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Physicochemical characteristic of chicken sausage substituting tapioca flour with sorghum seed flour (*Sorghum Bicolor L. Moench*)

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ABSTRACT

Chicken sausage is a widely consumed processed meat product due to its high protein content, desirable texture, and affordability. Its formulation generally involves meat proteins, carbohydrate-based fillers, and functional additives. Proteins act as structural stabilizers of emulsions, while fillers such as tapioca flour improve texture, water retention, and yield. However, tapioca flour has relatively low fiber compared to sorghum flour. Germinated sorghum (*Sorghum bicolor L. Moench*) contains 6.82% protein, 1.81% fat, 2.21% crude fiber, and 77.47% carbohydrates, with enhanced nutritional quality compared to ungerminated grains. This study aimed to evaluate the chemical and physical characteristics of chicken sausage with partial substitution of tapioca flour by germinated sorghum flour, focusing on protein, fat, moisture, crude fiber, texture, Water Holding Capacity (WHC), cooking loss, and Cielab color space (L*a*b*) color parameters. The experiment used a Completely Randomized Design (CRD) with five substitution levels (0%, 5%, 10%, 15%, and 20%) and four replications. Results showed that sorghum substitution significantly increased protein and crude fiber content, affected fat levels, but did not alter moisture. In terms of functional properties, germinated sorghum flour had a highly significant effect on WHC, texture, cooking loss, and color analysis. Sausage with 50% sorghum flour and 50% tapioca flour produced the best balance, yielding higher WHC, lower cooking loss, acceptable texture, and balanced color. Overall, germinated sorghum flour is a promising alternative filler to improve both nutritional and functional qualities of chicken sausage

Keyword: Chicken Sausage, Germinated Sorghum Flour, Nutritional Quality, Cooking Loss, Protein Content

1. Introduction

Chicken is a livestock commodity that is in high demand among Indonesians due to its high protein content, easy availability, and relatively low price compared to other types of meat. The increasing demand for animal protein has driven the consumption of chicken meat, which has a protein content of 21–22%, a water content of 70%, and a fat content of 1% [1]. The high nutritional content makes chicken a favorite food ingredient, but its perishable nature due to high water content triggers the growth of microorganisms, requiring further processing to extend its shelf life and increase its economic value. One of the most widely developed processed products is sausage, which is a mixture of meat and additional ingredients stuffed into a casing [2]. According to Indonesian National Standard 3820-2015, meat sausages must have a minimum protein content of 13%, a maximum water content of 67%, and a fat content of no more than 20% [3]. The sausage-making process requires meat as the main ingredient, a binder, and a filler that stabilizes the emulsion, increases water binding capacity, and reduces shrinkage [4]. Tapioca flour is commonly used as a filler because it can improve emulsions, but its nutritional content is relatively low, with 86.55% carbohydrates, 0.15% protein, 0.3% fat, 0.50% crude fiber, and 12% water [5]. According to Masyithoh et al. (2024), fiber content can correlate with Water Holding Capacity (WHC) because higher Total Dietary Fiber (TDF) values, both soluble and insoluble, indicate greater water retention capacity, where water is absorbed and retained between fiber particles [6]. This is in line with the statement by [7] that the addition of fiber to processed meat products can affect the physical properties of the final product by increasing yield, improving texture, maintaining shape after processing, and brightening the color of the product. Therefore, efforts to increase the nutritional value of chicken sausage can be made by using sorghum as a filler to replace tapioca flour a potential solution.

Red sorghum (*Sorghum Bicolor L. Moench*) belongs to the cereal group that has been developed and widely cultivated in various regions of Indonesia. Sorghum can be used as a filler because it has a fairly high carbohydrate content of 61.24–76.6%, and the criterion for a filler is that it has a high carbohydrate content so that it can reduce shrinkage during the cooking process and improve the texture and elasticity of the product [8]. The Bioguma variety of red sorghum has a protein content of 6.82%, fat 1.81%, ash 1.97%, crude fiber 2.21%, and carbohydrates 77.47% [9]. To increase the nutritional content and reduce tannins, red sorghum seeds can undergo further processing, namely through the germination method.

