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ARTICLE

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Effect of Halal-Certified Slaughterhouses and Storage Time on Microbiology and Organoleptic Quality of Broiler Chicken Meat

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Abstract: *Chicken slaughterhouses play an essential role in producing halal chicken. In previous study, only nine halal-certified chicken slaughterhouses in Banda Aceh. This study determined the effect of halal-certified slaughterhouses and storage time on broiler chicken meat's microbiology and organoleptic quality. This study uses a factorial randomized block design with two factors (halal-certified slaughterhouses (the slaughterhouse which already has a halal certificate (S1) and the slaughterhouse which has not yet halal certified (S2) and storage time (0 hours (P1), 3 hours (P2), 6 hours (P3), and 9 hours (P4)). Each treatment repeats three times. Data were statistically analyzed using analysis of variance (ANOVA) and continued with Duncan's New Multiple Range Test (DNMRT) at a 5% level. Samples were analyzed for total plate counts (TPC), pH, and descriptive organoleptic tests of meat color, aroma, moisture, elasticity, and skin color. The results showed that the quality of meat from chickens slaughtered at halal-certified slaughterhouses was better than that of not halal-certified slaughterhouses in terms of lower microbial number and pH value, as well as the higher value of descriptive organoleptic characteristics (meat color, aroma, elasticity, and skin color). There is no difference found in meat moisture.*
Keywords: *chicken meat broiler, halal-certified, quality, slaughterhouse, storage time*

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1. Introduction

Broiler chicken meat is an essential poultry commodity and is the most significant contribution of animal protein for people in all over the world. Compared to other types of livestock, the contribution of broiler chicken meat to national meat production in Indonesia is the highest (70.05%) (Ministry of Agriculture Directorate General of Livestock and Animal Health, 2021). Chicken meat is in great demand from the public because the price is relatively lower than beef and mutton (Priyambodo et al., 2020; Wahyono & Utami, 2018). Healthy chicken meat has the following characteristics: flesh that is light yellowish-white (not dark, not pale, not bluish); skin tone that is white-yellow chicken, bright, shiny, and clean; when it is touched, the flesh feels moist and not sticky; meat-specific odor (non-pungent odor, no fishy smell, no foul smell); the chest consistency thigh muscle is supple or elastic (not flabby); the inside of the carcass and fibers muscle is slightly pale white; and the veins on the neck and wings are empty (Hajrawati et al., 2016).

Meat quality depends on its physicochemical, microbiological, and organoleptic properties. One of the most common problems in chicken meat quality is a high number of microorganisms found in samples due to poor handling, slaughterhouse, storage, and market conditions (Bakara et al., 2014). Compared to being sold at a supermarket, most chicken meat sold in traditional markets in Indonesia is directly exposed to open air without appropriate refrigeration and packaging resulting in it being easily contaminated by microorganisms (Apriyanti et al., 2020; Septianty et al., 2016). Raw chicken is often contaminated with *Campylobacter*, *Escherichia coli*, *Salmonella*, and *Clostridium perfringens* bacteria (Al-Nehlawi et al., 2013; Balamatsia et al., 2007; Chousalkar et al., 2019; Friedman et al., 2004; Kassenborg et al., 2004; Kimura et al., 2004).

In addition, meat produced in chicken slaughterhouses is at quite a high risk of pathogenic microbial contamination. Equipment completeness, slaughter techniques, handling methods and wastewater treatment at chicken slaughterhouses are lack of hygiene and health (Ramdani et al., 2019; Yulistiani et al., 2019). This is because most chicken slaughterhouses in Indonesia are still traditional and still use improvised equipment and unhygienic handling where contamination can be from the hands of workers, during the carcass washing process, and from tools cutters and containers (Apriyanti et al., 2020).

