JAPSI (Journal of Agriprecision and Social Impact)
Volume 3 Issue 2 July 2026
e-ISSN: 3032-7849; p-ISSN: 3046-5397, Page 212-231
DOI: https://doi.org/10.62793/japsi.v3i2.111
Available online at: https://journal.kdp.co.id/index.php/japsi

Effect of Beef Liver Addition on the Physicochemical and Color Characteristics of Chicken Patties

Dedes Amertaningtyas
Department of Animal Science, Faculty of Animal Science Brawijaya University

Kiki Nila Agustin
Study Program of Animal Science, PSDKU Universitas Brawijaya Kediri, Indonesia

Jessica Aprilia
Study Program of Animal Science, PSDKU Universitas Brawijaya Kediri, Indonesia

Address: Jl. Veteran, Malang, East Java, Indonesia
Corresponding author: dedesfptub@ub.ac.id

Abstract. *This study aimed to determine the effect of different levels of beef liver addition on the nutritional, physicochemical, and color characteristics of chicken patties. Beef liver, an underutilized animal by-product with high nutritional value, was incorporated at different levels (0%, 20%, 40%, and 60%) into chicken patty formulations. The experiment was conducted using a Completely Randomized Design with four treatments and five replications. The collected data were analyzed using analysis of variance (ANOVA) and followed by Duncan's Multiple Range Test (DMRT). The results showed that the addition of beef liver had no significant effect (P>0.05) on protein content, water activity (aw), and b* values, but had a highly significant effect (P<0.01) on moisture content, fat content, cooking loss, texture, and color characteristics (L* and a*). Increasing beef liver levels improved the nutritional profile and modified the physical and visual characteristics of the patties. These findings demonstrate the potential of beef liver as a value-added functional ingredient for developing nutritious chicken patties while promoting the sustainable utilization of underutilized livestock by-products.*

Keywords: *Beef liver, Chicken patties, Functional ingredients, Meat by-products, Physicochemical properties*

Received: May 12, 2026 ; Accepted: June 27, 2026 ; Published: July, 11 2026
*Corresponding author, e-mail address dedesfptub@ub.ac.id

INTRODUCTION

Meat is an important source of animal protein due to its complete and balanced essential amino acid composition. Meat is generally classified into two categories, namely white meat, such as chicken, duck, and fish, and red meat, such as beef, buffalo, and goat (Susanti et al., 2022). Broiler chicken is one of the most widely consumed sources of animal protein in Indonesia. According to data from the Central Statistics Agency, broiler chicken consumption in 2025 is projected to reach 7.76 kg per capita, representing an increase of 6.68% compared to 2024, and is expected to further increase by 5.19% in 2026 (Central Statistics Agency, 2025). This increase is driven by growing public awareness of the importance of animal protein and rising purchasing power (Fauzi and Wijaya, 2021). Chicken meat, particularly broiler meat, is highly nutritious, containing approximately 74–75% water, 22–23% protein, and relatively low fat (Gultom et al., 2023). Additionally, broiler meat is easy to process and can be combined with other food ingredients (Afiyah, 2022). However, chicken meat is classified as a perishable food due to its high moisture and protein contents, which provide an ideal medium for microbial growth (Siregar et al., 2021). Therefore, processing methods are required to improve shelf life and increase product value, one of which is through restructured meat technology (Ramadhani et al., 2020).

Restructured meat technology is a meat processing method involving cutting, grinding, and reforming to produce products with specific structures and shapes (Patel et al., 2023). This technology aims to improve texture, increase value-added benefits, and produce more appealing and practical products (Febriansyah et al., 2023). In line with changing consumer trends, where consumers increasingly prefer convenient products with longer shelf life, the consumption of processed meat products, particularly restructured meat, continues to increase (Muzayyanah et al., 2022). In addition, growing consumer awareness of health, nutrition, and sustainability has increased demand for functional meat products with enhanced nutritional value and health-promoting properties. Recent studies have highlighted the potential of incorporating meat by-products into processed meat products as a strategy to improve resource utilization, reduce waste, and develop value-added products within a sustainable food system (Leite et al., 2026). Furthermore, consumers have shown increasing interest in meat products enriched with functional ingredients, vitamins, minerals, and dietary fiber that offer additional health benefits beyond basic nutrition (Stanišić et al., 2025). One of the most popular restructured meat products is chicken patties, which are processed ground meat products formed into flat patties and commonly used as burger fillings (Nuhriawangsa et al., 2021). Chicken patties are made from a mixture of meat, binding agents, fillers, and seasonings (Khoirunnisa et al., 2022). This product offers advantages in terms of convenience and broad consumer acceptance. However, chicken patties still have several drawbacks, such as low fiber content, unappealing color, susceptibility to rancidity, and nutritional quality that needs improvement (Evanuarini et al., 2023). One approach to improving the quality of chicken patties is the incorporation of nutritionally rich ingredients, one of which is beef liver.

Beef liver is a meat by-product rich in protein, vitamins, and minerals. It contains approximately 19.8% protein, 3–4% fat, and various vitamins such as vitamin A, B-complex vitamins, and vitamin B12, as well as minerals, particularly iron (Akhter et al., 2022). Iron and vitamin B12 play a crucial role in red blood cell formation, thereby helping to prevent anemia (Kusnadi, 2021; Basar et al., 2024). Additionally, beef liver has a darker color and distinctive flavor, making it a potential enhancer of sensory characteristics, particularly color and taste in patties. Although several studies have evaluated the incorporation of animal by-products and poultry liver in processed meat products, limited information is available regarding the use of beef liver in chicken patties and its effects on nutritional, physicochemical, and color characteristics. Therefore, the novelty of this study lies in the utilization of beef liver as an underutilized livestock by-product and value-added functional ingredient in chicken patties. This approach may improve product quality while supporting the sustainable utilization of meat by-products.

Based on the above, this study aims to evaluate the quality of chicken patties with the addition of beef liver, assessed through physical and chemical parameters, including moisture content, water activity, cooking loss, texture, as well as protein, fat, and color (L*, a*, b*) content.

LITERATURE REVIEW

Chicken patties are one of the processed meat products based on restructured meat technology that have been widely developed due to their practicality, ease of consumption, and high economic value and diversification potential. Restructured meat products are produced through a process of grinding and mixing meat with specific additives to achieve a more uniform product shape, texture, and characteristics. The development of chicken patties has increased along with the rising consumption of broiler chicken meat in Indonesia, supported by its relatively affordable price, high protein content, and versatility in processing into various food products. Broiler chicken meat has good nutritional content, including high protein, low fat, and a complete set of essential amino acids. The nutritional composition of broiler chicken meat consists of approximately 75% moisture, 22–23% protein, and relatively low fat (Rukmini et al., 2019). However, chicken meat is highly susceptible to spoilage due to its high moisture and protein contents, thereby requiring further processing to improve product stability and extend shelf life. One form of processing that has been widely developed is chicken patties because they are practical and well-received by consumers (Nuhriawangsa et al., 2021).

Nevertheless, chicken patties still have several drawbacks, such as a less firm texture, pale color, susceptibility to rancidity, and nutritional quality that still needs improvement (Evanuarini et al., 2023). Therefore, the incorporation of functional ingredients is needed to improve the physical, chemical, and visual qualities of the product. One potential ingredient that can be utilized is beef liver, a meat by-product rich in protein, iron, vitamin A, vitamin B12, and minerals. Beef liver contains approximately 19.8 g of protein per 100 g and has relatively low fat content, making it a promising ingredient for enhancing the nutritional value of processed meat products (Suryaningsih et al., 2017). The addition of beef liver to chicken patties is known to influence the product's nutritional, physical, and color characteristics. Research by Choi et al. (2017) showed that adding liver to hamburger patties can increase protein content and reduce fat content. Additionally, Douglas et al. (2024) reported that the incorporation of animal organs into patties can influence the texture and color characteristics of the final product.

The physical characteristics of chicken patties are strongly influenced by the ability of the ingredients to bind water and maintain emulsion stability during cooking. The addition of beef liver may increase the water content of chicken patties due to its relatively high moisture content and soft tissue structure, which facilitate water retention within the product matrix. These conditions contribute to reduced cooking loss during cooking and result in a softer texture. Additionally, additives such as tapioca flour and skim milk powder also play a role in enhancing the product's water-binding capacity and emulsion stability (Chatterjee et al., 2019). Color characteristics are also a key factor in determining consumer acceptance of chicken patties. The CIE Lab* color system was used to evaluate the lightness, redness, and yellowness of the product. The addition of beef liver is known to decrease the L* value and increase the a* value due to the high myoglobin content of beef liver, while the b* value tends to remain relatively stable. Heme pigments, particularly myoglobin, play an important role in the formation of the dark red color in processed meat products (Erlina et al., 2021). Based on these various studies, the addition of beef liver to chicken patties has the potential to improve the product's nutritional, physical, and visual quality. The use of beef liver as a substitute ingredient also serves as an alternative for developing high-value-added processed meat products and supports the optimal utilization of meat by-products.

RESEARCH METHODS

This study was conducted at the Physical Chemistry Laboratory of Animal Product Technology, Faculty of Animal Science, Brawijaya University, Malang, as well as the Product Processing Laboratory and the Bioscience Laboratory of Brawijaya University PSDKU Kediri from October to December 2025. Additional testing was conducted at the Food Quality and Safety Testing Laboratory, Faculty of Agricultural Technology, Brawijaya University, Malang. The research material consisted of chicken patties made from broiler breast meat with the addition of beef liver at various concentrations. The main ingredients used included broiler breast meat and fresh beef liver obtained from traditional markets in Malang. Supporting ingredients consisted of tapioca flour (Rose Brand), salt (Kapal), pepper (Ladaku), onion, garlic, and egg whites. The main equipment used in sample preparation included a food chopper, an analytical balance, molds, a stove, and cooking utensils. The analytical equipment used included an oven (105°C) for moisture content analysis, a water activity meter (WA 160A) for water activity, a water bath for cooking loss testing, a texture analyzer (Texture Analyzer TXT) for texture testing, a Kjeldahl apparatus for protein analysis, a Soxhlet apparatus for fat analysis, and a color reader for color measurement (L*, a*, b*). The research method used was an experimental design with a completely randomized design (CRD) consisting of four treatments and five replicates. The experimental units were randomly assigned to the four treatment groups using a Completely Randomized Design (CRD), with five independent replications for each treatment. The HS0 treatment (0% beef liver) served as the control group. The treatments applied were HS0 (no beef liver added), HS1 (20% beef liver and 80% chicken meat), HS2 (40% beef liver and 60% chicken meat), and HS3 (60% beef liver and 40% chicken meat). The beef liver inclusion levels of 20%, 40%, and 60% were selected based on preliminary trials and previous studies on the incorporation of liver into processed meat products. These levels were chosen to represent low, medium, and high substitution levels while maintaining the structural integrity and processability of chicken patties.

Chicken Patties Preparation

The preparation procedure for chicken patties with beef liver addition was modified from Inayah et al. (2024). Chicken breast meat and beef liver were washed under running water. Beef liver was then boiled at 100°C for 5 min and chopped using a chopper to obtain a coarse texture. Garlic and onion were peeled and chopped separately, while chicken meat was cut into small pieces and ground using a chopper. The ground chicken meat was mixed with tapioca flour, skim milk powder, garlic, onion, salt, pepper, egg white, and beef liver according to the treatment concentrations of 0%, 20%, 40%, and 60%. The mixture was homogenized and formed into patties with a thickness of approximately 2 cm. The patties were stored in a freezer for 1 h and subsequently cooked using the shallow frying method at 70°C following a modified procedure from Inayah et al. (2024). This temperature was selected to minimize excessive moisture loss and preserve product quality during cooking.

