temperature until the weight is constant. Ash content was measured by burning the sample at a temperature of 550°C until ash of a constant weight was formed. This method also follows SNI 01-2891-1992. Fat content is measured by the gravimetric method using an appropriate solvent. This procedure also refers to the standards set out in SNI 01-2891-1992. Protein levels were analyzed using the titrimetric method, referring to the AOAC 2001 and SNI procedures. This process involves measuring total nitrogen and converting the results into protein levels. Carbohydrate content is calculated using the by-difference method, namely by subtracting the total value of water, ash, protein, and fat content from 100%.

2.2.1.2. Vitamin C

Vitamin C was measured using the iodometric titrimetric method. The sample is crushed and prepared in solution form, then titrated with a standard iodometric solution. Vitamin C concentration is calculated based on the volume of titrant used. This test is carried out using procedures that have been validated in the laboratory according to international standards.

2.2.1.3. pH

Sample pH measurements were carried out using a pH meter (digital pH meter). Before measurement, the sample was diluted with distilled water in a ratio of 1:10 (sample:water), then the pH was measured at room temperature.

2.2.1.4. Color

Sample color analysis was carried out using the Hunter Lab Colorimeter system which measures color parameters using the CIE Lab* model. Color is measured by 3 main parameters: L (Lightness)* which describes the brightness of the sample, a* for red-green color intensity, and b* for yellow-blue color intensity. Apart from that, b/a (ratio between yellow and red) and Hue (dominant color) are also calculated using these two systems. Measurements were carried out at three different points per sample to obtain representative results. The data obtained were used to analyze the color differences caused by the substitution of sorghum flour and the addition of strawberries, as well as to evaluate the impact on the overall color of the product.

Sensory tests were through the hedonic scoring test with criteria dislike extremely (score 1), dislike (score 2), usual (score 3), like (score 4), and like extremely (score 5). The attribute sensory were color, aroma, taste, and texture. For quality of color presented yellow pale until white, less sour to sour for aroma dan taste, watery to thicky for texture. This study involved 30 semi-trained panellists.

2.2.2. Sensory Properties

The sensory test was carried out using a hedonic scoring test to assess the level of acceptance of the sample. The panelists involved in this test were 30 semi-trained people consisting of students from the Nutrition Science Master's Study Program and the Agricultural Products Technology Study Program at Andalas University. Panelists were asked to provide an assessment of color, aroma, taste, texture, aftertaste, and overall of the sample using a 9-point scale, with rating as follows dislike

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extremely(1), dislike very much(2), dislike moderately (3), dislike slightly (4), neither like nor dislike (5), like slightly (6), like moderately (7), like very much (8), and like extremely (9).

2.2.3. Data Analysis

Data obtained from all physicochemical and sensory analyses are presented in the form of average values along with standard deviation. Data were analyzed using two-way ANOVA with SPSS software to test differences between treatments (substitution of sorghum flour and addition of strawberries). If a significant difference is found (p-value < 0.05), a further test is carried out using the Duncan test to determine which treatment pairs are significantly different. All data were analyzed in triplicate to ensure the validity of the results.

3. Results

3.1. Physicochemical Properties

3.1.1. Moisture

The moisture content of sorghum-substituted bread samples with strawberry vla filling in this study ranged from 37.13-39.15% (Table 1). The results of the two-way ANOVA analysis provide information that there is a significant difference (P<0.05) in the water content of the bread samples which is caused independently by both the sorghum substitution treatment and the addition of strawberries (Table 1). Referring to Duncan's further test results, bread that was substituted for sorghum and added strawberry vla at all concentrations had a significantly high water content compared to bread without sorghum substitution or without the addition of vla.

Table 1. Moisture Content of Sorghum Substitute Bread with Strawberry Dadih Vla.