Chicken slaughterhouses play an essential role in producing chicken carcasses that meet the criteria of the Indonesian National Standard. In addition, Law Number 33 of 2014 concerning guaranteed halal products states that the product must fit the category of halal product. Halal food products are foods that have met the required halal standards and followed the provisions of Islamic law. The halal standards state that food must be halal in many aspects, such as essence, obtaining, slaughtering, processing, storage, transportation, and serving (Huda, 2012). For Muslims, the halal quality of food products is essential to their belief, not only because of religious teachings, but also in quality and healthy aspects (Ambali & Bakar, 2014). In addition, halal certification and halal awareness both simultaneously have positive effects on buyer purchase intentions of halal food products (Hammam, 2022; Septiani & Ridlwan, 2020). Halal-certified chicken slaughterhouses have the opportunity to get a bigger turn over than slaughterhouses that have not been halal certified because buyers already have a preference to buy halal chicken meat (Ryan et al., 2022). According to Paly (2022), 85.35% of consumers are willing to pay halal chicken meat with a 5% price increase.

Meat quality must be considered thoroughly, starting from the living conditions of the animal, the method of slaughter, meat processing, and its halal status. Implementation of a quality assurance system and food safety in animal slaughterhouses as part of halal certification standards is crucial since it will also impact the meat quality (Dewi et al., 2016; Wahyono & Utami, 2018).

Therefore, further study to ensure the protection of consumers to obtain safe and halal meat is needed. Storage temperature and duration plays an important role in chicken meat processing (Aziz et al., 2020). This study aimed to determine the effect of halal-certified slaughterhouses and storage time on microbiology and organoleptic quality of broiler chicken meat.

2. Materials and Methods

2.1. Experimental Design

The study used a factorial randomized block design consisting of two factors. The first factor was the halal certification or halal certified slaughterhouse (S) consisting of two levels: slaughterhouse which already has a halal certificate (S1) and slaughterhouse which has not yet halal certified (S2). The second factor was storage time (P) consisting of four levels: 0 hours (P1), 3 hours (P2), 6 hours (P3), and 9

hours (P4). Each treatment was repeated three times so that there were 24 experimental units. The block design was based on the S treatment.

The halal-certified slaughterhouses have met the Indonesian Ulema Council standards: 1) Animals slaughtered must be alive and healthy; 2) The facilities used are only for the production of halal animal meat; the room and equipment used must be clean; the toilet must not be in the production room; the water used must be boil and always replaced; and 3) The slaughterer is Muslim, able-bodied and understands the procedure for slaughter according to Islamic law.

2.2. Sample Collection

All chicken samples were attempted to be homogeneous. Broiler chickens which came from the same farm, diet, and management were selected. They also had ages ranging between four and seven weeks and weighed between 0.8 kg and 1 kg. Broiler chickens were slaughtered at chicken slaughterhouses in Banda Aceh (the capital of Aceh Province). In Indonesia, there are still few slaughterhouses that have been halal certified (Harwati et al., 2021; Sumiati et al., 2019). In Banda Aceh, only nine halal-certified chicken slaughterhouses were found (Ryan et al., 2022).

For S1 samples in this study, chickens were slaughtered at halal-certified slaughterhouses. In contrast, for the needs of S2 samples, chickens were slaughtered in slaughterhouses that are not halal-certified. After the chickens were slaughtered, the blood was removed. They were then immersed in hot water for approximately 2.5–3.2 minutes. Furthermore, removal of chicken feathers was done using a de-feathering machine. These whole chicken meats were put in clean plastic bags and placed at room temperature (23°C–31°C) at the meat processing laboratory of Universitas Syiah Kuala (USK) for 0, 3, 6, and 9 hours.