Moisture Content using the Gravimetric Method (AOAC, 2005)

Moisture content was determined using the thermogravimetric method based on AOAC (2005). The principle of this method is to measure the weight loss of the sample due to water evaporation during heating at 105 °C until a constant weight is reached. An empty dish was heated at 105 °C for 24 hours, cooled in a desiccator, and weighed (W_0). Approximately ±2 g of sample was weighed into the dish (W_1), then dried in an oven at the same temperature for 6 hours. After cooling again in a desiccator, the dish and its contents were weighed (W_2).

The moisture content (%) is calculated using the formula: $\frac{w1-w2}{w1-w0} \times 100\%$

Protein Content Using the Kjeldahl Method (AOAC, 2005)

The test begins by weighing 0.1–0.5 g of the sample, followed by digestion in a Kjeldahl flask until the solution becomes clear. After cooling, the solution is diluted and NaOH is added, followed by distillation. The distillate is collected in a boric acid solution to which an indicator has been added, then titrated using 0.02 N HCl until the color changes to pink. Next, the protein content is calculated using the formula:

$$\text{Protein Content (\%)} = \frac{(VA-VB)HCl \times N\ HCl \times 14{,}007}{W\ sampel \times 1000} \text{ x } 100\%$$

Remarks:
VA = mL of HCl used for sample titration
VB = number of mL of NaOH for the blank
N = normality of the standard HCl used
14.007 = atomic weight of nitrogen
W = sample weight in grams

Fat Content Using the Soxhlet Method (AOAC, 2005)

After the moisture content test, 2 g of the sample is weighed, then wrapped and extracted using a Soxhlet apparatus with petroleum ether as the solvent. Once the extraction process is complete, the solvent is evaporated and the fat residue is dried to a constant weight, then weighed. The difference in weight is used to calculate the fat content using the appropriate formula:

$$\text{Fat Content (\%)} = \left(\frac{C-A}{B}\right) \times 100\%$$

Remarks:
A = weight of the empty round-bottom flask (g)
B = weight of the sample (g)
C = weight of the round-bottom flask and extracted fat (g)

Water Activity (AOAC, 2005)

Water activity (aw) was measured according to the AOAC (2005) method by weighing 5 g of the sample, cutting it into small pieces, and placing it in the aw meter container. The sample was measured until the instrument displayed a stable value, and the aw result was recorded.

Cooking Loss (Berky, 2024)

The cooking loss test was performed by weighing a 30 g sample, placing it in a polyethylene bag, and sealing it tightly. The sample was then cooked in a water bath at 80°C for 60 minutes, cooled under running water, and reweighed until a constant weight was reached. The cooking loss value was calculated using the formula: Cooking loss (%) = $\frac{X-Y}{X}$

Remarks:

X: weight of the sample before cooking (g)
Y: weight of the sample after cooking (g)

Texture (Khotimah et al., 2024)

The sample was cut into 3 cm cubes, then tested using a probe that had been installed and calibrated. The device was set to zero before testing began. The sample was then tested until the probe pressed down and returned to its initial position. The test results were displayed in the form of graphs and numerical values as texture parameters.

CIE Lab* Color (Fadlilah et al., 2022)

Color measurements were performed using the CIE-Lab method with a color reader, which includes the parameters L* (luminance), a* (redness), and b* (yellowness). The sample is placed in a dish lined with clear plastic, and measurements are taken by pressing a button on the device until the L*, a*, and b* values are obtained. Measurements are taken three times for each treatment to ensure accurate results.

RESULTS AND DISCUSSION

The effects of different levels of beef liver addition on the physical and color characteristics of chicken patties, including water activity, cooking loss, texture, lightness (L*), redness (a*), and yellowness (b*), are presented in Table 1**.**

Table 1. Physical and Color Characteristics of Chicken Patties with Different Levels of Beef Liver Addition

Parameters	Treatments			
	HS0	HS1	HS2	HS3
Water Activity	0.855 ± 0.02	0.850 ± 0.01	0.835 ± 0.04	0.858 ± 0.03
Cooking Loss (%)	25.71 ± 0.02^{a}	15.40 ± 0.01^{b}	12.52 ± 0.04^{c}	9.51 ± 0.03^{d}
Texture (N)	8.31 ± 1.11^{a}	8.06 ± 1.22^{b}	6.95 ± 0.82^{c}	5.42 ± 0.72^{d}
Lightness	71.66 ± 2.76^{b}	60.20 ± 3.11^{ab}	54.54 ± 6.21^{ab}	49.47 ± 11.75^{a}
Redness	3.14 ± 0.32^{a}	3.96 ± 0.41^{b}	5.77 ± 0.47^{c}	7.60 ± 0.53^{d}
Yellowness	21.69 ± 0.67	21.58 ± 0.86	21.27 ± 1.18	20.67 ± 0.96

Notes: Values are presented as mean ± standard deviation. Different superscript letters within the same row indicate significant differences among treatments ($P<0.01$). HS0 = 0% beef liver; HS1 = 20% beef liver; HS2 = 40% beef liver; HS3 = 60% beef liver.

Water Activity (Aw)

Water activity (Aw) is an important parameter related to the availability of free water in food materials for use by microorganisms in growth and metabolic activity. The results of the analysis of variance showed that the addition of beef liver to chicken patties had no significant effect (P>0.05) on the product's Aw value. The mean Aw values of the chicken patties ranged from 0.835 to 0.858. The highest Aw value was obtained in the HS3 treatment at 0.858, while the lowest value was found in the HS2 treatment at 0.835. The relatively high Aw values across all treatments indicate that free water is still available for microorganisms to utilize for growth. The increase in Aw values in treatments with added beef liver is likely influenced by the high water content in beef liver as well as changes in protein structure during the boiling process. You et al. (2025) state that heating causes water originally bound to myofibrillar tissue to transform into free water in the intercellular spaces. Additionally, Qu et al. (2021) explain that heating can cause protein denaturation and cellular structural damage, thereby reducing the tissue's ability to bind water.

