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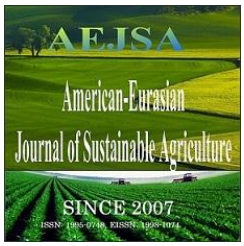

Physical Characteristics of Meat Part of Longissimus dorsi Muscle Marinated in Collagen Extract

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ABSTRACT

The research has been conducted to evaluate the physical characteristics of the meat of the Longissimus dorsi (LD) muscle part, which is marinated in a solution of in collagen extract. A total of 10 kg of meat (LD muscle) from male Bali cattle. The treatment that was applied consisted of 2 factors, the first factor was the three marination times (MT) (0,4 and 8 days), and the second factor was the three levels of collagen extract (LCE) (0%; 1% and 2% w/w). The study was designed based on a completely randomized design (CRD) with a 3x3 factorial pattern, where each treatment was repeated 3 times. The results showed that the difference in MT had a very significant effect ($p<0.01$) on the pH value, meat shear force (MSF) and cooking loss (CL), but did not affect the water holding capacity (WHC). The difference in the LCE had a very significant effect ($p<0.01$) on MSF, but had no significant effect ($p>0.05$) on the pH, CL and WHC values. The two factors that were applied have a significant interaction on the MSF, CL and WHC values. The pH value is relatively stable at pH 6-7. The MSF value was relatively the lowest at 8 days of MT with 2% of LCE (M8-C2). The lowest CL values were MT for 4 days and LCE for 2 days (M4-C2). The results showed that the increase in MT by increasing the amount of LCE provided better functional properties. The combination of 8 days of MT with LCE of 2% (M8-C2 treatment) and applied together was considered as the best recommendation to use.

KEYWORDS

Physical characteristics, meat, muscle, marination, collagen extract

INTRODUCTION

Bali cattle are one of the local livestock types that are widely cultivated in Indonesia. Bali cattle are the superior type of cattle in Indonesia and are beef cattle. As a meat producer in Indonesia, the beef cattle population currently reaches 16,599,000 heads. Approximately 55% are Balinese cattle [1]. Meat is one of the animal products which people in Indonesia widely consume. Meat contains complete nutrition, especially protein, so it is widely chosen as a menu choice for protein sources. The physical and functional characteristics of beef sometimes undergo a change process due to several factors such as temperature, humidity and storage

conditions. One of the techniques to maintain beef's physical and functional properties is the marination process. This process is carried out to extend the shelf life of meat products.

The functional properties of the meat will easily decrease, especially the water-holding capacity (WHC) and the meat shear force (MSF) (tenderness). One of the factors that can affect the functional characteristics is stress conditions in the cattle. The treatment of the cattle causes this condition during the slaughtering process [2].

The marination process is the process of soaking the meat before further processing. One of the goals of the marination process is to maintain the physical condition of the meat during the storage process. The marination process maintains the flavor of the meat and creates a condition for the meat to stay wet when further processing is carried out. The use of collagen as a marination ingredient is considered because collagen has several properties suitable for extending the product's shelf life. Collagen is a type of fibrous protein that can protect the surface of the meat from environmental influences. In addition, collagen is thought to bind to meat protein so that it will affect the properties of meat. This study aims to evaluate the physical characteristics of the meat, especially the Longissimus Dorsi (LD) muscle which is marinated in a collagen extract solution at different times and levels.

MATERIALS AND METHODS

The main samples used in the study were meat obtained from male Bali cattle aged 2-3 years. Meat samples were obtained from the Longissimus dorsi (LD) muscle. Sources of meat were obtained from the Mini Slaughterhouse, Faculty of Animal Science, Hasanuddin University, Makassar. The raw material for marination was collagen extract which is produced from the extraction process of Bali cattle's scapula (Os Scapula). Several supporting equipment were used, such as: CD-Shear Force (modification), Filter Paper Press (modification), UV-1800 spectroscopy (*Shimadzu*), electric oven (*Memmert 100-800*); pH meter (*Lutren PH-201*); analytical scales; color meter (*TeS 135*).

The production process of collagen extract as a marination ingredient

The multi-extraction technique [3,4] (modified) was used to obtain collagen extract. The raw materials were the shoulder blade (os scapula). It was cut 1-2 cm in size and washed. For 2x2 h with bone ratio, 60 percent (v/v) of ethanol was used as a decreasing material (fat removal process. A total of H_2SO_4 0.5 M solution was used as a material demineralization (mineral component removal) for 2 days. A bone (os Scapula) sample (300 g) was used and then placed in the extractant solution produced before the bone ratio: extractant (1:1.5) (v/v). Bone samples collected were stratified for 2 days (stage 1 for 24 h, temperature 55-60° C), resulting in fraction 1 and stage 2 for 24 h, temperature 65-70 °C resulting in fraction 2. Fractions 1 and 2 were combined and then filtered to create a filtrate by the fine filter. To obtain a dense collagen extract, the filtrate was then dried for 48 h at an oven temperature of 55-60° C.

Process of marinating of meat samples

A total of 200g of meat samples were prepared for one treatment unit. The meat samples were put into each vacuum plastic container. Next, the marinated ingredients (collagen extract) were put into a plastic container mixed with the meat samples according to the level of use of the marinated ingredients. The level of use of marinated ingredients was determined by the weight of meat (0%, 1% and 2%).

Research design and data analysis

For the analysis process of research data, statistical analysis was used. First, the research data were analyzed using ANOVA based on a completely randomized design CRD) with a 3 x 3 factorial pattern. The repetition process was carried out 3 times. The significant effect results were then carried out using the Duncan's Multiple Range Test (DMRT) at the 5% level [5].

Samples analysis method

pH [6]. The pH meter was calibrated at a specific pH (pH 4, 7 and 10). The electrode tip was pressed against the surface of the meat in several different places. The measurement results will appear after the value becomes constant.

Meat shear force (MSF) [6]. This test uses a sample of measurement results in the cooking loss (CL) test. The sample was formed according to the bore (cylinder) model on the CD-Shear Force tool. The meat sample was inserted into the hole parallel to the meat fibers. The handle was pulled down to cut perpendicular to the meat

fibers. The value of the tensile force will be read on the scale (kg). Meat shear force (MSF) (kg/ cm^2) = F/L, where: F = tensile force (kg), L = cross-sectional area of sample ($\pi.r^2$ = 3.14 x $(0.635)^2$ = 1.27 cm^2); r = radius of sample hole (0.635 cm).

Cooking loss (CL) [6]. Meat samples (20 g) were cut into blocks of 2x3 cm size with the direction of the muscle fibers parallel to the ends of the samples. The sample was put in a plastic clip bag that had been labeled. Samples in plastic were heated in a water bath at a temperature of 75^{o}C for 30 minutes. Furthermore, the plastic was removed and flushed with cold water. The sample was removed and dried with a tissue without being pressed. