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THE EFFECT OF TOFU DUMP SUBSTITUTION ON THE CHEMICAL CHARACTERISTICS AND SENSORY QUALITY OF CHICKEN SAUSAGE

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Abstract

Chicken sausage is a widely consumed processed meat product, but its relatively high production costs and low fiber content encourage the need for innovative formulations based on alternative ingredients. Tofu dregs, a byproduct of the tofu industry, contain vegetable protein and dietary fiber that have the potential to be used as a substitute ingredient in making chicken sausages. This study aims to analyze the effect of tofu dregs substitution on the chemical and organoleptic qualities of chicken sausages. The research method used was a laboratory experiment with a one-factor completely randomized design, namely tofu dregs substitution levels of 10%, 30%, 50%, and 60%. Parameters observed included protein, fat, and carbohydrate levels, as well as organoleptic tests for color, aroma, texture, and taste using a hedonic scale. Chemical quality data were analyzed using ANOVA, while organoleptic data were analyzed nonparametrically. The results showed that tofu dregs substitution affected the chemical quality and organoleptic acceptance levels of chicken sausages. Substitution at certain levels was able to increase fiber content without significantly reducing consumer acceptance. This study shows that tofu dregs have the potential to be used as a substitute ingredient in making chicken sausages to produce a more nutritious and sustainable product.

Keywords: tofu dregs, chicken sausage, substitution, chemical quality, organoleptic test

INTRODUCTION

Chicken sausage is a processed meat product that is highly sought after by the public due to its delicious taste, chewy texture, and practicality in serving (Zulfahmi et al., 2014). In general, chicken sausage is made from ground chicken mixed with binders, spices, and other additives to enhance the taste, texture, and shelf life of the product (Soeparno, 2015). However, the high price of chicken meat often becomes a constraint in the production process, especially for small and medium-scale businesses. This condition encourages the need for innovation in chicken sausage formulations through the use of alternative ingredients that are more economical, while still being able to maintain the quality and nutritional value of the product (Amanah, 2017). One alternative ingredient with the potential to be used as a substitute is tofu dregs. Tofu dregs are solid waste produced from the process of filtering soybean extract in tofu production. Although often considered waste, tofu dregs still contain quite high nutritional content, especially vegetable protein, dietary fiber, and carbohydrates, and contain bioactive compounds such as isoflavones that are beneficial for health (Astawan, 2010). However, to date, the use of tofu dregs in the food industry is still limited and most are only used as animal feed or discarded, thus potentially causing environmental pollution. The use of tofu dregs as a substitute in the manufacture of chicken sausages not only has the potential to reduce production costs but can also increase the nutritional value of the final product, particularly in terms of protein and fiber content. Furthermore, this approach is in line with the principles of *sustainable food processing* and *zero waste* , which emphasize the utilization of food waste into value-added products. Several previous studies have shown that tofu dregs have good potential as a plant-based filler in various processed food products. Putri (2018) reported that substituting tofu dregs in meatball products can increase fiber content and reduce fat content, with a good level of organoleptic acceptance at certain concentrations. Another study by Rahmawati (2020) showed that the addition of tofu dregs to chicken nugget products can increase protein content without significantly reducing consumer acceptance. In addition, Sari and Lestari (2023) stated that the use of tofu dregs flour in cookies *can* increase fiber content and produce sensory characteristics that are still acceptable to panelists. Nida Ul Haq et al. (2025) reported that the combination of fiber-rich plant ingredients and bioactive compounds can produce processed products with good nutritional and organoleptic characteristics, thus having the potential to be applied to various processed food products. Although several studies have reported the potential of tofu dregs as a substitute ingredient in various processed products, research on the use of tofu dregs as a substitute ingredient in chicken sausage products is still very limited. Sausages have different emulsion system and texture characteristics compared to meatballs, nuggets, and *cookies* , so the effect of adding tofu dregs on the chemical and sensory characteristics of chicken sausages requires further research. Substitution of the main ingredient with tofu dregs has the potential to affect the texture, color, taste, and aroma of sausages, which are important factors in consumer assessment. Therefore, further research is needed to evaluate the effect of tofu dregs substitution on protein, fat, and carbohydrate levels as well as the organoleptic quality of chicken sausages through varying concentrations of 10%, 30%, 50%, and 60%, in order to obtain an optimal formulation that has high nutritional value and sensory quality that is still acceptable to consumers. The novelty of this study lies in the use of tofu dregs as a partial substitute ingredient in an emulsion-based chicken sausage formulation with a relatively high substitution level of up to 60%, which is still rarely studied in emulsion sausage products. Unlike previous studies, which generally used limited amounts of tofu dregs and focused solely on chemical aspects, this study integrated chemical characteristics analysis, sensory quality, and determination of the best formulation through effectiveness testing. This comprehensive approach is expected to produce a chicken sausage formulation that not only has better nutritional value and sensory characteristics acceptable to consumers, but also contributes to the innovation of emulsion-based food products and the sustainable use of soybean food waste.