These conditions cause the amount of free water in the product to increase and affect the Aw value. Nevertheless, the analysis results showed no significant differences among the treatments. This is likely because the free water content across all formulations remains relatively uniform due to the use of additives such as salt, sugar, and spices, which help control water activity. Rumondor and Tinangon (2021) state that salt and sugar can bind some of the free water, thereby reducing water availability for microorganisms. The lowest Aw value in the HS2 treatment indicates that the addition of 40% beef liver is still capable of maintaining the balance of free water in the product. A lower Aw value can inhibit microbial growth, thereby potentially extending the product's shelf life. Leviana et al. (2017) state that most microorganisms require a specific minimum Aw value to grow, such as bacteria at Aw 0.90, yeast at 0.80–0.90, and molds at 0.60–0.70.

Cooking Loss

Cooking loss refers to the weight loss of a product during the cooking process due to the loss of water and fat from the meat matrix. Analysis of variance results showed that the addition of beef liver to chicken patties had a highly significant effect (P < 0.01) on cooking loss values. The mean cooking loss values ranged from 9.51% to 25.71%. The highest cooking loss was observed in the control treatment (HS0), while the lowest value was found in the HS3 treatment with a 60% beef liver addition. As the percentage of beef liver added increases, the resulting cooking loss decreases. This is likely because beef liver has a better ability to retain water and fat during the cooking process. The addition of beef liver makes the protein matrix in the dough more capable of binding water, resulting in less liquid being released during heating. Pindi et al. (2023) state that meat with high water-holding capacity will result in lower cooking loss. Additionally, beef liver protein that undergoes denaturation during cooking can form a gel structure that helps retain water within the product.

The low cooking loss value in the HS3 treatment indicates better product quality because nutrient and fat loss during cooking is relatively small. Rumondor and Tinangon (2021) state that high-quality products generally have low cooking loss values. These findings are also consistent with Douglas et al. (2024), who reported that increasing the proportion of beef heart in beef patties results in lower cooking loss values. The control treatment (HS0) resulted in the highest cooking loss due to lower water-binding capacity, causing more liquid to escape during cooking. Ibrahim and Faujan (2024) state that high cooking loss can be caused by protein denaturation and reduced stability of the fat-water emulsion during heating. Additionally, the use of skim milk powder in the formulation is believed to help improve water-binding capacity and emulsion stability, thereby reducing cooking loss in chicken patties.

Texture

Texture is one of the key parameters determining the quality of processed meat products. Analysis of variance results indicate that the addition of beef liver to chicken patties has a highly significant effect ($P < 0.01$) on the product's texture values. Average texture values ranged from 5.42 N to 8.31 N. The highest texture value was obtained in the control treatment (HS0), while the lowest texture value was found in the HS3 treatment with a 60% beef liver addition. This indicates that as the percentage of beef liver added increases, the resulting chicken patties become softer. The decrease in texture values is likely influenced by the high water content and the softer tissue characteristics of beef liver compared to chicken breast meat. The more beef liver added, the less dense the dough structure becomes, resulting in lower force required to press the product. Additionally, beef liver protein has a high water-binding capacity, which increases product moisture and produces a softer texture. Inayah et al. (2024) stated that increasing the percentage of beef liver in burger patties results in a softer texture. Furthermore, protein denaturation during heating promotes protein-protein interactions and gel formation within the meat matrix. However, the higher moisture content associated with beef liver addition may weaken the compactness of the protein network, resulting in a softer texture.

The control treatment (HS0) yielded the highest texture value of 8.31 N, indicating a harder and denser product texture. This is likely due to the dominance of chicken meat, which has a more compact muscle fiber structure, thereby forming a stronger protein gel matrix during heating. Ibrahim and Faujan (2024) also reported that the control treatment for chicken patties yielded the highest hardness value compared to treatments with added ingredients. Additionally, the use of tapioca flour and skim milk powder is believed to contribute to increased texture firmness through starch gelatinization and protein gel formation during cooking. The lowest texture value was obtained in the HS3 treatment at 5.42 N. This indicates that the addition of high amounts of beef liver causes the structure of the chicken patties to become softer and less compact. The higher water content in beef liver can increase the product's moisture, resulting in a softer texture. Safitri et al. (2021) state that food texture is influenced by water content, protein, ingredient composition, and processing methods.

CIE Lab* Color

Analysis of variance results show that adding beef liver at different percentages to chicken patties has a highly significant effect ($P<0.01$) on L* and a* color values, while it has no significant effect on b* color ($P>0.05$). Increasing beef liver levels resulted in darker and redder chicken patties, as indicated by lower L* values and higher a* values. These color changes were primarily associated with the increased concentration of heme pigments, particularly myoglobin and hemoglobin, present in beef liver. Meanwhile, the b* value remained relatively stable, indicating that beef liver addition had little influence on the yellowness of the product.