2.3. Sample and Data Analysis

The broilers were analyzed for total plate counts (TPC), pH, and descriptive organoleptic tests. In the TPC measurement, five g of chicken meat is put into 45 mL of sterile buffered peptone water (BWP). After homogenization, dilutions were made up to $1{:}10^{-6}$. The samples from the three highest dilutions were pipetted (100 µl) aseptically (duple) and were put into a sterile petri dish. Sterile Plate Count Agar (PCA; Oxoid CM325) were poured and then were incubated at 37°C for 48 hours. The number of colonies were counted on petri dishes, which had the range of 30–300 colonies (Julqarnain et al., 2022).

$$\text{TPC}\left(\frac{\text{CFU}}{\text{ml}}\right) = \text{number of bacteria growing on plate} \times \frac{1}{\text{Dilution Factor}}$$

The organoleptic (descriptive) test was conducted at the sensory laboratory using 30 semi-trained panelists. Score ranges from 1 to 7 were used to describe meat color, aroma, moisture, elasticity, and skin color which was different according to each quality parameter tested. The definition of these attributes follows Chumngoen & Tan (2015).

The data obtained was analyzed by ANOVA. If the test results showed that the calculated F is greater than or equal to the F table, a further test was carried out with Duncan's New Multiple Range Test (DNMRT) at the 5% level to determine the difference of each treatment.

3. Results and Discussion

3.1. Total Plate Counts

Microbial contamination can decrease meat quality and reduce its shelf life (Sabow & Majeed, 2020). The average total plate count (TPC) of broiler chicken meat in this study ranged from 7.8×10^6 CFU/g to 9.4×10^6 CFU/g, with a general average of 9.9×10^6 CFU/g. The results of the variance showed that halal certification (S) had a significant effect ($P \leq 0.05$) on the number of microorganisms, while the storage time (P) and their interaction (SP) had no significant effect ($P > 0.05$). The effect of halal certification (S) on the TPC of broiler chicken meat can be seen in Figure 1. The TPC of halal-certified slaughterhouse chicken meat (S1) was lower (8.7×10^6 CFU/g), compared to meat from slaughterhouses which has not yet halal-certified (S2). One of the reasons contributing the to the high TPC of S2 was the less sterile place and equipment used at the slaughterhouse, which has not yet halal-certified. This insufficient sterility can trigger bacterial growth in chicken meat. According to Khoiriyah (2021), a halal label is not enough to ensure that a product is always halal. So, in this case, especially meat products, regular attention must be paid to the meat production process and the role of the state is needed to periodically inspect the meat production process, including the conditions at the slaughterhouse, so that its halal status can always be ascertained. Harwati et al. (2021) mentioned that there are two types of slaughterhouses based on their behavior: the slaughterhouses that are always obedient in providing halal

chicken and the vulnerable slaughterhouse with a high halal risk even though so far still produce halal chicken.

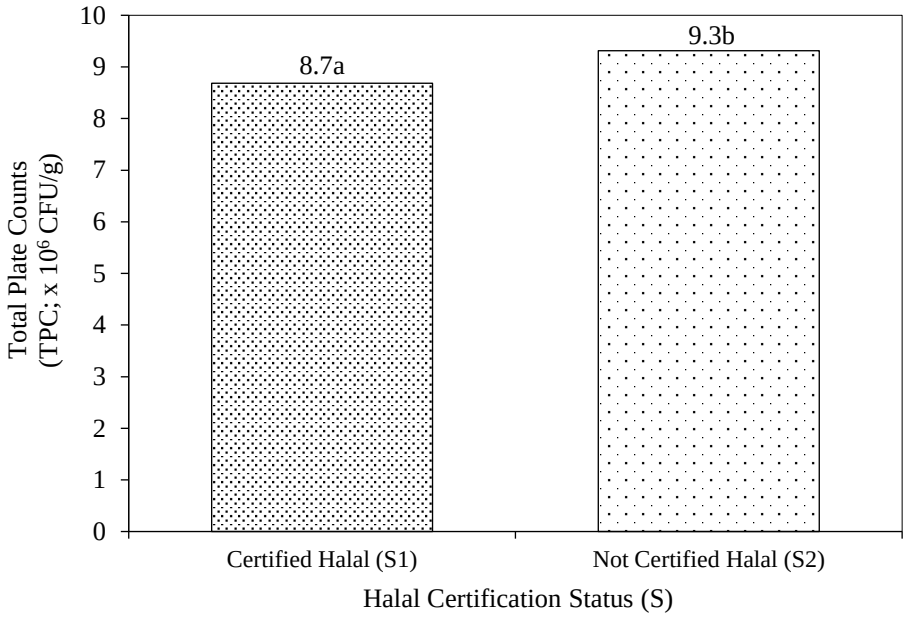

Figure 1. Effect of halal certification (S) on the total plate counts (TPC) of broiler chicken meat.