Sorghum substitute bread (%)	Vla strawberry (%)		
	0	15	20
0	37.13±0.29^{Bb}	38.24±0.67^{Ba}	37.84±0.60^{Ba}
5	38.20±0.15^{Ab}	39.14±0.49^{Aa}	38.75±0.61^{Aa}
10	37.50±0.39^{Ab}	38.93±0.87^{Aa}	39.15±0.38^{Aa}

Note: $^{a-b}$Different letters in the same row indicate significantly different (P<0.05) based on the difference in strawberry vla. $^{A-B}$Different letters in the same column indicate significant differences (P<0.05) based on differences in sorghum substitute bread—further test using Duncan.

3.1.2. Carbohydrate

The carbohydrate content of sorghum substituted bread samples with strawberry vla filling in this study ranged from 45.78-51.73% (Tabel 2). The results of the two-way ANOVA analysis showed that there were significant differences in the carbohydrate content of the bread samples (P<0.05) by both the sorghum substitution treatment and the addition of strawberry vla (Table 2). Based on Duncan's further tests, the carbohydrate content of bread substituted with 10% sorghum with the addition of 15% strawberry vla was significantly lower than other formulas. This shows that the substitution of sorghum and the addition of strawberry vla to bread can reduce the carbohydrate content of bread.

Table 2. Carbohydrate Content of Sorghum Substitute Bread with Strawberry Dadih Vla.

Sorghum substitute bread (%)	Vla strawberry (%)		
	0	15	20
0	51.73±0.13^{Aa}	48.55±1.24^{Ac}	49.73±1.51^{Ab}
5	51.16±0.26^{Aa}	48.51±0.38^{Ac}	49.74±0.49^{Ab}

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10	48.32±0.55[Ba]	45.78±1.08[Bc]	47.85±0.18[Bb]

Note: [a-b]Different letters in the same row indicate significantly different (P<0.05) based on the difference in strawberry vla. [A-B]Different letters in the same column indicate significant differences (P<0.05) based on differences in sorghum substitute bread—further test using Duncan.

3.1.3. Ash, Protein, Fat, Crude Fiber, and Vitamin C

The ash percentage of all samples of sorghum substituted bread with strawberry filling ranged between 0.68-0.98% and did not have a significant difference (P>0.05) (Table 3).

The protein content of all samples ranged from 3.85-6.15%. The results of the two-way ANOVA analysis showed that there was a significant difference (P<0.05) in the protein levels of both samples caused by the interaction between the sorghum substitution treatment and the addition of strawberry vla (Table 3). Bread substituted for sorghum in various vla additions had significantly higher protein content than bread without sorghum substitution.

The fat content of all samples ranged from 1.15-8.33%. The results of the two-way ANOVA analysis showed that there was a significant difference (P<0.05) in the fat content of both samples which was caused by the interaction between the sorghum substitution treatment and the addition of strawberry vla (Table 3). In each sample of sorghum substitute bread, there was a tendency for the fat content of the bread to be higher with the addition of 15% strawberry vla compared to other strawberry vla formulas.

The crude fiber content of bread samples ranged from 1.15-2.19%. Bread without sorghum substitution with the addition of 20% strawberry VLA has significantly the highest crude fiber content compared to other bread formulas.

Vitamin C levels in bread samples ranged from 21.97-73.19%. Bread that was substituted for 10% sorghum and added 20% strawberry VLA had significantly higher levels of vitamin C compared to other bread formulas.

Table 3. Ash, Protein, Fat, Crude Fiber, and Vitamin C Content of Sorghum Substitute Bread with Strawberry Dadih Vla.