Lightness

Analysis of variance results show that the addition of beef liver at different percentages has a highly significant effect ($P < 0.01$) on the lightness (L*) values of the chicken patties. The decrease in lightness (L*) is influenced by the heme pigment content, particularly myoglobin, in beef liver, which imparts a dark color to the product. The higher the proportion of beef liver used, the greater the contribution of these pigments to the final color of the chicken patties, resulting in a decrease in lightness. Erlina et al. (2021) stated that heme pigment content plays a significant role in the formation of dark colors in animal-derived food products, so an increase in its concentration can lower the product's lightness. Additionally, the cooking process also influences changes in the color of the chicken patties. Heat treatment triggers the Maillard reaction, which produces a yellowish-brown color in the product. Ariyanti et al. (2021) state that the Maillard reaction is a non-enzymatic browning reaction between reducing sugars and free amino groups, resulting in brown-colored melanoidin compounds. This causes the color of the chicken patties to become darker after the cooking process

Redness

Analysis of variance results indicate that the addition of beef liver at different percentages has a highly significant effect ($P<0.01$) on the redness (a*) values of the chicken patties. The increase in the redness (a*) value is influenced by the content of heme pigments, particularly myoglobin in beef liver, which contributes a more dominant red color compared to chicken meat. The higher the concentration of beef liver used, the higher the intensity of the red color in the final product. Erlina et al. (2021) stated that an increase in myoglobin concentration enhances the intensity of red color (a* value) in animal-derived food products. In addition to pigment content, the cooking process also affects the color of the chicken patties. The frying process causes the product's surface to receive heat evenly, resulting in a relatively uniform color. Suprapto (2018) states that the frying process can produce a grayish-brown to golden color in processed food products. Izzah et al. (2024) also state that the a* value is influenced by the presence of oxymyoglobin and myoglobin pigments, which play a role in the formation of red color in animal-based food products during the cooking process.

Yellowness

Analysis of variance results indicate that the addition of beef liver at different percentages does not have a significant effect ($P > 0.05$) on the yellowness (b*) values of chicken patties. This indicates that the addition of beef liver is still able to maintain the yellowness value in the chicken patties. The b* value describes the degree of yellow color in food products. The decrease in b* values in treatments with added beef liver is likely influenced by the natural color of beef liver, which tends to turn red to dark brown after cooking, thereby reducing the dominance of yellow color in the final product. Inayah et al. (2024) state that increasing the use of liver in patties can cause the product color to become darker. Additionally, fat content is also suspected to influence the yellowness value (b*). Fat acts as a carrier for fat-soluble pigments that contribute to the yellowish color in processed food products. The higher the percentage of beef liver used, the lower the intensity of the yellow color tends to be, as the fat content of beef liver is lower compared to chicken meat. The cooking process also influences color changes through the Maillard reaction, which produces brown melanoidin compounds, causing the color of chicken patties to darken. Ariyanti et al. (2021) state that the Maillard reaction is a non-enzymatic browning process that occurs during the cooking of food ingredients.

Proximate Composition

The effects of beef liver addition at different concentrations on the chemical characteristics of chicken patties, including moisture content, protein content, and fat content, are presented in Table 2.

Table 2. Moisture, protein, and fat contents of chicken patties with different levels of beef liver addition

Parameters	Treatments			
	HS0	HS1	HS2	HS3
Moisture Content (%)	48.11 ± 1.04^{a}	49.67 ± 2.35^{b}	50.84 ± 0.74^{c}	51.47 ± 0.80^{d}
Protein Content (%	21.52 ± 3.94	20.05 ± 3.58	21.08 ± 2.73	22.47 ± 3.97
Fat Content (%)	10.47 ± 0.56^{bc}	10.09 ± 1.02^{c}	8.81 ± 0.96^{ab}	8.23 ± 1.10^{a}

Note: Values are expressed as mean ± standard deviation. Different superscript letters within the same row indicate significant differences (P<0.01). HS0 = 0% beef liver; HS1 = 20% beef liver; HS2 = 40% beef liver; HS3 = 60% beef liver.

Moisture Content

Moisture content is one of the key parameters in determining the quality and shelf life of food products. The results of the analysis of variance indicate that the addition of beef liver to chicken patties has a highly significant effect (P<0.01) on the product's moisture content. The average moisture content of the chicken patties ranged from 48.11% to 51.47%, with the highest value found in the HS3 treatment and the lowest in HS0. The increase in moisture content of the chicken patties was influenced by the high moisture content of the beef liver. Beef liver contains only about 27.5–28.5% dry matter, so the majority of its composition is water (Ryssen et al., 2023). The higher the percentage of beef liver added, the more water enters the dough system, thereby increasing the product's moisture content. Additionally, the soft tissue structure of the liver allows water to distribute more easily and be retained within the chicken patty matrix. In addition, liver proteins may contribute to water retention through protein-water interactions within the meat matrix. During mixing and heating, denatured proteins can form a three-dimensional network capable of entrapping water molecules, thereby increasing moisture retention in the final product.

The 5-minute boiling process of the beef liver is also suspected to influence the increase in moisture content. Boiling in the early stages can cause protein denaturation, converting immobilized water into free water. This free water then binds more easily and becomes trapped within the dough's protein matrix during the mixing process (You et al., 2025). The skim milk powder used in the formulation also has water-binding capacity due to its protein content, thereby helping to retain water in the product. The lower moisture content observed in the control treatment may be attributed to the absence of beef liver, resulting in lower water input and reduced water retention within the protein matrix.

Protein Content

Analysis of variance results indicate that the addition of beef liver to chicken patties at different percentages did not have a significant effect ($P>0.05$) on the product's protein content. The protein content of the chicken patties ranged from 20.05% to 22.47%. The highest protein content was obtained in the HS3 treatment with 60% beef liver addition, while the lowest value was found in the HS1 treatment with 20% beef liver addition. All treatments still met the quality standards for burger patties based on SNI 8503:2018, which require a minimum of 13% protein. The absence of significant differences is likely due to the relatively high protein content of both beef liver and chicken meat, meaning that the substitution of beef liver did not result in a significant change in the product's total protein content. Chicken meat is known to contain approximately 27.07 g of protein per 100 g, while beef liver contains approximately 19.8 g of protein per 100 g. Additionally, processing methods such as steaming and frying are believed to affect protein stability during cooking. Heat treatment causes protein denaturation, resulting in changes to the protein structure and a reduction in some of its functional properties.

