MOISTURE CONTENT, TEXTURE, AND SENSORY PROPERTIES OF CHICKEN SAUSAGE WITH TEMPEH FLOUR, ARROWROOT FLOUR AND CARRAGEENAN SUBSTITUTION

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ABSTRACT

Sausage is a processed minced meat product with added fillers, emulsifiers, and flavor enhancers. In line with the trend of reducing low-fat consumption, many animal-based products are being partially or completely substituted with plant-based ingredients. This study aims to formulate and characterize sausages by adding tempeh flour as the main meat substitute protein and arrowroot flour as a filler with five percentage ratios (0:80; 20:60; 40:40; 60:20; 80:0) to the total dough. The study used a completely randomized design with one factor and analyzed the texture, moisture content, and sensory data using descriptive statistical methods. The results showed that the higher the tempe flour substitution, the more brittle the texture became. Conversely, the higher the arrowroot flour content, the higher the firmness value. Based on sensory tests for taste, color, and overall texture, sausages with the highest proportion of arrowroot flour were actually preferred.

KEYWORDS arrowroot flour, carrageenan, sausage, tempeh flour

INTRODUCTION

Sausage is a processed meat product that is quite popular among the public, mainly as a source of protein for main dishes or as a snack. Sausage is made from minced meat with added fillers such as flour or starch, spices, and other ingredients, which are stuffed into casings and then steamed or boiled. The main protein source in sausages is generally chicken, beef, or even fish. However, with the health trend linking high-fat and high-cholesterol animal products to several diseases, many substitutions and nutritional enrichments have been made in sausage products. Some plant-based protein ingredients that have been used include red beans (Pinardi et al., 2020), tofu pulp (Kurniawan et al., 2023), and oyster mushrooms (Karyantina et al., 2025).

Indonesia is the world's largest producer of tempeh, with an average consumption rate of 6.45 kg per person per year (Larasati et al., 2017). Several reasons support this, including abundant availability, affordable prices, a texture similar to meat, and public awareness of balanced nutrition and tempeh as a potential source of plant-based protein. The main nutritional content of tempeh is protein, which reaches 20.8 g per 100 g of tempeh with various essential amino acids (Sifera et al., 2022). Due to tempeh's limited shelf life caused by continuous fermentation, it is now commonly processed into tempeh flour, which is expected to serve as an alternative in the production of various wheat-based food products. Because of its meat-like texture, tempeh has been widely used as a meat analog, especially for vegetarians (Amalia, 2020).

In addition to protein as the main ingredient, sausages also require fillers that act as water binders to create a good emulsion (Purwosari, 2016). Flour or starch such as corn flour, rice flour, and generally tapioca flour are commonly used in sausages (Ashari et al., 2023). Diversification is needed to increase the variety and utilization of local food ingredients as fillers in sausages, in addition to enriching their nutritional content. In Indonesia, there is a local tuber that is currently popular and can be used as a source of fiber and functional ingredients, namely arrowroot flour (Maranta arundinacea), which contains starch and soluble fiber that can expand, helping to retain water and increase the viscosity of the dough. This is due to the high amylopectin content in arrowroot flour. The branched structure of amylopectin allows for higher water binding and encapsulation, resulting in strong water-binding capacity in processed products. Additionally, arrowroot contains starch that can gelatinize at low temperatures, has high solubility, and swelling power, thereby influencing viscosity increase (Malki et al., 2023).

The use of a combination of both ingredients, namely tempe flour and arrowroot flour, in sausages, especially when added with carrageenan hydrocolloid, is still very limited. Therefore, this study aims to formulate chicken sausage with tempe flour and arrowroot flour substitution and analyze the physical characteristics in the form of texture profile, namely hardness and chewiness, moisture content analysis, and sensory characteristics in the form of taste, color, and overall texture of the resulting sausage product.

RESEARCH METHOD

Time and Location of Research

The research was conducted at the Agribusiness Laboratory of Duta Bangsa University Surakarta from March to July 2025.

Tools and Materials

The materials used in this research were chicken meat, arrowroot flour, tempeh flour, carrageenan, ice cubes, ground pepper, granulated sugar, garlic, salt, powdered chicken stock, cooking oil, and sausage casings. The tools used in this research were a chopper, digital scale, stove, pot, bowl, spoon, knife, and cutting board.