Treatment	Parameter				
	Ash	Protein	Fat	Crude Fiber	Vitamin C
0% Shorgum, 0% Strawberry	0.88±0.26[a]	3.85±0.06[b]	6.40±0.24[c]	1.18±0.11[c]	58.44±12.72[abc]
0% Shorgum, 15% Strawberry	0.84±0.07[a]	4.04±0.26[b]	8.33±0.71[a]	1.54±0.32[bc]	21.97±0.07[f]
0% Shorgum, 20% Strawberry	0.71±0.07[a]	4.04±0.28[b]	7.67±1.22[a]	2.19±0.12[a]	29.25±12.70[ef]
5% Shorgum, 0% Strawberry	0.68±0.19[a]	4.45±0.29[b]	5.51±0.75[cd]	1.62±0.28[bc]	51.11±12.64[bcd]
5% Shorgum, 15% Strawberry	0.76±0.05[a]	5.85±0.59[a]	5.74±0.18[c]	1.81±0.38[ab]	43.89±0.04[cde]
5% Shorgum, 20% Strawberry	0.98±0.35[a]	6.02±0.38[a]	4.49±0.59[d]	1.31±0.14[c]	51.20±12.81[bcd]
10% Shorgum, 0% Strawberry	0.88±0.03[a]	5.72±0.29[a]	7.57±0.28[ab]	1.27±0.17[c]	36.60±12.69[def]

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10% Shorgum, 15% Strawberry	0.87±0.04a	6.15±0.64a	8.26±0.57a	1.15±0.15c	73.19±12.71a
10% Shorgum, 20% Strawberry	0.77±0.12a	5.68±0.24a	6.54±0.02bc	1.32±0.35c	65.74±0.17ab

Note: a,b.c.d.e.f = significantly different ($P < 0.05$)

3.1.4. Physical Properties

The pH value of the bread samples ranged between 4.83-5.38 and did not experience a significant difference (P>0.05) (Table 4). The levels of brightness (L), redness (a), and yellowness (b) of the samples ranged between 56.87-69.48, 1.19-6.12, and 13.27-19.85, respectively. The results of the two-way ANOVA analysis showed that there was a significant difference (P<0.05) due to the interaction between the sorghum substitution treatment and the addition of strawberry vla on the level of brightness (L) and yellowness (b) of the bread, but there was no significant difference (P>0.05) at the degree of redness (a) (Table 4).

Table 4. Physical Characteristics of Sorghum Substitute Bread with Strawberry Dadih Vla.

Treatment	Parameter					
	pH	L	a	b	b/a	Hue
0% Shorgum, 0% Strawberry	4.99±0.64a	60.75±10.74abc	2.52±1.50a	15.66±1.09cd	7.71±3.78a	80.67±6.11a
0% Shorgum, 15% Strawberry	5.24±0.10a	69.48±8.02a	1.37±0.69a	17.95±0.76abc	15.19±6.37a	85.55±2.45a
0% Shorgum, 20% Strawberry	5.02±0.39a	49.00±4.55c	1.19±0.43a	13.27±1.11d	12.75±6.85a	84.73±2.23a
5% Shorgum, 0% Strawberry	5.38±0.24a	64.15±6.48ab	2.13±0.28a	15.93±1.34bcd	7.53±0.40a	82.42±0.39a
5% Shorgum, 15% Strawberry	4.89±0.45a	56.87±8.23bc	5.60±2.97a	16.97±2.45abc	4.08±3.15a	71.59±9.56a
5% Shorgum, 20% Strawberry	4.83±0.56a	63.41±7.64ab	4.92±0.49a	18.87±2.05ab	6.35±3.77a	76.69±11.48a
10% Shorgum, 0% Strawberry	5.03±0.39a	60.18±1.17abc	4.95±2.88a	19.46±2.68a	5.42±3.85a	76.44±6.79a
10% Shorgum, 15% Strawberry	5.26±0.34a	57.66±1.04abc	6.12±0.30a	19.85±0.53a	3.24±0.07a	72.85±0.38a
10% Shorgum, 20% Strawberry	5.06±0.41a	57.99±0.84abc	3.25±0.67a	17.09±0.85abc	5.38±0.84a	79.29±1.79a

Note: a,b.c.d.e.f = significantly different ($P < 0.05$)

3.2. Sensory Properties

The acceptability scores of bread samples based on color, aroma, taste, and aftertaste ranged between 6.68-7.07, 6.32-7.07, 5.58-6.32, and 5.60-6.40 respectively, and did not experience significant differences (P>0.05) (Table 5) . The bread acceptability scores based on texture and overall ranged between 5.68-7.04 and 6.08-6.88 respectively. The results of the two-way ANOVA analysis showed that there were significant differences (P<0.05) in the texture of the bread samples which were caused independently by both the sorghum substitution treatment and the addition of strawberry vla (Table

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6). Referring to Duncan's further test results, the acceptability based on the texture of bread without sorghum substitution which added 15% strawberry vla was significantly higher than other formulations. The results of the two-way ANOVA analysis based on overall acceptability showed that there was a significant difference (P<0.05) caused by the sorghum substitution treatment (Table 7). Panelists significantly preferred the bread texture without sorghum substitution.