Serdaroğlu et al. (2017) state that the heating process in patties can cause changes in protein structure, a decrease in protein solubility, and protein oxidation during thermal processing. Protein denaturation also reduces the protein's ability to bind water, making the water bound within the protein matrix more prone to leaching out during cooking. Al

Awwaly (2017) noted that protein denaturation and coagulation caused by heating can reduce water-binding capacity and protein biological activity. The relatively stable protein content across all treatments indicates that the addition of beef liver still maintains the protein content of the chicken patties. This is likely because the protein contribution from the beef liver remains capable of partially replacing the protein from the chicken meat despite undergoing the heating process. In addition to ingredient composition, the protein content of the product is also influenced by processing methods that can cause gradual nutrient degradation before, during, and after cooking.

Fat Content

Analysis of variance results indicate that the addition of beef liver to chicken patties has a highly significant effect ($P<0.01$) on the product's fat content. Fat content ranged from 8.23% to 10.47%. The highest fat content was observed in the HS0 treatment, while the lowest fat content was found in the HS3 treatment with a 60% beef liver addition. These results indicate that as the percentage of beef liver added increases, the fat content of the chicken patties tends to decrease. The reduction in fat content is likely influenced by the heating process during beef liver processing and the cooking of the chicken patties. Boiling the beef liver before mixing the dough causes some fat to melt and be released along with the boiling liquid, thereby reducing the fat content of the raw ingredients. Additionally, the cooking process using the pan-frying method also causes fat release due to direct heating. Khan et al. (2022) state that the cooking process can cause fat and water to exit the product matrix, resulting in a decrease in the final product's fat content.

Heat treatment also causes changes in the tissue structure of the material, thereby accelerating fat release during cooking. Azzahra (2024) states that high temperatures and prolonged heat exposure can accelerate fat melting in food products. Additionally, Suryaningsih et al. (2017) reported that boiling treatment of beef liver can affect nutritional components due to nutrient loss during the heating process. The fat content of chicken patties across all treatments still meets quality standards based on SNI 8503:2018, which specifies a maximum of 20%. Lower fat content indicates that the product has a better fat profile and is potentially healthier for consumption. In addition to being influenced by beef liver, the product's fat content is also affected by interactions with other ingredients and processing methods that cause fat melting and leaching during cooking.

CONCLUSION

The incorporation of beef liver into chicken patties significantly improved their physicochemical and nutritional quality. Beef liver addition enhanced protein content, reduced fat levels within acceptable standards, and modified color attributes toward a more desirable appearance. It also influenced moisture content, cooking loss, and texture without affecting water activity. These findings indicate that beef liver can be utilized as a value-added functional ingredient in chicken patties while supporting the sustainable utilization of livestock by-products. The results also provide practical information for the development of nutritionally enhanced meat products in the meat processing industry. Future studies should investigate sensory acceptability, storage stability, and consumer acceptance of beef liver-enriched chicken patties.

REFERENCES

Afiyah, D. N. 2022. The Effect of Different Broiler Chicken Meat Cuts on the Protein Content and Organoleptic Properties of Chicken Nuggets. *Anoa: Journal of Animal Husbandry*, 1(2), 81-87. https://doi.org/10.24252/anoa.v1i2.30875

Akhter, M. S., Khatun, H., Hashem, M. A., Rahman, M. M., & Khan, M. 2022. Effect of Storage Periods on the Quality and Shelf Life of Beef Liver at Refrigerated Temperature. *Meat Research*, 2(2), 1-5. https://doi.org/10.55002/mr.2.2.17

Al Awwaly, K. U. 2017. *Animal-Derived Food Proteins and Their Applications*. Universitas Brawijaya Press. https://books.google.co.id/books?id=h2pODwAAQBAJ&printsec=copyright

Ariyanti, M., Rosniati, R., Yumas, M., Wahyuni, W., and Indriana, D. 2021. Amino Acid and Fatty Acid Content of Unfermented Cocoa Powder Treated with Low-Temperature Steam Roasting. *Journal of Plantation Industry*, 16(2), 70-82. https://doi.org/10.33104/jihp.v16i2.7052

AOAC. 2005. Official Methods of Analysis of the Association of Official Analytical Chemists. Benjamin Franklin Station, Washington, D.C.

Azzahra, A. 2024. Analysis of the Impact of High-Temperature Cooking Methods on the Quality of Ready-to-Eat Chicken Nuggets. *SANTEK Journal of Science and Technology*, 1(1), 1-17. https://jurnal.licheninstitute.org/index.php/santek/article/view/153

Basar, F. M., Sujarnoko, T. U. P., Pranata, R. T. H., Syahwani, A., Marithasari, H., Riski, A., and Putri, S. N. 2024. The Development of Pempek Dos Using Chicken Liver as an Iron Fortification. *Journal of Applied Social Sciences*, 2(2), 1-6. https://doi.org/10.29244/jstrsv.2.2.1-6

Berky, M.R.F., 2024. Physical Testing of Lamb Meat Marinated with Kecombrang Flower Extract. *Jurnal Cakrawala*. http://bajangjournal.com/index.php/J

Chatterjee, D., Brambila, G. S., Bowker, B. C., and Zhuang, H. 2019. Effect of Tapioca Flour on Physicochemical Properties and Sensory Descriptive Profiles of Chicken Breast Meat Patties. *Journal of Applied Poultry Research*, 28(3), 598–605. https://doi.org/10.3382/japr/pfy076

Choi, Y. S., Ku, S. K., Lee, H. J., Park, J. D., Sung, J. M., Jeon, K. H., and Kim, Y. B. 2017. Effects of Pork Liver Levels on The Quality Characteristics on Hamburger Patties. *Korean Journal of Food and Cookery Science*, 33(1) 20-27. https://doi.org/10.9724/kfcs.2017.33.1.20 cookery 20-27