Germination is a process of treating sorghum seeds by soaking them in a solution to produce sprouts under certain conditions. The germination process can increase nutritional content by activating the metabolic process in the seeds, thereby reactivating inactive enzymes such as protease, lipase, and amylase to produce energy to support germination. Germination for 24 hours can increase the protein content from 10.35% to 12.99%, so that germinated red sorghum has better nutritional content than red sorghum without germination treatment [10]. The application of red sorghum sprouts in food products needs to be processed into red sorghum sprout flour so that it can be used as a filler in food products. Research conducted by [11] on the addition of sorghum flour as a filler in salami sausage showed an increase in fat and carbohydrate content with the addition of 10% sorghum flour, and a significant decrease in water content in salami sausage as the amount of sorghum flour added increased. The addition of sorghum flour has water-binding properties because water is tightly bound by proteins and prevented from evaporating. High water-binding capacity affects water loss during cooking and product texture. Based on the potential of sorghum sprout flour, which has high nutritional content as a filler, and the lack of research on the substitution of tapioca flour with sorghum sprout flour in chicken sausage in terms of chemical and physical characteristics, this research needs to be conducted.

2. Method

Research on the chemical and physical characteristics of chicken sausage substituted with tapioca flour and sorghum sprout flour (*Sorghum Bicolor L. Moench*) was conducted at the Animal Product Technology Laboratory, Faculty of Animal Science, Brawijaya University; the Meat Technology Laboratory, Faculty of Animal Science, Gadjah Mada University; and the Food Quality and Safety Testing Laboratory, Faculty of Agricultural Technology, Brawijaya University, from August to November 2025.

2.1. Research Method

This study used a Completely Randomized Design (CRD) with 5 treatments and 4 replicates. The sorghum sprout flour substitution treatment was based on the use of tapioca flour in the formulation, which was 20% of the total meat. The treatments are described as follows:

- T0: Chicken sausage with 20% tapioca flour (control)of the amount of meat used.
- T1: Chicken sausage with sorghum sprout flour substitution: tapioca flour using a ratio of 5%:15% of the amount of meat used.
- T2: Chicken sausage with sorghum seed sprout flour:tapioca flour substitution using a ratio of 10%:10% of the amount of meat used.
- T3: Chicken sausage with sorghum seed sprout flour:tapioca flour substitution using a ratio of 15%:5% of the amount of meat used.
- T4: Chicken sausage with 20% sorghum grain sprout flour of the amount of meat used.

2.2. Preparation of germination sorghum

The procedure for making sorghum sprout flour according to [12] begins with washing the red sorghum seeds until they are clean of various impurities, then soaking them for 24 hours at room temperature. The soaked sorghum seeds are washed again until clean, then spread on a basket lined with a damp cloth and placed in an oven for 24 hours at 35°C in the dark. The sorghum sprouts that had been spread out for 24 hours were then cleaned again by washing and dried using a food dehydrator for 2 hours at a temperature of 60°C. The dried sorghum seeds were cleaned to remove the outer skin, leaving only the sorghum sprouts. The clean sorghum sprouts were weighed and then ground until smooth for 5 minutes. The ground sorghum seeds were then sieved using a 100 mesh flour fraction. The sorghum seed sprout flour was analyzed proximately to analyze the nutritional content in the sorghum sprout flour. The sorghum seed sprout flour was packaged in polypropylene ziplock plastic and stored at a temperature of 19-24°C. The procedure for making sorghum sprout flour is shown in Figure 1.