LITERATURE REVIEW

Chicken Sausage

Chicken sausage also has the potential to be developed as a functional food product if formulated with the addition of ingredients rich in nutrients and dietary fiber. The addition of these functional ingredients not only plays a role in increasing the nutritional value of the product but can also provide additional health benefits for consumers. Substituting some chicken sausage ingredients with tofu dregs is a prospective alternative because tofu dregs still contain a significant amount of vegetable protein and dietary fiber. Research on the use of tofu dregs as a substitute ingredient in chicken sausage formulations is important to support the development of local food innovations that are nutritious, environmentally friendly, and in line with the concept of sustainable food processing *(* Afifah, 2024).

Tofu Dregs as a Substitute

Tofu dregs are solid waste produced from the soybean extraction process in tofu production and still possess significant nutritional potential. Recent studies have shown that tofu dregs contain vegetable protein, dietary fiber, and carbohydrates, which play a significant role in increasing the nutritional value of processed food products (Rahmawati et al., 2020). The relatively high fiber content makes tofu dregs a potential substitute for developing healthier food products, as they can help increase fiber intake in modern consumer habits. In addition to contributing to improved nutritional value, utilizing tofu dregs also opens up opportunities for developing more functional and value-added local resource-based food products.

Supporting Ingredients in Making Chicken Sausage

In the food industry, chicken meat is widely used as the main ingredient in various processed products, such as sausages, nuggets, meatballs, and shredded meat. Chicken meat is chosen because of its relatively soft texture, bright color, and neutral flavor, making it easy to process and apply in various product formulations. These characteristics make chicken meat suitable for food products aimed at various consumer groups, including children and the elderly, and it has a high level of acceptance in the community (Putri et al., 2022). Tapioca flour acts as a filler and binder in chicken sausage production, providing texture and increasing the product's structural stability. The starch content in tapioca flour helps produce a chewier and more compact sausage texture during processing and cooking (Wulandari, 2018). Salt is also used to enhance flavor and help develop the sausage's sensory characteristics, although its use needs to be controlled to avoid reducing consumer acceptance due to an overly salty taste (Astawan, 2010). Eggs are used as an additive, acting as a binder and as a source of protein and fat, contributing to the nutritional value of chicken sausage. The presence of eggs also helps maintain a balanced nutritional composition, especially in formulations involving the substitution of tofu dregs for some ingredients (Winarno, 2008). The addition of *garlic powder* aims to enhance the aroma and flavor of the product and contribute bioactive compounds, although used in limited quantities (Winarno, 2008). Granulated sugar is added to balance the flavor of chicken sausages and help improve the texture of the dough. During the heating process, sugar plays a role in the formation of color and aroma through the *Maillard reaction* between reducing sugars and proteins, thereby increasing the sensory appeal of the product (Winarno, 2020; Fellows, 2019). Cooking oil, as a fat source, contributes to the tenderness, *juiciness* , and energy value of chicken sausages and helps balance the nutritional composition of the formulation by substituting tofu dregs (Astawan, 2010).

Chicken Sausage Making Process

The chicken sausage-making process begins by mixing ground chicken with salt and ice cubes. The initial addition of salt aids in the extraction of myofibrillar proteins, while the ice cubes maintain the temperature of the mixture, thus maintaining protein stability during the mixing process. After protein extraction, fillers, fats, and seasonings are gradually added and stirred until a homogeneous and stable emulsion forms. The formed sausage mixture is then placed into *casings* and steamed until the sausage reaches the optimal doneness. The cooking stage plays a crucial role in developing the texture, flavor development, and stabilizing the product's emulsion structure. Therefore, controlling temperature, cooking time, and ingredient composition are key factors determining the physical, sensory, and emulsion stability of chicken sausage (Wulandari, 2018).