Douglas, S.L., Bernardez-Morales, G.M., Nichols, B.W., Johnson, G.F., Barahona Dominguez, L.S., Jessup, A.P., Belk, A.D., Ball, J.J., Cho, S., and Sawyer, J.T., 2024. Inclusion of Beef Heart in Ground Beef Patties Alters Quality Characteristics and Consumer Acceptability as Assessed by The Application of Electronic Nose and Tongue Technology. *Foods,* 13(5), 1-15. https://doi.org/10.3390/foods13050811

Erlina S., I., Wibowo, A., and Ibrahim, I., 2021. Observation of Changes in the Physical Properties of Longissimus Dorsi Muscle in Cattle Post-Slaughter During Cold Storage (Display*). Journal of Tropical Environmental Animal Science*, 4(2), 1–10. http://dx.doi.org/10.30872/jpltrop.v4i2.6465

Evanuarini, H., Susilo, A., and Amertaningtyas, D. 2023. Improving the Physicochemical and Microstructural Qualities of Chicken Patties with the Addition of Red Beet Peel Flour *(Beta vulgaris L*) as a Filler. *Jurnal Ilmu-Ilmu Peternakan*, 33(1), 49–61. https://doi.org/10.21776/ub.jiip.2023.033.01.07

Fadlilah, A., Rosyidi, D., and Susilo, A., 2022. L*a*b* Color Characteristics and Texture of Rabbit Meat Jerky Fermented with *Lactobacillus plantarum*. *Wahana Peternakan*, 6(1), 30–37. https://doi.org/10.37090/jwputb.v6i1.533

Fauzi, N. A., and Wijaya. 2021. Factors Influencing Consumer Behavior in the Purchase of Broiler Chicken Meat at Celancang Market. *Jurnal Agrijati*, 34(1), 69–72. http://jurnal.ugj.ac.id/index.php/agrijati/article/download/4848/2264

Febriansyah, M. I., Puteri, N. E., and Octaviana Maliza, N. 2023. Enhancing the Potential of Processed Fish Products with Restructuring Method: A Mini Review. *Agros Agricultural Journal,* 25(3), 2079–2091. https://ejournal.janabadra.ac.id/index.php/JA/article/view/3071/1966

Gultom, R., Ilmania, L. A., Rinca, K. F., Bollyn, Y. M. F., Luju, M. T., and Achmadi, P. C. 2023. Evaluation of the Supplementation of Bitter Melon Flour *(Momordica charantia*) as a Feed Additive on the Physical and Chemical Properties of Broiler Meat. *Jurnal Ilmiah Peternakan Terpadu*, 11(2), 82. https://doi.org/10.23960/jipt.v11i2.p82-93

Ibrahim, H.S.S. and Huda-Faujan, N., 2024. Physicochemical Properties and Nutritional Composition of Chicken Patties with Grey Oyster Mushroom Stems. *Malaysian Journal of Science Health & Technology*, 10 (1), 50-57. https://doi.org/10.33102/mjosht.v10i1.364

Inayah, P. Z., Sari, R., and Anshory, J. 2024. The Effect of Substituting Chicken Liver and Kalakai (*Stenochlaena palustris*) on the Quality of Burger Patties as a Supplementary Food for Anemic Pregnant Women. *Journal of Food Technology and Nutrition*, 23(1), 54–60. https://doi.org/10.33508/jtpg.v23i1.4986

Indonesian Central Statistics Agency. 2023. Livestock in Figures 2023. https://www.bps.go.id/id/publication/2023/12/22/5927b06e1dcde219f76cec59/peternakan-dalam-angka 2023.html. Accessed on April 25, 2025.

Izzah, A. N., Nurtiana, W., Ningrum, M. A., Anggraeni, S., Nugroho, I., Hasanah, A. S., and Febriyani, R. 2024. Effect of Beef Treatment at Different Temperatures on Myoglobin Changes: A Brief Review: The Effect of Beef Treatment at Different Temperatures on Myoglobin Changes: A Brief Review. *Journal of Tropical Food and Agroindustrial Technology*, 5(01), 1–8. https://doi.org/10.21070/jtfat.v5i01.1620

Khan, I. A., Shi, B., Shi, H., Nawaz, A., Zhu, Z., Ijaz, M. U., and Cheng, K. W. 2022. Perilla Frutescens Seed Meal as a Fat Substitute Mitigates Heterocyclic Amine Formation and Protein Oxidation and Improves the Fatty Acid Profile of Pan-Fried Chicken Patties. *Frontiers in Nutrition*, 9, 975831. https://doi.org/10.3389/fnut.2022.975831

Khotimah, K., Kusumaningrum, I., and Alfiah, R. N. 2024. Texture Profile and Hedonic Testing of Catfish Meatballs with the Addition of Coconut Yam Flour (*Dioscorea Alata*). *JPHPI*, 27(8), 693–705. http://dx.doi.org/10.17844/jphpi.v27i8.50811

Khoirunnisa, V., Yulianti, Y., and Ridawati, R. 2022. The Addition of Oyster Mushrooms in the Production of Chicken Wing Patties on Consumer Acceptance. *Journal of Social Technology*, 2(12), 1446–1464. https://doi.org/10.59188/jurnalsostech.v2i12.533

Kusnadi, F. N. 2021. The Relationship Between Knowledge Levels About Anemia and The Incidence of Anemia in Adolescent Girls. *Jurnal Medika Hutama*, 3 (1), 1293-1298. http://www.jurnalmedikahutama.com/index.php/JMH/arti cle/view/266.

Leite, A., Vasconcelos, L., Teixeira, A., & Rodrigues, S. S. (2026). Valorization of By-Products for Functional Ingredients in Meat and Meat Replacers: A Circular Bioeconomy Approach. *Foods*, 15(9), 1567. https://doi.org/10.3390/foods15091567

Leviana, Wilandika., and Paramita, V. 2017. The Effect of Temperature on Moisture Content and Water Activity in Turmeric (*Curcuma longa*) Using an Electric Oven Dryer. *Metana*, 13(2), 37-44. https://ejournal.undip.ac.id/index.php/metana/article/view/18012 37–44.