3.2. pH

The degree of acidity (pH) is one of the requirements to determine the quality of meat. According to Beauclercq et al. (2022), meat quality has not been fully controlled because it is still common to find meat with a pH that is too low or too high. This study showed that the pH value of broiler meat ranged from 5.7 to 5.9, with an average of 5.8. Halal certification (S) had a significant effect ($P \leq 0.05$) on the pH of broiler chicken meat. From Figure 2, the pH of meat from halal-certified slaughterhouse (S1: 5.7) was lower than that from a slaughterhouse which was not halal certified (S2: 5.9). The pH value of fresh chicken meat varies greatly, which is 5.5-5.8 (Cao et al., 2021), 5.7-6.3 (Irmayani et al., 2019), and 5.9 (Mothershaw et al., 2009). Differences in pH values reported in various studies are most probably due to different chicken portions under study, storage temperatures, storage periods, and initial microorganisms in the chicken meat. The pH value of fresh chicken meat is lower than that of chilled and frozen chicken meat (Mothershaw et al., 2009). In the research on chicken meat samples from traditional markets, Irmayani et al. (2019) found that the highest total microorganism (8×10^7 cfu/gr) was obtained in sample with the highest pH (6.3).

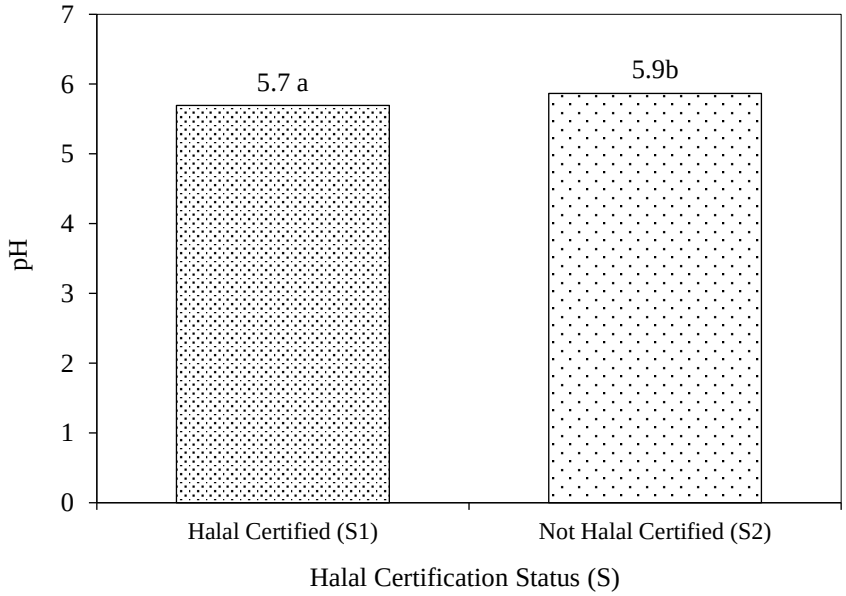

Figure 2. Effect of halal certification (S) on the pH of broiler chicken meat.