Types of Tests in Chicken Sausage Quality Assessment

Chemical Test

Chemical tests were conducted to determine the nutritional value of chicken sausages substituted with tofu dregs, including analysis of protein, fat, and carbohydrate levels. Protein levels were analyzed using the Kjeldahl method by measuring total nitrogen as an indicator of protein content (Sudarmadji et al., 2007). Fat levels were analyzed using the Soxhlet method to determine the fat's contribution to the energy value and texture of the sausage (Winarno, 2008). Meanwhile, carbohydrate levels were determined indirectly using *the carbohydrate by difference method* (Sudarmadji et al., 2007).

Organoleptic Test

Organoleptic testing was used to assess consumer preference for chicken sausage based on color, aroma, taste, and texture. This testing was conducted using a hedonic test with a specific rating scale and involved untrained panelists, thus representing general consumer preferences (Setyaningsih et al., 2010).

Effectiveness Test

Effectiveness testing is used to determine the best treatment based on the achievement of product development objectives and the evaluation results obtained. The concept of effectiveness in the context of product development refers to a *design research framework* that emphasizes the achievement of objectives and the quality of results (Nieveen *et al.* , 2013). In experimental research, the determination of the best formulation is carried out based on a combination of chemical and organoleptic test results to obtain chicken sausages with good nutritional value and a high level of panelist preference (Sugiyono, 2015).

RESEARCH METHODS

This research was conducted for one month, from November to December 2025. The research activities were conducted at the Chemistry Laboratory of the Faculty of Food Technology and Fisheries, Dr. Soetomo University, Surabaya, while chemical quality testing of chicken sausages was conducted at Trunojoyo University, Madura. The research implementation included product formulation stages, the chicken sausage manufacturing process, chemical quality analysis, and organoleptic testing to assess the level of product acceptance. The tools used in this study include a drying oven, microwave, precision digital scales, blender, and electric *steamer* used in the processing and cooking of chicken sausages. In addition, a set of proximate analysis tools was used, including a Soxhlet apparatus for fat analysis, a Kjeldahl apparatus for protein analysis, a convection oven for sample drying, and supporting equipment such as spatulas, measuring cups, pipettes, and *food-grade sausage molds* . Organoleptic testing was carried out with the help of evaluation sheets and panelists.

The main ingredients in this study were chicken meat and tofu dregs, formulated in four substitution treatments: 10%, 30%, 50%, and 60% of the total sausage mixture. The formulations for each treatment were composed of the same additional ingredients, so that differences in product quality could be directly related to the level of tofu dregs substitution. The chemicals used included distilled water and silica gel for water content analysis, organic solvents such as ether or hexane for fat analysis, and Kjeldahl reagent for protein analysis. Crude fiber analysis was performed using strong acid and base solutions in accordance with food quality testing standards. The research method used was a laboratory experiment with a quantitative approach to assess the effect of tofu dregs substitution formulations on the chemical and organoleptic quality of chicken sausages. The study included product formulation, processing, nutritional content analysis, and organoleptic testing by panelists. The data obtained were then statistically analyzed to determine the effect of the treatment on the observed parameters.

The experimental design used was a Completely Randomized Design (CRD) with one factor, namely the concentration of tofu dregs in the chicken sausage dough formulation, consisting of four treatment levels. Each treatment was repeated three times, taking into account relatively homogeneous laboratory conditions, so that the research results still met the requirements for statistical analysis. The research began with the production of chicken sausages using skinless, fatless chicken breast and fresh tofu dregs according to the formulations for each treatment. The manufacturing process included ingredient preparation, grinding and mixing to form a homogeneous emulsion, molding the mixture into *casings* , steaming at approximately 90°C until cooked, and cooling and storing at a cool temperature prior to further analysis. Organoleptic testing was conducted to evaluate the level of consumer acceptance of the attributes of color, aroma, taste, and texture of chicken sausage. The testing used a hedonic test method with a 1–5 rating scale, involving untrained panelists who represented general consumers and were accustomed to consuming sausage products. The hedonic scale assessment of 1–5, including 1 = dislike very much, 2 = dislike, 3 = neutral, 4 = like, 5 = like very much. Non-parametric organoleptic data were analyzed using the Mann-Whitney test to determine differences in the level of preference between treatments. *Statistical Product and Service Solution* (SPSS) software . Parametric chemical data were analyzed using ANOVA, and if significant differences were found, the BNJ test was used. Nonparametric organoleptic data were analyzed using the Mann–Whitney test to determine differences in preference levels between treatments, thus obtaining a comprehensive evaluation of the quality of chicken sausages formulated with tofu dregs substitution.