Table 5. Sensory Acceptance According to Color, Aroma, Taste, and Aftertaste of Sorghum Substitute Bread with Strawberry Dadih Vla.

Treatment	Parameter			
	Color	Aroma	Taste	Aftertaste
0% Shorgum, 0% Strawberry	7.07±1.64^{a}	7.07±1.29^{a}	6.11±1.55^{a}	6.27±1.61^{a}
0% Shorgum, 15% Strawberry	6.84±1.67^{a}	6.32±1.65^{a}	5.68±1.67^{a}	5.60±1.82^{a}
0% Shorgum, 20% Strawberry	7.00±1.53^{a}	6.64±1.89^{a}	6.08±1.70^{a}	6.00±1.61^{a}
5% Shorgum, 0% Strawberry	6.72±1.72^{a}	6.80±1.35^{a}	6.48±1.50^{a}	6.40±1.41^{a}
5% Shorgum, 15% Strawberry	6.68±1.60^{a}	6.68±1.49^{a}	6.12±1.16^{a}	6.12±1.42^{a}
5% Shorgum, 20% Strawberry	6.76±.145^{a}	6.36±1.84^{a}	5.68±1.57^{a}	5.84±1.46^{a}
10% Shorgum, 0% Strawberry	6.88±1.51^{a}	6.72±1.06^{a}	6.08±1.49^{a}	5.76±1.58^{a}
10% Shorgum, 15% Strawberry	6.72±1.62^{a}	6.60±1.47^{a}	6.32±1.49^{a}	5.88±1.72^{a}
10% Shorgum, 20% Strawberry	6.68±1.34a	6.68±1.31a	5.68±1.28a	5.68±1.34a

Note: $^{a,b.c.d.e.f}$ = significantly different (P < 0.05)

Table 6. Texture Sensory Acceptance of Sorghum Substitute Bread with Strawberry Dadih Vla.

Sorghum substitute bread (%)	Vla strawberry (%)		
	0	15	20
0	7.04±1.61^{Aab}	6.84±1.65^{Aa}	6.20±1.84^{Ab}
5	5.80±1.75^{Bab}	6.48±1.23^{Ba}	5.68±1.84^{Bb}
10	6.12±1.36^{Bab}	6.24±1.64^{Ba}	5.88±1.33^{Bb}

Table 7. Overall Sensory Acceptance of Sorghum Substitute Bread with Strawberry Dadih Vla.

Sorghum substitute bread (%)	Vla strawberry (%)		
	0	15	20
0	6.65±1.41^{Aa}	6.08±1.75^{Aa}	6.28±1.51^{Aa}
5	6.88±1.16^{Ab}	6.36±0.99^{Ab}	6.08±1.28^{Ab}
10	6.48±1.16^{Ab}	6.24±1.50^{Ab}	6.16±0.98^{Ab}

4. Discussion

4.1. Physicochemical Properties

The substitution of sorghum flour to the bread significantly influenced the color parameters, especially the level of lightness (L*), yellowness (b*), and redness (a*). Increasing sorghum flour content tends to reduce brightness (L*) and yellowness (b*), while increasing redness (a*). These findings were consistent with Adzqia et al., (2023) These changes are mainly caused by natural pigments found in the sorghum pericarp, as explained by (Aguiar et al., 2020). These pigments have

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a dominant role in determining the final color of the product compared to the Maillard reaction and caramelization that occur during processing (Jafari et al., 2018).