In Figure 2, it can be seen that the pH of S1 meat is lower than that of S2 meat. The high and low pH values in meat are influenced by the glycogen content in meat, bacterial activity, and storage time (Soeparno, 2021). As shown in Figure 1, the number of microbial (TPC) of S1 meat was lower than that of S2 meat. The pH of meat is also closely linked to muscle glycogen stores (Beauclercq et al., 2022). Glycolysis leads to the conversion of glycogen into lactic acid in chicken muscles, causing the reduction of the pH value. Rigor mortis is characterized by a decrease in pH (Xu et al., 2022). The decrease in pH is caused by the cessation of oxygen supply after the animal dies, causing the respiration process to stop. This condition causes the formation of lactic acid due to anaerobic glycogen breakdown, which results in a decrease in pH value. The decrease in meat pH is caused by the anaerobic glycolysis process, which produces lactic acid and lowers the pH value (Septinova et al., 2018). Stress experienced by broilers during life could also affect the pH of the meat from excess movement in the chicken's body, which causes acid to accumulate in the meat's muscle and affects the pH value (Baierle et al., 2015). Friendly chicken handling at halal-certified slaughterhouses is thought to have contributed to the lower pH value of S1 meat.

3.3. Descriptive Organoleptic Test

3.3.1. Meat Color

Color is one of the important quality parameters that determining the purchasing decision of consumer and it has become a challenge for the meat industry to deal with (Wibowo et al., 2021). The average meat color of broiler chickens ranged from 3 (pale) to 5 (white), with an average of 4 (neutral). The results of the ANOVA showed that the halal certification (S) had a very significant effect ($P \leq 0.01$) on the color of the broiler chicken meat. The effect of halal certification (S) on the color of meat can be seen in Figure 3. The descriptive color value of S1 meat is 5 (white), which was higher that S2 meat (3; pale).

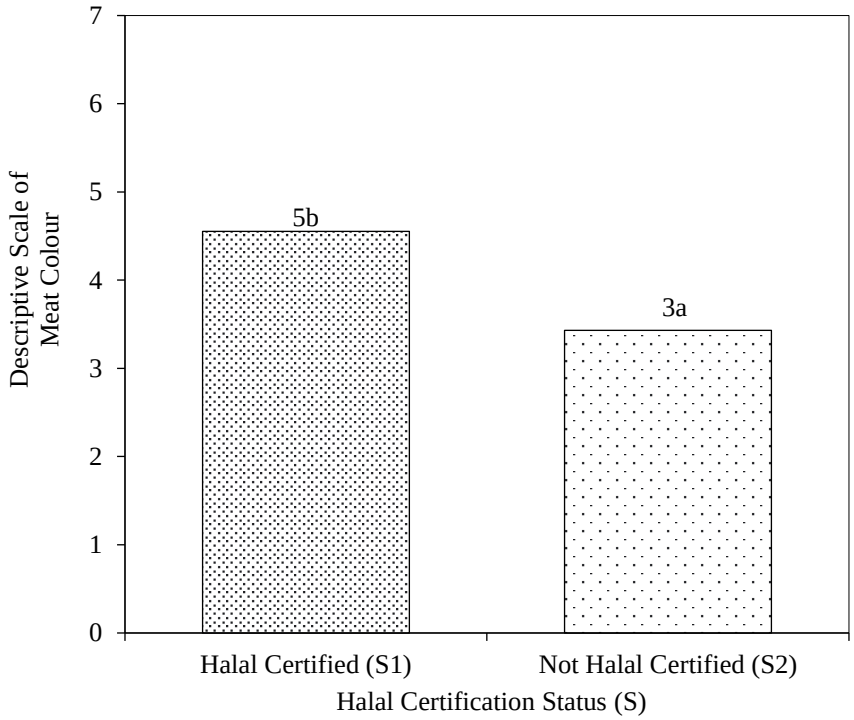

Figure 3. Effect of halal certification (S) on the color of broiler chicken meat (Scale: 1= black, 2= pale black, 3= pale, 4= neutral, 5= white, 6= white bright, 7= bright yellowish white).