Figure 1. Procedure for making sorghum sprout flour

2.3. Preparation for sausage

Procedure for making chicken sausage substituting tapioca flour with sorghum sprout flour according to [2] begins with the preparation of ingredients such as chicken meat, sorghum sprout flour, tapioca flour, ice cubes, nutmeg, salt, garlic, candlenut, egg yolk, pepper, sugar, and oil. All additional ingredients are weighed according to the measurements in the sausage dough formulation. The chicken meat is cut into small pieces, weighed according to the sausage dough formulation, and ground together with 50% ice cubes and 100% salt using a meat grinder or meat chopper. The grinding process is carried out for 2 minutes. The ground chicken meat was then mixed with all the additional ingredients according to the sausage dough formulation, such as sugar, nutmeg, egg yolk, pepper, garlic, and the remaining ice cubes, then ground until smooth for 2 minutes. Tapioca flour and sorghum flour were added to the finely ground dough according to the sausage dough formulation and ground again until evenly mixed for 2 minutes. Oil is then added to the evenly mixed dough and ground until well blended for 1-2 minutes. Once the dough has been evenly ground, it is transferred to a basin to be prepared for the molding process. The evenly mixed dough is put into a sausage stuffer to be molded. A casing of sufficient length is inserted into the end of the stuffer, then the casing is filled with sausage dough until it is sufficiently compact. After the dough has been filled into the casing, the sausage is tied using knitting yarn according to the desired length. Once the casings are ready to be boiled, pierce them evenly with a needle to prevent the mixture from bursting during the boiling process. The prepared sausages are then placed in a pot of water heated to 80°C for about 45 minutes. Once the sausages are cooked, drain and cool them until they are cold, then package them. The sausage-making process is shown in Figure 2.

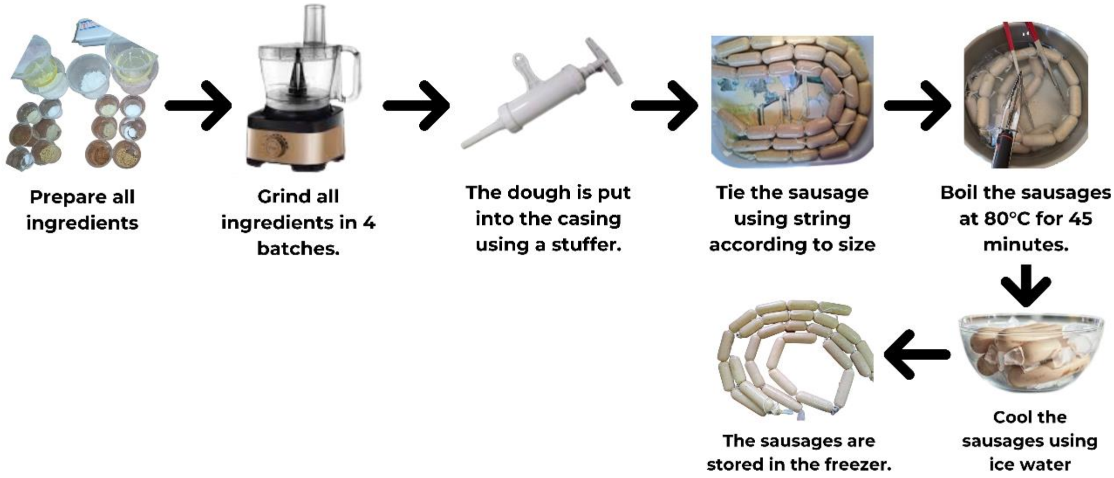

Figure 2. The sausage-making process

2.4. Analysis of germinated sorghum flour

The proximate content examined in this study includes moisture, ash, fat, protein, and carbohydrate. The parameters of chemical qualities were determined using a proximate analysis, which included the gravimetric method for analyzing the moisture and ash content, the Kjeldahl method for determining the protein content, and the Soxhlet method using fat extractor for analyzing the fat content.

2.5. Chemical quality analysis

Chemical quality analysis includes testing water content, fat content and protein content using using FoodScan (FOSS) with Artificial Neural Network (ANN) calibration and related databases. Chemical analysis was carried out according to the Association of Official Analytical Chemists (AOAC, 2007) method [13]. Crude fiber content analysis using the Association of Official Analytical Chemists (AOAC, 2005) method [14].