The significant correlation between the color of sorghum flour and the color of the mixture shows that the color of the raw material greatly determines the visual characteristics of the final product (Nieto-Mazzocco et al., 2020). This is in line with the consumer trend of increasingly appreciating products with darker colors because they are associated with health benefits. For example, in countries like Germany and Eastern Europe, darker colors are often considered healthier. This trend is also supported by increasing consumer interest in dark colored foods which are known to contain antioxidants and bioactive compounds with various health benefits (Jafari et al., 2018; Nieto-Mazzocco et al., 2020).

Thus, the influence of sorghum flour on color can be an additional attraction, not only for visual characteristics but also to meet market preferences that prioritize products based on natural ingredients and high health value.

4.2. Sensory Properties

According to the sensory analyses, the acceptance score for bread substituted with sorghum and added with strawberry vla showed insignificant variations for the parameters of color, aroma, taste and aftertaste ($P > 0.05$). Acceptance scores based on texture and overall showed a significant difference ($P < 0.05$) in bread texture which was influenced independently by the sorghum substitution treatment and the addition of strawberry vla. In particular, in the texture test, bread without sorghum substitution with the addition of 15% strawberry vla showed a higher acceptance score compared to other formulations, indicating that the addition of strawberry vla had a positive impact on the texture of the bread.

However, based on the overall test (overall acceptability), sorghum substitution had a significant effect ($P < 0.05$), where panelists preferred bread with a texture that did not use sorghum. Although sorghum provides variation in bread composition, these results suggest that the addition of strawberry vla can improve the sensory quality of bread in terms of texture, but the sorghum substitution may not be favorable in terms of overall texture.

In general, the addition of strawberry vla has a more positive impact on consumer acceptance, especially in bread formulations with 15% strawberry vla. This can explain that although sorghum has the potential to increase the nutritional value of bread, the addition of strawberry vla has a better effect on consumer preferences, especially on the texture and taste aspects of bread.

On the other hand, based on the overall perception of the panelists, it can be seen that the addition of sorghum and vla can increase the color of the bread to become browner, while vla becomes brighter and more attractive. The aroma is not that different from bread made from other nuts. The average taste of bread with the addition of strawberry curd vla was almost the same in each formula, indicating that vla did not change the flavor profile significantly. However, the aftertaste perceived by panelists became increasingly unfavorable as the percentage of sorghum substitution increased, which is in line with findings by lyArdhea et al. (2015) who reported that increasing the level of sorghum flour substitution in bread caused a decrease in taste and texture preferences. A part from that, the addition of sorghum flour and curd flour tended to reduce the panelists' preference scores for the color of the bread. Color is an important factor in determining the quality of bread because it is one of the first characteristics that attracts consumers' attention. Mixing sorghum flour with other types of flour, such as wheat flour, can produce bread with a darker color of crumb and crust, as also reported in previous research (Saeed Omer et al., 2023).

5. Conclusions

Bread substituted with sorghum and filled with strawberry vla had significantly differences in water, carbohydrate, protein, fat, crude fiber and vitamin C content compared to control bread. The water content of bread substituted with sorghum and added with strawberry is higher, while the carbohydrate content tends to be lower in bread with 10% sorghum and 15% strawberry. Sorghum substitution also increases the protein, fat and vitamin C content, especially in bread with 10%

sorghum and 20% strawberry. In terms of physical properties, these breads showed significant variations in lightness and yellowness, but no significant differences in pH or degree of redness. The results of the sensory test showed that consumer preference for the texture of bread containing 15% strawberry vla was more favorable, but overall, there was no significant difference in the acceptance of the taste, aroma or appearance of the bread.

6. Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

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Data Availability Statement: We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required. Suggested Data Availability Statements are available in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics.

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Appendix A

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data is shown in the main text can be added here if brief, or as Supplementary data. Mathematical proofs of results not central to the paper can be added as an appendix.

Appendix B

All appendix sections must be cited in the main text. In the appendices, Figures, Tables, etc. should be labeled starting with "A"—e.g., Figure A1, Figure A2, etc.

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