According to SNI 01-4258-2010 (Indonesian National Standards), the color of good chicken meat is yellowish-white. Research by Afrianti et al. (2013) also states that the color of fresh broiler chicken meat is yellowish-white. Soeparno (2011) mentioned that the color of fresh broiler meat is affected by the feed, species, nation, age, gender, stress (activity level and muscle type), pH, and oxygen. These factors can affect the concentration of the meat pigment myoglobin because myoglobin reacts with other compounds or undergoes oxygenation, oxidation and reduction (redox), and denaturation. There is a strong correlation between muscle pH and meat color (Mothershaw et al., 2009; Wibowo et al., 2021). Color deterioration during storage is usually attributed to an increase in meat pH and biochemical

reactions between oxygen, meat color pigments and volatile microbial catabolites (Suman & Joseph, 2013). High pH values can cause the color of the meat to darken. Usual chicken meat has a lower pH value. As shown in Figure 2, the pH value of S2 meat in this study was higher than S1 meat.

3.3.2. Skin Color

Carcass skin color is one of the factors determining the quality of broiler meat. Fresh chicken meat has yellowish-white skin color indicating that the meat is from healthy chickens. The average skin color of broiler chickens ranged from 3 (pale) to 5 (white), with an average of 4 (neutral), which is similar to the results on meat color. The effect of halal certification (S) on skin color can be seen in Figure 4. The skin color descriptive value of S2 broiler meat was lower than that of S1. As mentioned, the poor slaughtering sanitation and sterilization condition at slaughterhouses that have not been halal certified (S2) could stimulate the growth of microbes (Figure 1) and causes higher pH (Figure 2). High pH value can also cause the skin color to darken.

On the other hand, Wu et al. (2021) found that yellowness value of abdominal fat presents a very significant negative correlation with abdominal fat weight leading to lighter skin color. Therefore, the potential underlying mechanism may be the dilution of the pigment deposited in the fat by lipids, resulting in a decrease in the yellowness value.

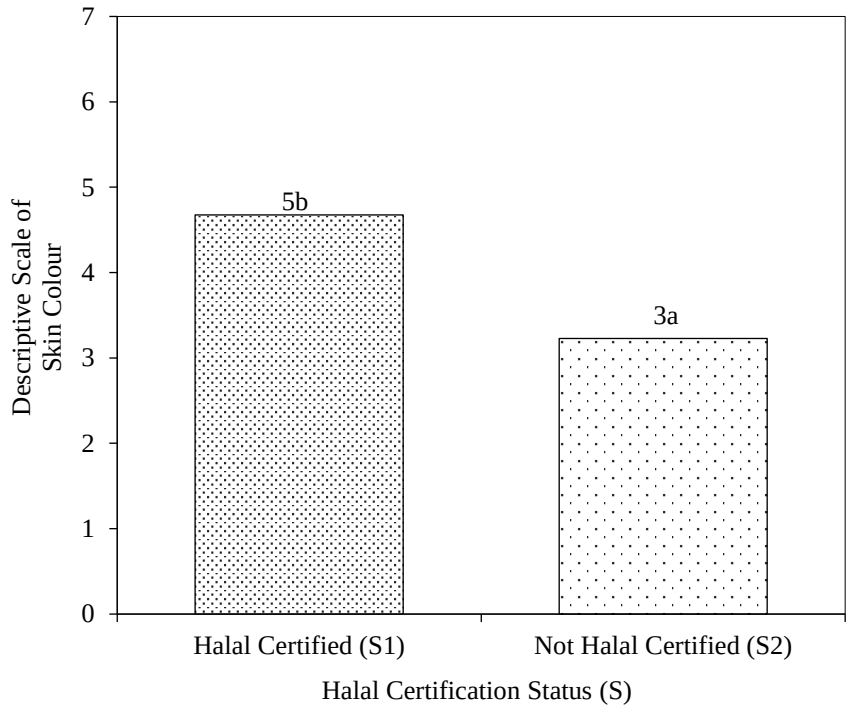

Figure 4. Effect of halal certification (S) on the skin color (Scale: 1= black, 2= pale black, 3= pale, 4= neutral, 5= white, 6= white bright, 7= bright yellowish white).