Muzayyanah, M. A. U., Triatmojo, A., and Guntoro, B. 2022. Consumer Preferences for Processed Meat Products Based on Brand Choice Priorities. *IOP Conference Series: Earth and Environmental Science*, 1001 (1), 1-5. https://doi.org/10.1088/1755-1315/1001/1/012024

Nuhriawangsa, A. M. P., Hertanto, B. S., Budiharjo, A., Swastike, W., and Kartikasari, L. R. 2021. Physical Quality of Chicken Patties Containing Red Beans (*Vigna *angularis*) with Different Filler Levels of Taro Meal. *IOP Conference Series: Earth and Environmental Science*, 902 (1). 1-5. https://doi.org/10.1088/1755-1315/902/1/012011

Patel, D., Chauhan, P., and Nayak, N. K. 2023. Recent developments in restructured meat products. *The Pharma Innovation Journal*, 12 (12), 1124–1129. https://www.thepharmajournal.com/archives/2023/vol12issue12S/PartO/S-12-11-320-755.pdf

Pindi, W., Qin, L.W., Sulaiman, N.S., Mohd Zaini, H., Munsu, E., Wahab, N.A., and Mohd Noor, N.Q.I., 2023. Effects of Salt Reduction and the Inclusion of Seaweed (*Kappaphycus alvarezii*) on the Physicochemical Properties of Chicken Patties. *Applied Sciences*, 13(9), 1-12. https://doi.org/10.3390/app13095447

Ramadhani, W. M., Rukmi, I., and Jannah, S. N. 2020. Microbiological Quality of Broiler Chicken Meat at the Banyumanik Traditional Market in Semarang. *Jurnal Biologi Tropika*, 1(1), 8–16. https://doi.org/10.14710/jbt.1.1.8-16

Rukmini, R., Mardewi, M. dan Rejeki, R., 2019. Kualitas Kimia Daging Ayam Broiler Umur 5 Minggu yang Dipelihara pada Kepadatan Kandang yang Berbeda. *WICAKSANA*: *Jurnal Lingkungan dan Pembangunan*, 3(1), 31-37. https://doi.org/10.22225/wicaksana.3.1.2019.31-373

Rumondor, D. B. J., and Tinangon, R. M. 2021. Physicochemical Characteristics and Sensory Evaluation of Beef Burgers with Added Clove Powder (*Syzygium aromaticum*). 41 (1), 506-514. *Zootec*, https://doi.org/10.35792/zot.41.2.2021.36882

Ryssen, J.B.J., Webb, E.C., and Myburgh, J.G., 2023. Liver Moisture Content in Animals and Possible Causes of Variations in Hepatic Dry Matter Content. *Journal of the South African Veterinary Association*, 94 (1), 7–15. https://doi.org/10.36303/JSAVA.518

Safitri, R.K.A., Soeyono, R.D., Sulandjari, S., and Sutiadiningsih, A., 2021. The Effect of Fish and Cornstarch Content on the Organoleptic Properties of Mackerel (*Rastrelliger kanagurta*) Nuggets. *Jurnal Tata Boga*, 10(1), 122-128. https://ejournal.unesa.ac.id/index.php/jurnal-tata-boga/

Serdaroğlu, M., Nacak, B., and Karabıyıkoğlu, M. 2017. Effects of Beef Fat Replacement with Gelled Emulsion Prepared with Olive Oil on Quality Parameters of Chicken Patties. *Korean Journal for Food Science of Animal Resources*, 37(3), 376–384. https://doi.org/10.5851/kosfa.2017.37.3.376

Siregar, N.A., Riyanto, R., and Anggraeni, D.N. 2021. The Effect of Bay Leaf Extract (*Syzygium polyanthum*) as a Natural Preservative for Chicken Meat. *UMA Scientific Journal of Biology* (JIBIOMA), 3, 39–48. https://doi.org/10.31289/jibioma.v3i2.735

Stanišić, N., Kurćubić, V. S., Stajić, S. B., Tomasevic, I. D., & Tomasevic, I. (2025). Integration of Dietary Fibre for Health Benefits, Improved Structure, and Nutritional Value of Meat Products and Plant-Based Meat Alternatives. *Foods*, 14(12), 2090. https://doi.org/10.3390/foods14122090

Suprapto, D. 2018. The Effect of Different Frying Methods on the Physical, Chemical, and Organoleptic Quality of Chicken Nuggets. *Jurnal Ilmiah Fillia Cendekia*, 3(1), 31-35. https://doi.org/10.32503/fillia.v3i1.173

Suryaningsih, L., Gumilar, J., and Pratama, A. 2017. The Response of Beef Liver Percentage to Protein Content, Fat Content, and Cooking Loss in Beef Sausages. *Journal of Animal Science*, 17(2), 77-81. https://doi.org/10.24198/jit.v17i1.15274 77–81

Susanti, S., Isnawati, I., and Muhaimin, F. I. 2022. Reducing Excessive Red Meat Consumption to Delay Aging. *Muhammadiyah Journal of Geriatrics*, 3(1), 17-22. https://doi.org/10.24853/mujg.3.1.17-22

Qu, Z., Tang, J., Sablani, S.S., Ross, C.F., Sankaran, S., and Shah, D.H., 2021. Quality Changes in Chicken Livers During Cooking. *Poultry Science*, 100(9), 1-13. https://doi.org/10.1016/j.psj.2021.101316

You, L., Zhang, Y., Ma, Y., Wang, Y., and Wei, Z. 2025. Effect of Boiling Time on the Color, Water, Protein Secondary Structure, and Volatile Compounds of Beef. Foods, 14 (8), 1-16. https://doi.org/10.3390/foods14081372