2.6. Physical quality analysis

The physical quality analysis includes cooking loss, water holding content, color analysis using a color reader (CIELAB color space), and texture analysis using a texture analyzer.

2.7. Data Analysis

The data on chemical quality (moisture, ash, fat, and protein content) and physical quality (cooking loss, color, and texture analysis) were evaluated using ANOVA. When significant differences were observed, the analysis was further conducted with Duncan's Multiple Range Test.

3. Result and Discussion

3.1 The Effect of Germination on Sorghum Seeds on the Nutritional Content of Sorghum Seed Sprout Flour

Proximate analysis of sorghum seed sprout flour that has been germinated for 24 hours. The purpose of the proximate analysis was to determine the effect of germination on the nutritional value of sorghum seed sprout flour. The data from the proximate analysis of sorghum seed sprout flour can be seen in Table 1.

Table 1. Proximate analysis of sorghum seed sprout flour

Parameters	Analysis Results (%)	Reference Source (Derbew and Morgez, 2017)
Protein Content	7.40	11.16%
Moisture Content	8.19	8.33%
Fat Content	3,14	3.09%
Ash Content	1.19	1.36%
Carbohydrate Content	80.08	74.34%

Based on the data in Table 1, it can be seen that the germination treatment of sorghum seeds resulted in an increase in the nutritional content of the sorghum seeds. It is suspected that the increase in the nutritional content of sorghum seed sprout flour is due to germination for 24 hours. This is in line with the research by

[15], which states that the germination process triggers metabolic activity in seeds by reactivating previously inactive enzymes. This activation produces primary and secondary metabolites that contribute to an increase in the functional content and nutritional value of the seeds. [16] also added that during the germination process, some of the enzymes bound in the seeds are reactivated so that storage macromolecules, such as carbohydrates, proteins, and fats, undergo hydrolysis and are converted into a more digestible form. Germination can also reduce the levels of anti-nutrient components, such as tannins and phytic acid. According to [17], germination increases proteolytic and amylolytic enzyme activity in cereals, thereby improving the availability of protein and essential amino acids. The activation of the lipid biosynthesis pathway during germination also plays a role in the production of new lipids needed for cell division and expansion, so that the increase in fat content during sorghum germination reflects complex biochemical processes that are essential for seedling growth and development. The decrease in water content during the germination process can be influenced by the drying process that occurs after germination [16].

3.2 Chemical Charateristic of Sausages with Sorghum Seed Sprout Flour

Table 2. Chemical characteristic of sausages with sorghum seed sporut flour

Treatment	Protein content (%) ± SD	Fat content (%) ± SD	Moisture content (%) ± SD	Crude fiber content (%) ± SD
T0	19.00^{a} ± 0,24	8.73^{a} ± 0,96	69.51 ± 1,06	0.08^{a} ± 0,02
T1	19.51^{a}± 0,32	8.18^{a} ± 1,13	69.26 ± 0,66	0.11^{a} ± 0,01
T2	20.11^{b} ± 0,14	8.41^{a} ± 1,32	69.21 ± 0,46	0.21^{b} ± 0,06
T3	20.93^{c}± 0,26	10.03^{a} ± 0,14	69.98 ± 0,81	0.39^{c} ± 0,09
T4	21.57^{d} ± 0,43	10.57^{b} ± 0,29	70.03 ± 0,77	0.47^{c} ± 0,08

Based on Table 2, the results of the analysis of variance show that the substitution of sorghum seed sprout flour in chicken sausage has a very significant effect on protein content ($P<0.01$). This is thought to be because the use of sorghum seed sprout flour can increase the protein content in chicken sausage. This is supported by the results of the proximate analysis in Table 1, which shows that the protein content of sorghum seed sprout flour is 7.40%. The high protein content is due to the germination of sorghum seeds, which can increase their protein content. The comparison of sorghum seed sprout flour substitution with tapioca flour also had an effect on the protein content of the sausage, with the protein content of tapioca flour being lower at 0.59% compared to sorghum seed sprout flour. The most significant increase in protein content was found in treatments T3 (20.93%) and T4 (21.57%). The increase in protein content from T0 to T4 was due to the increasing substitution of sorghum seed sprout flour in chicken sausage. This is in line with the research by [8] that the higher the addition of sorghum seed sprout flour substitution in sausage, the higher the protein content of chicken sausage. The protein content in this study met the SNI standard, which is a minimum limit of 13% protein content in combination sausages [3].