Sausage Production Process

The sausage production process begins with grinding chicken meat mixed with ice cubes in the following proportions: 1 kg of meat and 300 g of ice cubes. The mixture is then divided into 10 portions for 5 formulations and 2 sample replicates (@100 grams of meat). Each treatment is added with seasonings consisting of 0.5 g of ground pepper, 2 g of granulated sugar, 4 g of garlic, 1.5 g of salt, 0.8 g of powdered broth, as well as tempeh flour, arrowroot flour, and carrageenan according to the formulation (Table 1). After

mixing thoroughly, 8 g of cooking oil was added. The mixture was put into sausage casings, tied every 3 cm, and steamed for 30 minutes.

Table 1. Sausage Production Formulation

Filler	Persentage (%)				
	A	B	C	D	E
Carragenan	8	8	8	8	8
Tempeh Flour	0	20	40	60	80
Arrowroot Flour	80	60	40	20	0

Moisture Content Analysis

An empty porcelain dish is heated in an oven at 105°C for 30 minutes, then cooled in a desiccator and weighed. A 2-gram sample in the dried dish is weighed, then heated in an oven at 105°C for 6 hours. After the dish is removed from the oven, it is cooled in a desiccator for 30 minutes. The drying process is repeated until a balanced weight of the material is obtained. The percentage of moisture content can be calculated using the formula: (Ismanto et al., 2020)

Moisture content (%) = (final sample weight - initial sample weight) / initial sample weight 100%

Texture Analysis

Physical texture characteristics such as hardness and chewiness were tested using a texture analyzer (Loyd type No. 01/TALS/LXE/EU, UK) with a 35 mm diameter cylinder probe, a sample thickness of 1.6 cm, a test speed of 0.1 mm/s, a compression level of 50%, and a wait time of 0.5 s (Apriantini, 2021).

Sensory Characteristics Analysis

Sensory analysis was conducted to determine the quality of the sausage by involving the use of human senses (sight, taste, smell) to determine the level of acceptance of the sausage product. Sensory analysis was conducted on 30 panelists, involving hedonic sensory responses to the overall attributes of taste, color, and texture with values ranging from 1 to 5, with the smallest number (1) indicating a very negative assessment. Sensory testing was conducted on 30 panelists, including hedonic sensory responses for the attributes of taste, color, and texture as a whole, with scores ranging from 1 to 5, where the smallest number (1) indicates a rating of "dislike" and the number (5) indicates a rating of "like very much" (Ismanto et al., 2020).

Data Analysis

The study used a completely randomized design consisting of one factor, namely the ratio of arrowroot flour to tempe flour (0:80; 20:60; 40:40; 60:20; 80:0), with two replicates. The results of the moisture content, texture, and sensory tests were analyzed using descriptive statistics.

RESULT AND DISCUSSION

The sausages resulted from this study are shown in Figure 1. Overall, the sausages produced have a dense and compact appearance and varied colors, but tend to be normal. Based on SNI No. 3820 concerning sausages, the quality requirements for meat sausages are that they should be of normal color, i.e., not bright red and not too pale (BSN, 2015). The compact texture is produced by a good emulsification process and is also influenced by the presence of a hydroloid component in the form of carrageenan, which has many

functions. According to Indarti & Ismawati, carrageenan in chicken sausages acts as a gel former, emulsifier, maintains product stability, and improves product texture.

Figure 1. Sausages with Various Treatments Comparing Garut Flour and Tempe Flour (Description: A = 0% tempeh flour + 80% garut flour, B = 20% tempeh flour + 60% garut flour, C = 40% tempeh flour + 40% garut flour, D = 60% tempeh flour + 20% garut flour, and E = 80% tempeh flour + 0% garut flour)

Moisture Content and Texture

The moisture content of the sausage is in the range of 35-45%, which means that it also meets the maximum moisture content standard for meat sausages according to SNI, which is 67% (BSN, 2015). The high moisture content in the sausage comes from the water content of the raw material, namely meat. Chicken meat has a moisture content of 70-75%. The water in the mixture is bound and trapped by arrowroot starch and carrageenan. Starch has amylose and amylopectin components which, when added to water, cause the starch granules to absorb and swell, thereby affecting the moisture content of the product (Ismanto et al., 2020). Carrageenan, as a hydrocolloid, also has the ability to form a gel where polymer chains form a connected three-dimensional mesh structure, which then traps water inside and forms a strong and rigid structure (Gani et al., 2014). The increase in moisture content can also be caused by the ability of tempeh fiber and protein to bind more water (Hasibuan et al., 2024).