3.3.3. Meat Aroma

The average aroma of broiler chicken meat in this research ranged from 2 (rotten) to 5 (less fresh), with an average of 4 (neutral). The results of the ANOVA showed that the interaction between two treatments (SP) had a very significant effect ($P \leq 0.01$) on the meat aroma (Figure 5). The aroma value of S1 chicken meat was better than that of S2 in all storage time (up to 9 hours). The highest aroma score was reached by chicken from the interaction of S1P2 (meat from halal-certified slaughterhouse which is stored for 3 hours). The decrease in the value of chicken aroma is expected to be due to the oxidation process during the storage (Hajrawati et al., 2016). In this study, the broiler meat was storage in room temperature. According to Kim et al. (2014), muscles entering rigor mortis at a high temperature have reduced aging potential in terms of sensory tenderness.

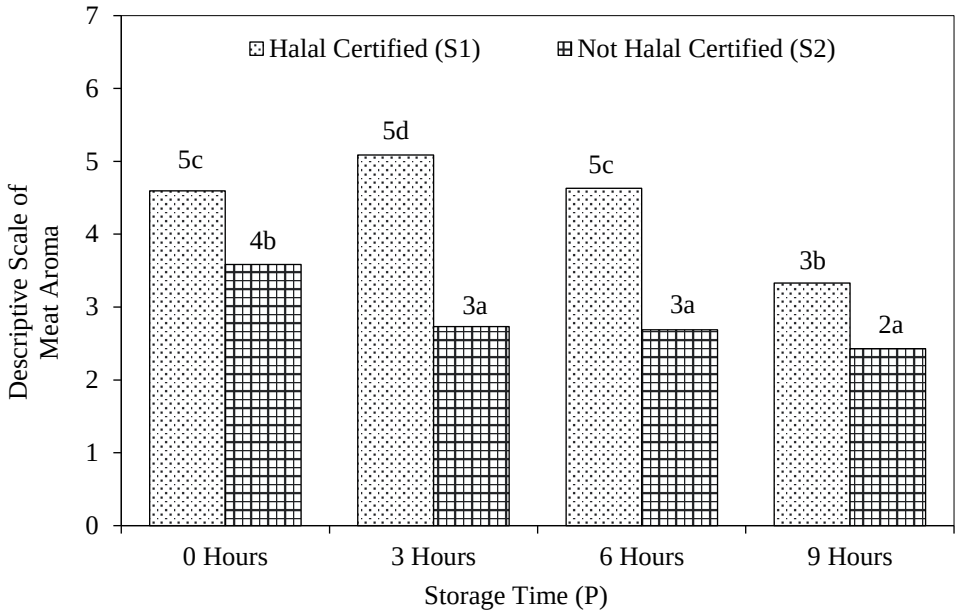

Figure 5. Effect of halal certification (S) and storage time (P) on the meat aroma (Scale: 1= very rotten, 2= rotten, 3= slightly rotten, 4= neutral, 5= less fresh, 6= slightly fresh, 7= very fresh).

3.3.4. Meat Moisture

The value of the description test of meat moisture in this study has a scale of 1-7, with details: 1 (very dry), 2 (dry), 3 (slightly dry), 4 (neutral), 5 (poorly moist), 6 (slightly moist), and 7 (moist). The research shows that halal certification, storage time, and the interactions had no significant effect ($P > 0.05$) on meat moisture. The average value of the descriptive scale of meat moisture was 5 (poorly moist). Typically, meat has a relatively dry surface to resist the growth of microorganisms from the outside. Thus, this will affect the shelf life of meat.