The substitution of sorghum seed sprout flour in chicken sausage resulted in a significant difference in fat content ($P<0.01$). It is suspected that the increase in fat content in chicken sausage was influenced by the higher substitution of sorghum seed sprout flour, which has a high fat content, as shown in Table 1, namely 3.14%. The high fat content is caused by germination in sorghum seeds, which can increase their fat content, resulting in oil absorption due to oil binding associated with non-polar fatty acid side chains [15]. The most significant fat content values were found in treatments T3 (10.03%) and T4 (10.57%) due to the increasing substitution of sorghum seed sprout flour in chicken sausage. This is in line with the research conducted by [8] that the fat content in chicken sausage has a range that is not much different between treatments, but the higher the addition of sorghum, the higher the fat content. The high fat absorption capacity of red sorghum seeds can also be utilized to bind fat in meat and sausage products. The fat content in this study met the SNI standard, which is a maximum limit of 20% fat content in combination sausages [3].

The substitution of sorghum sprout flour in chicken sausage did not result in a significant difference in moisture content ($P>0.05$). This is thought to be because the moisture content of chicken sausage substituted with sorghum sprout flour is influenced by the moisture content of sorghum sprout flour, which is shown in Table 1 to be 3.14%. The moisture content of chicken sausage was not affected because the sorghum seed sprout flour production process involved drying, which reduced the moisture content. This decrease in moisture content can be attributed to sorghum seed sprout flour, where the flour production process involves drying the seeds, which can reduce the moisture content [16]. The moisture content from T0 to T4 did not have a significant effect due to the increasing substitution of sorghum seed sprout flour in chicken sausage. This is in accordance with the statement by [2] that the moisture content in Manila duck sausage with the addition of white sorghum flour did not cause a significant difference. A water content that is not too high has the advantage of affecting appearance, texture, taste, and shelf life. Foods with high water content can accelerate the growth of microorganisms [8]. The water content of chicken sausage in this study did not meet the meat sausage quality standards based on SNI requirements, which is a maximum of 67% [3].

The substitution of sorghum seed sprout flour in chicken sausage resulted in a significant difference in crude fiber content (P<0.01). This is thought to be due to the use of sorghum seed sprout flour, which can increase the protein content in chicken sausage. This is supported by research conducted by [19] with a sorghum flour fiber content of 1-3%. The high fiber content is due to the germination of sorghum seeds, which increases their crude fiber content. The comparison of sorghum seed sprout flour substitution with tapioca flour also had an effect on the fiber content of the sausage, with the crude fiber content of tapioca flour being lower at 0.2% compared to sorghum seed sprout flour. The most significant crude fiber content values were found in treatments T3 (0.39%) and T4 (0.47%). The increase in fiber content from T0 to T4 was due to the increasing substitution of sorghum seed sprout flour in chicken sausage. This is supported by [20], who stated that the higher the addition of sorghum flour, the higher the insoluble fiber content. [16] also added that the increase in fiber content can be triggered by dry mass loss caused by starch hydrolysis through enzyme action triggered during germination, increased lignin content, and degradation of cellular components such as lipids and proteins.