The texture of the sausage analyzed includes the level of hardness and the level of chewiness, which is close to deformation or change in shape. The more arrowroot flour added, the more chewy and sticky the chicken sausage will be. This is because arrowroot flour contains starch that contains amylose and amylopectin at 24.64% and 75.36%, respectively (Mawarni et al., 2025). The chewiness mainly comes from amylopectin, which has strong stickiness. The higher the amylopectin, the more chewy the product will be. These results are in line with the research by Yuniar & Azizah, 2021, which found that sausages with more starch added as a filler are more chewy.

Table 2. Moisture Content and Texture Profile of Chicken Sausages with Various Treatments

Parameter	Ratio of Garut Flour : Tempeh Flour				
	A	B	C	D	E
Moisture content (%)	40,75	42,14	35,15	40,85	45.54
Hardness (N)	164, 36	83,17	37,29	34,73	35,76
Chewiness (N)	60,23	39,56	13,15	11,62	11,43

Description A = 0 tempeh flour + 80 garut flour, B = 20 tempeh flour + 60 garut flour, C = 40 tempeh flour + 40 garut flour, D = 60% tempeh flour + 20% arrowroot flour, and E = 80% tempeh flour + 0% arrowroot flour)

When it is related to the water content, sausages with too high water content can reduce elasticity and make the texture softer or more fragile, thus affecting the panelists'

level of preference. This is what happened to sausages with the highest addition of tempeh flour, which had a water content of 45.54%.

Sensory Characteristics

The results of sensory analysis are shown in Table 3. Overall, all parameters ranged from 2.66 to 4.06. This means that each treatment affected the sensory quality attributes. The same trend was observed for the parameters of taste, color, and overall texture, where the more tempeh flour was added, the lower the panelists' ratings (disliked). The expected texture for sausages is chewy and elastic, which was not the case for sausages with increasing amounts of tempeh flour. The unpleasant taste of sausages with added tempeh flour may originate from the natural flavor profile of tempeh, where soybeans as raw materials contain compounds such as glycosides, saponins, and estrogens, which are off-flavor compounds that impart a bitter taste (Pemilia et al., 20219).

Table 3. Sensory Characteristics of Chicken Sausages with Various Treatments

Parameter	Ratio of Garut Flour : Tempeh Flour				
	A	B	C	D	E
Taste	3,30 ± 1,04	3,03 ± 1,19	3,00 ± 1,21	3,00 ± 1,06	2,96 ±1,08
Color	3,60 ± 1,05	3,43 ± 1,08	3,26 ± 1,20	3,00 ± 1,34	2,66 ± 1,16
Texture	4,06 ± 0,81	3,76 ± 0,95	3,46 ± 1,11	3,16 ± 1,27	2,86 ± 1,20

Note: values = mean + standard deviation with two sample replicates (A = 0% tempe flour + 80% garut flour, B = 20% tempe flour + 60% garut flour, C = 40% tempe flour + 40% garut flour, D = 60% tempe flour + 20% arrowroot flour, and E = 80% tempe flour + 0% arrowroot flour)

The increasingly intense color was derived from the natural pigments in tempeh and the Maillard reaction during processing, where the high protein content of tempeh contributed significantly to the final color of the product. Larasati et al. (2023) stated that an increase in plant protein increased color intensity but did not always increase panelist acceptance because consumer visual expectations greatly influenced sensory perception.

CONCLUSION

The difference in the concentration of tempe flour as a meat substitute protein and arrowroot flour as a filler affects the moisture content, hardness, chewiness, and sensory characteristics of the chicken sausage produced. The addition of tempe flour affects the hardness level in relation to the increasing moisture content. Increasing the amount of arrowroot flour results in higher chewiness due to the amylose and amylopectin it contains. This texture affects the panelists' liking level, as well as the off-flavor compounds contained in tempeh, which make the chicken sausage less appealing.

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