3.3.5. Meat Elasticity

The average meat elasticity of broiler chickens in this study ranged from 3 (slightly soft) to 6 (slightly squishy), with an average of 5 (less chewy). The results of the ANOVA showed that storage time had a very significant effect ($P \leq 0.01$) on meat elasticity. The effect of storage time on the elasticity of broiler meat can be seen in Figure 6. The lowest elasticity score, as shown in Figure 6 and also according to Lubis et al. (2020), was for chicken which is stored for 9 hours.

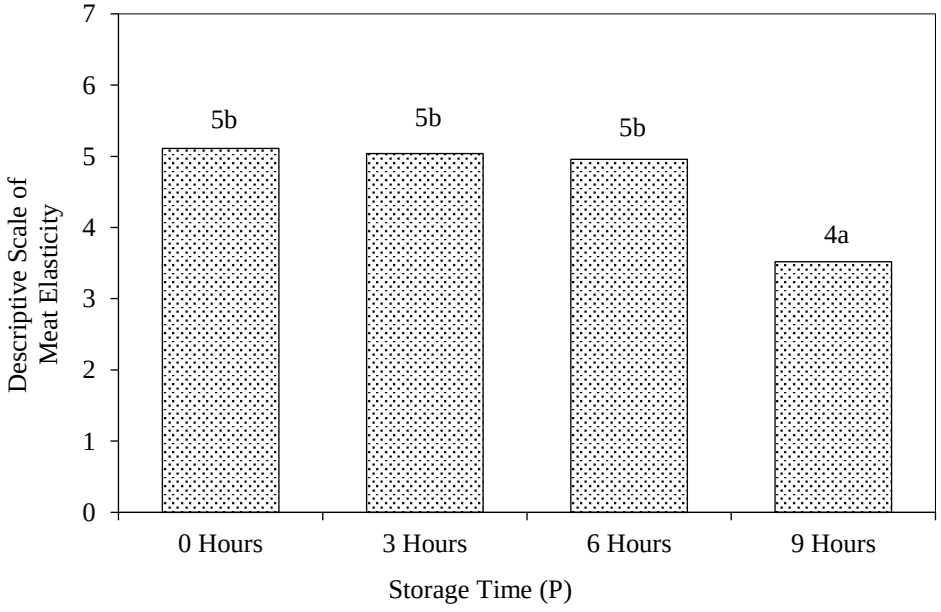

Figure 6. Effect of storage time (P) on the meat elasticity (Scale: 1= very soft, 2= soft, 3= slightly soft, 4= neutral, 5= less spongy, 6= slightly squishy, 7= squishy).

The texture of fresh chicken meat has a high level of elasticity. The shape will immediately return to its original shape when the chicken is pressed but still feels soft when pressed. However, if the skin of the chicken meat looks dented, it tends to be hard (Kholili et al., 2021). The decrease in the elasticity of chicken meat during storage is expected to be because of some of the connective tissue has started to break down. According to Hajrawati et al. (2016), the inner tissues can quickly decompose and cause a soft texture.

4. Conclusion

The quality of meat from halal-certified slaughterhouses was better than that of slaughterhouses without halal certification. Halal certification affected the microbiology, pH value, and organoleptic descriptive of characteristics of chicken meat. The main takeaway was the number of microorganisms (total plate count) and the pH of halal-certified slaughterhouses chicken meat were lower compared to those of the meat from uncertified slaughterhouses. Better hygiene standard at halal-certified slaughterhouses could contribute to lower number of microorganisms in chicken meat. Low microbial number and low pH played an important role in maintaining the quality of chicken meat during storage, including its organoleptic characteristics. Therefore, in organoleptic test of this study, it was found that meat color, skin color, meat aroma and meat elasticity of meat from halal-certified slaughterhouses was better than that of that of slaughterhouses without halal certification. As recommendation, chicken slaughterhouses that are not yet halal certified need to apply for halal certification in order to make consumers feel comfortable buying chicken that is guaranteed to be halal and the chicken meat produced is of higher quality. For future research, it is better to go deeper into the aspects of the growth of various types of pathogenic microbes that develop in meat originating from halal and not halal slaughterhouses.

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