3.3 Physical Charateristic of Sausages with Sorghum Seed Sprout Flour

Table 3. Physical charateristic of sausages with sorghum seed sprout flour

Treatment	Cooking Loss (%) ± SD	Water Holding Capacity (%) ± SD	Texture (%) ± SD
T0	2.01^{e} ± 0.05	37.25^{a} ± 0.55	3.95^{e} ± 0.02
T1	1.87^{d} ± 0.04	40.26^{b} ± 0.62	3.87^{d} ± 0.03
T2	1.69^{c} ± 0.03	43.03^{c} ± 0.44	3.03^{c} ± 0.06
T3	1.40^{b} ± 0.03	45.23^{d} ± 0.42	2.86^{b} ± 0.03
T4	1.00^{a} ± 0.03	46.20^{e} ± 0.36	2.64^{a} ± 0.07

Based on Table 3, the addition of sorghum sprout flour at different percentages had a very significant effect (P<0.01) on the cooking shrinkage value. This is likely due to the chemical characteristics of sorghum sprout flour, including its protein content as shown in Table 1, which is 7.40%, and its fiber content of 1.72% according to [21]. This protein content can bind water molecules and form a gel network to retain water, and the fiber content in sorghum sprout flour can trap water within the fiber particles thereby directly affecting the sausage's ability to retain water during the testing process. This is reinforced by [21], who state that the germination process can increase the ability to absorb water and form higher viscosity. This increase makes sorghum sprout flour more effective in retaining water during the processing stage.

The addition of sorghum sprout flour at different percentages had a very significant effect (P<0.01) on the WHC value. It is suspected that the addition of sorghum sprout flour changed the properties of the sausage dough, such as increasing the fiber and starch content that can absorb water, thereby improving the sausage's ability to retain water. The relatively high protein content in sorghum sprout flour, as listed in Table 1 (7.40%), can help bind water molecules contained in the sausage dough. The starch content in sorghum sprout flour forms a gel that traps water within the dough, while the fiber content forms a porous structure that can absorb and retain water. This is supported by [22], who stated that the addition of sorghum sprout flour increases the amount of dietary fiber, which acts as a hydrophilic matrix capable of binding and retaining water during the processing. [23]) stated that the addition of certain types of starch to processed meat products can increase their ability to retain water, as evidenced by increased gel strength and network formation, which demonstrates the role of starch in creating an effective water-retaining network in processed meat products.

Based on Table 3, the addition of sorghum sprout flour at different percentages had a very significant effect (P<0.01) on texture values. This is thought to occur because the addition of sorghum sprout flour changes the composition and properties of the sausage dough, such as soluble proteins, thereby altering the dough structure and ultimately affecting the hardness and tenderness of the sausage. This is supported by [24], who state that an increase in the water-binding capacity of a product can alter the texture value of that product. The average texture value of chicken sausage with added sorghum sprout flour ranged from 3.95 N to 2.64 N. The texture values in this study showed a decrease as the amount of sorghum sprout flour added to the chicken sausage increased. This decrease is suspected to be due to more water being bound by the starch and fiber in sorghum sprout flour, resulting in a less elastic protein gel structure. The water-binding capacity of a product is directly related to the texture characteristics of processed meat products, as the water-binding capacity is related to the ability of the tissue to maintain the water content that affects the texture of processed meat products [25].Lower texture values mean that the addition of sorghum sprout flour makes the sausage structure softer or less firm compared to the control without sorghum. The sorghum filler replaces part of the starch in the sausage mixture. Lower texture values indicate that the addition of sorghum sprout flour makes the sausage structure softer or less firm compared to the control without sorghum. Sorghum filler replaces part of the dense protein tissue from chicken meat with a less dense matrix, resulting in a softer final texture [26].

Table 4. Color analysis of sausages with sorghum seed sprout flour

Treatment	L*± SD	a*± SD	b*± SD
T0	$66.93^{c} \pm 0.21$	$5.30^{a} \pm 0.16$	$21.25^{d} \pm 0.26$
T1	$65.30^{b} \pm 0.14$	$7.43^{c} \pm 0.05$	$19.05^{c} \pm 0.17$
T2	$64.55^{b} \pm 0.97$	$6.93^{b} \pm 0.17$	$17.63^{b} \pm 0.17$
T3	$62.55^{a} \pm 0.25$	$6.98^{b} \pm 0.13$	$16.95^{a} \pm 0.06$
T4	$61.75^{a} \pm 0.39$	$6.80^{b} \pm 0.16$	$17.50^{b} \pm 0.18$

Based on Table 4, the addition of sorghum sprout flour at different percentages had a very significant effect ($P<0.01$) on the L* color value. This is thought to be due to the sorghum sprout flour changing the color of the sausage surface by adding colored or scattered pigment and fiber components to the sausage mixture. This is supported by the opinion of [27] that the addition of fiber to processed meat products can cause significant changes in color values, as the color characteristics and natural properties of these additives can affect the final appearance of the product. The average L* color value of chicken sausage with sorghum sprout flour ranged from 61.75 to 66.93. The L* color value showed a decrease due to the darker color of sorghum sprout flour compared to tapioca flour. This decrease indicates that the higher the addition of sorghum sprout flour, the lower the resulting L* color value. A lower L* color value means that the addition of sorghum sprout flour makes the sausage color slightly darker (less bright) compared to sausages without sorghum addition.

The addition of sorghum sprout flour at different percentages had a significant effect ($P<0.01$) on the a* color value. This is thought to be due to the content of phenolic compounds such as tannins and flavonoids found in sorghum seeds. The average a* color value of chicken sausage with sorghum sprout flour ranged from 5.30 to 7.43. [9] stated that sorghum seeds contain high levels of phenolic compounds, especially tannins and flavonoids, which contribute to differences in the appearance and color of sorghum, particularly in colored varieties. A higher a* color value means that the addition of sorghum sprout flour higher a* color values indicate that the addition of sorghum sprout flour makes the sausage color tend to be redder than sausages without sorghum addition. Chicken meat generally has a slightly pale color, and the addition of sorghum pigments makes the final sausage color tend to be redder. The a* color value in this study showed an increase compared to the control treatment as the amount of sorghum sprout flour added to the chicken sausage increased. Based on research conducted by [8], the a* color value in chicken sausage with sorghum added as a filler increased from 1.62 to 7.29. This indicates that adding sorghum flour to chicken sausage can increase the intensity of the redness. The content in sorghum seeds, such as tannins, can also influence the increase in red color in chicken sausages. Natural pigments in sorghum, such as polyphenols, flavonoids, or seed coat pigments, interact with the meat protein matrix and, through the cooking process, change the final color of the sausage [8]. This interaction produces a different light reflection compared to sausages without fillers. The increase in redness (a*) is accompanied by a decrease in lightness, which combines to produce a slightly dark or reddish-brown final color.

Based on Table 4, the addition of sorghum sprout flour at different percentages had a very significant effect ($P<0.01$) on the b* color value. This is thought to be due to the particles of sorghum sprout flour and phenolic compounds in the sausage, which can change the color of the dough. This is supported by the statement of [27] that the addition of high-fiber grain ingredients in processed meat products can alter the lightness and yellowness color values. The average b* color value of chicken sausage with added sorghum sprout flour ranged from 14.88 to 21.25. The b* color value in this study showed a decrease compared to the control treatment as the amount of sorghum sprout flour added to the chicken sausage increased. The decreasing b* color value is suspected to be due to the reduced contribution of the natural yellow color from the substituted tapioca flour, as well as the increased dominance of the color of the sorghum sprout flour component, which tends to be duller or more brownish.A lower b* color value means that the addition of sorghum sprout flour makes the color of the sausage slightly darker (less bright than the sausage without sorghum addition). The lower b* color value means that the addition of sorghum sprout flour makes the color of the sausage slightly darker (less bright than sausage without sorghum addition).

4. Conclusion

Based on the research conducted, it was concluded that substituting sorghum sprout flour can improve the chemical and physical characteristics of chicken sausage in terms of protein content, fat content, fiber content, moisture content, water holding capacity, texture, cooking loss, and color analysis. Chicken sausage with 50% sorghum sprout flour substitution showed optimal chemical and physical characteristics, resulting in chicken sausage with good nutritional value, high fiber content, and high protein content

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