RESULTS AND DISCUSSION

1. Chemical Test

Fat Content

The results of the analysis of variance (ANOVA) on the fat content of chicken sausages substituted with tofu dregs showed a significance value of 0.001. This value is <0.05, which means there is an effect of tofu dregs substitution on the fat content of chicken sausages. The results of the average fat content of chicken sausages substituted with tofu dregs are presented in Table 1.

Table 1. Average fat content results of chicken sausages

Treatment	Fat Content (%)
A1	$7.36^{a} \pm 0.24$
A2	$8.19^{b} \pm 0.13$
A3	$9.03^{c} \pm 0.20$
A4	$10.23^{d} \pm 0.20$

Differences in fat content of chicken sausages are influenced by the characteristics of tofu dregs which still contain residual fat fractions and dietary fiber with fat-binding ability, so that increasing their concentration in the dough contributes to an increase in the fat content of the final product. Based on Table 1, the results of the ANOVA analysis show that the substitution of tofu dregs has a significant effect on the fat content of chicken sausages ($p = 0.001$; $p < 0.05$). Further tests of BNJ 5% showed significant differences between all treatments, with the fat content increasing from 7.36% in A1 to 10.23% in A4. Sari et al. (2021) reported that the addition of soybean waste-based ingredients to processed meat products significantly increased fat content due to the role of dietary fiber and vegetable protein in forming a network capable of retaining fat during the heating process. Utami and Wahyuni (2022) also explained that the insoluble fiber and residual fat content in tofu dregs contributed to increased fat retention in meat emulsion products as the proportion of substitute ingredients increased. Furthermore, Rahman et al. (2023) showed that increasing the concentration of fibrous vegetable ingredients in chicken sausages and analog sausages caused a significant increase in fat content, but the fat was trapped within the fiber-protein matrix and thus did not exceed the established quality limits. Despite the increase in fat content, the value obtained in this study was still below the maximum limit of SNI 01-3820-1995 of 25%, so that the chicken sausage produced still met national quality standards and had the potential to be developed as a product with a relatively low fat content.

Protein Content

The results of the analysis of variance (ANOVA) on the protein content of chicken sausages substituted with tofu dregs showed a significance value of 0.001. This value is <0.05, which means that there is an effect of tofu dregs substitution on the protein content of chicken sausages. The results of the average protein content of chicken sausages substituted with tofu dregs are presented in Table 2.

Table 2.2 Average results of protein content of chicken sausages

Treatment	Protein Content (%)
A1	$10.62^{a} \pm 0.34$
A2	$11.68^{b} \pm 0.41$
A3	$14.78^{c} \pm 0.18$
A4	$16.70^{d} \pm 0.07$

Differences in protein content in chicken sausages are influenced by the high vegetable protein content in tofu dregs, which still ranges from 20–25% (dry basis), so that increasing the substitution level directly increases the total protein content of the product. Based on Table 2, the results of the ANOVA analysis show that tofu dregs substitution significantly affected the protein content of chicken sausages ($p = 0.001$; $p < 0.05$), with the average protein increasing gradually from 10.62% in treatment A1 to 16.70%

in A4, and all treatments were significantly different based on the 5% BNJ test. The results obtained are in accordance with the research of Putri et al. (2022) who reported that tofu dregs still contain functional protein that can survive the heating process and contribute significantly to increasing the protein content of chicken sausage products. In addition, Wulandari and Santoso (2023) stated that substitution of soy-based ingredients in poultry meat emulsion products increases protein retention efficiency due to the formation of a more stable protein-fiber matrix network during cooking. Recent research by Fauzan et al. (2024) also shows that the use of tofu dregs in chicken sausages significantly increases protein content without reducing sensory quality, thus having the potential to be an economical and functional substitute for animal protein. Referring to SNI 01-3820-1995 which stipulates a minimum protein content of 13% for sausages, treatments A3 and A4 have met the quality standard, while A1 and A2 are still below the minimum limit, so increasing the substitution level of tofu dregs has proven effective in improving the nutritional quality of chicken sausages.

Fiber Content

The results of the analysis of variance (ANOVA) on the fiber content of chicken sausages substituted with tofu dregs showed a significance value of 0.001. This value is <0.05, which means there is an effect of tofu dregs substitution on the fiber content of chicken sausages. The results of the average fiber content of chicken sausages substituted with tofu dregs are presented in Table 3.

Table 3. Average fiber content results of chicken sausages

Treatment	Fiber Content (%)
A1	4.40 ^{a} ± 0.05
A2	3.78 ^{b} ± 0.24
A3	3.34 ^{c} ± 0.06
A4	3.04 ^{d} ± 0.04

Differences in fiber content of chicken sausages are influenced by physical and chemical changes in tofu dregs fiber during thermal processing, particularly steaming, which can cause softening of the cell walls and a decrease in the measured crude fiber fraction. Based on Table 3, the results of the ANOVA analysis show that tofu dregs substitution significantly affected the fiber content of chicken sausages ($p = 0.001$; $p < 0.05$), with the average fiber content decreasing from 4.40% in treatment A1 to 3.04% in A4, and all treatments were significantly different based on the 5% BNJ test. This phenomenon is supported by research by Hapsari et al. (2022) who reported that increasing the proportion of fibrous material in meat emulsion products was not always followed by an increase in the measured crude fiber value, because some of the fiber fraction disintegrated and dissolved during the wet heating process. In addition, Kurniawan and Mulyani (2024) stated that in sausage products based on a mixture of animal and vegetable proteins, the interaction of fiber with denatured protein can form a composite structure that reduces the efficiency of fiber extraction in proximate analysis, so that the measured crude fiber value tends to decrease even though the fibrous material is increased.

Carbohydrate Content

The results of the analysis of variance (ANOVA) on the carbohydrate content of chicken sausages substituted with tofu dregs showed a significance value of 0.001. This value is <0.05, which means that there is an effect of tofu dregs substitution on the carbohydrate content of chicken sausages. The results of the average carbohydrate content of chicken sausages substituted with tofu dregs are presented in Table 4.

Table 4. Average carbohydrate content of chicken sausages

Treatment	Carbohydrate Content (%)
A1	13.61 ^{a} ± 0.43
A2	12.34 ^{b} ± 0.29
A3	8.84 ^{c} ± 0.08
A4	6.01 ^{d} ± 0.18

Differences in carbohydrate content in chicken sausages are not only influenced by the reduced use of starch fillers, but also by changes in the dough matrix composition due to the increased protein and fiber fractions from tofu dregs. Based on Table 4, the results of the ANOVA analysis show that the substitution of tofu dregs significantly affected the carbohydrate content of chicken sausages ($p = 0.001$; $p < 0.05$), with the average carbohydrate content decreasing significantly from 13.61% in treatment A1 to 6.01% in treatment A4, and all treatments were significantly different based on the 5% BNJ test. This decrease in carbohydrate content is related to the reduction in the starch fraction that is easily hydrolyzed during the cooking process, because tofu dregs are dominated by non-starch components such as protein and structural fibers that are relatively stable to heat. Prasetyo et al. (2020) reported that replacing starchy ingredients with non-starch vegetable ingredients in meat emulsion products can reduce the available carbohydrate fraction due to the reduction in starch that undergoes gelatinization during cooking. Similarly, Hidayat and Lubis (2022) stated that the use of soy-based substitutes in sausage formulations contributes to a decrease in carbohydrate content due to the dominance of non-carbohydrate macronutrient components that form a more compact dough matrix. Referring to SNI 01-3820-1995 , which sets a maximum carbohydrate content limit of 8%, only the A4 treatment meets the quality requirements, while the A1–A3 treatments are still above the threshold. This indicates that increasing the proportion of tofu dregs has the potential to produce chicken sausages with low-carbohydrate characteristics that comply with standard requirements.

2. Organoleptic Test

Color

The Kruskal-Wallis organoleptic test results for chicken sausage color showed a significance value of 0.261. This value is >0.05, indicating no significant difference between the tofu dregs substitutions in chicken sausage color. The median chicken sausage color values are presented in Table 5.

Table 5. Organoleptic test results for color parameters

Treatment	Color Median
A1	4 ^{a} ± 0.73
A2	4 ^{a} ± 0.66
A3	4 ^{a} ± 0.72
A4	4 ^{a} ± 0.77

The absence of a significant color difference in chicken sausages with tofu dregs substitution is due to the characteristic color of tofu dregs which tends to be yellowish white and is relatively similar to the basic color of chicken meat, so it does not create a real visual contrast in the final product. Based on Table 5, the median color value of all treatments (A1–A4) is at a score of 4 with the same letter notation, and the results of the Kruskal–Wallis test show a significance value of 0.261 ($p > 0.05$), which indicates that the variation in the level of tofu dregs substitution does not significantly affect the level of panelists' preference for the color of chicken sausages. The same result was obtained from the study Ananda et al. (2021) reported that the addition of neutral-colored plant-based ingredients to processed poultry products did not significantly alter consumer color perception. Furthermore, Wijayanti and Laksmi (2023) stated that the use of soy-based substitutes in chicken sausages tends to maintain product color because the natural pigments in these ingredients do not undergo intensive browning during the cooking process.

Flavor

The Kruskal-Wallis organoleptic test results for chicken sausage flavor parameters showed a significance value of 0.295. This value is >0.05, indicating no significant difference between the tofu dregs substitutions in chicken sausage flavor. The median chicken sausage flavor scores are presented in Table 6.

Table 6. Organoleptic test results for taste parameters

Treatment	Median Taste
A1	$4^{a} \pm 0.81$
A2	$4^{a} \pm 0.96$
A3	$4^{a} \pm 0.73$
A4	$4^{a} \pm 0.93$

The absence of a significant difference in taste between chicken sausages with tofu dregs substitution is due to the neutral (*bland*) taste characteristics of tofu dregs, so it does not dominate or change the distinctive taste of chicken meat in the final product. Based on Table 6, the median taste score for all treatments (A1–A4) was at a score of 4 with the same letter notation, and the Kruskal–Wallis test results showed a significance value of 0.295 ($p > 0.05$), indicating that variations in the level of tofu dregs substitution did not significantly affect the level of taste preference of chicken sausages. These results are supported by research by Pratama and Lestari (2021) which stated that the use of soy-based substitutes in poultry meat emulsion products did not cause significant changes in taste attributes due to the relatively neutral sensory characteristics of soy. Furthermore, Yuliana et al. (2022) reported that plant-based fillers without dominant volatile compounds were able to maintain the flavor intensity of processed meat products, so that consumer acceptance was maintained even though some of the main ingredients were substituted.

Texture

The Kruskal-Wallis organoleptic test results for chicken sausage texture parameters showed a significance value of 0.575. This value is >0.05, indicating no significant difference between the tofu dregs substitutions in chicken sausage texture. The median chicken sausage texture values are presented in Table 7.

Table 7. Organoleptic test results for texture parameters

Treatment	Median Texture
A1	$4^{a} \pm 0.81$
A2	$4^{a} \pm 0.72$
A3	$4^{a} \pm 0.73$
A4	$4^{a} \pm 0.77$

The absence of significant differences in texture in chicken sausages with tofu dregs substitution indicates that tofu dregs fiber still functions physically in forming the product structure, although some fiber fractions experience changes due to the heating process. Based on Table 7, the median texture value of all treatments (A1–A4) is at a score of 4 with the same letter notation, and the results of the Kruskal–Wallis test show a significance value of 0.575 ($p > 0.05$), which indicates that variations in tofu dregs concentration do not have a significant effect on the texture of chicken sausages. This condition indicates that tofu dregs fiber is still able to bind water and fat and plays a role in the formation of a relatively stable protein matrix, so that the sausage texture remains compact and acceptable to panelists. Similarly, Sania (2023) reported that the addition of fibrous plant materials to poultry meat emulsion products does not always reduce texture quality because the fiber functions as a natural *texturizing agent* . In addition, Pramudya and Lestari (2024) stated that the interaction between denatured meat protein and vegetable fiber is able to form a stable three-dimensional network, so that variations in the concentration of substitute ingredients do not have a significant effect on the texture perception of sausage products.

Aroma

The organoleptic test results using the Kruskal-Wallis method on the aroma parameter of chicken sausage showed a significance value of 0.012. This value is <0.05, indicating a significant difference between the tofu dregs substitutions in the aroma of chicken sausage. The median aroma values for chicken sausage are presented in Table 8 .

Table 8. Organoleptic test results for aroma parameters

Treatment	Median Aroma
A1	$4^{a} \pm 0.69$
A2	$3.5^{ab} \pm 0.78$
A3	$4^{b} \pm 0.72$
A4	$3.5^{b} \pm 0.86$

The significant difference in aroma in chicken sausages is due to the emergence of a distinctive soybean aroma (*beany flavor*) from tofu dregs which becomes more intense as the substitution level increases. Based on Table 8, the results of the Kruskal–Wallis test show a significance value of 0.012 ($p < 0.05$), which indicates that the substitution of tofu dregs has a significant effect on the aroma attributes of chicken sausages. Treatment A1 has the highest median aroma with the notation *a* , while treatments A3 and A4 show different letter notations (*b*), indicating that at higher concentrations of tofu dregs, panelists begin to detect a clear difference in aroma. Halim and Nugroho (2022) also reported that increasing the proportion of soybean ingredients and their derivatives in processed meat products can produce volatile compounds such as *hexanal* and *2-pentylfuran* which strengthen the characteristic unpleasant aroma of soybeans after heat treatment. In addition, Sari and Utami (2023) stated that the substitution of high-fiber vegetable ingredients in emulsified meat products can strengthen the perception of soybean aroma due to the mild oxidation reaction of soybean protein and lipids during heating, which produces different volatile constituents compared to products without substitution.

3. Determining the Best Treatment

Effectiveness testing was conducted to determine the best and most preferred treatment based on all physicochemical and organoleptic parameters. The test results in Appendix 17 indicate that the best treatment was characterized by the highest yield (NH) value, while the average NH for all effectiveness test parameters is presented in Table 9.

Table 9. Effectiveness Test Calculation

Parameter	Weight	Weight Value	NH (A1)	NH (A2)	NH (A3)	NH (A4)
Protein	9	0.18	0	0.079	0.126	0.18
Fat	8	0.16	0	0.08	0.125	0.16
Flavor	7	0.14	0.14	0.14	0	0
Aroma	7	0.14	0.14	0.14	0.14	0
Texture	6	0.12	0.12	0.12	0	0
Carbohydrate	5	0.1	0	0.044	0.09	0.1
Water	4	0.08	0.08	0.049	0.027	0
Ash	4	0.08	0.08	0.065	0.022	0
TOTAL	50	1	**0.560**	**0.717**	**0.530**	**0.440**

Based on the effectiveness test of the De Garmo method, treatment A2 was determined as the best formulation with an effectiveness value of 0.717, because it was able to balance the increase in nutritional value and sensory acceptance optimally. Although treatment A4 had the highest protein and fat content (10.68% and 8.65%), a significant decrease in organoleptic parameters caused its effectiveness value to be low (0.440). Physicochemically and sensorially, treatment A2 showed a proportional increase in protein and fat without disturbing the structure and taste of the product, with a median organoleptic score of 4, so it was at the most optimum formulation point and worthy of further development. Figure 1 shows the condition of the chicken sausage mixture made from mixing ground chicken with tofu dregs, as well as the appearance of the chicken sausage as a finished product after cooking. The visual differences between the mixture and the cooked sausage illustrate the changes in structure and texture that affect the physical and organoleptic qualities of the product.

Figure 1. Chicken Sausage

CONCLUSION

Based on the results of the analysis and discussion of the research, it can be concluded that treatment A2 is the most optimal chicken sausage formulation with tofu dregs substitution, marked by the highest effectiveness value of 0.717 compared to other treatments. This formulation is able to achieve an ideal balance between nutritional quality, especially in protein and fat content, with maintained sensory characteristics, indicated by the median organoleptic score at the maximum level (score 4). Increasing the substitution of tofu dregs in treatments A3 and A4, although increasing nutritional value, has a less than optimal impact because it reduces panelist acceptance, especially in texture and taste. Therefore, formulation A2 is recommended as the best choice because it provides increased nutritional value from tofu dregs with structural quality and sausage flavor that are still well accepted by consumers.

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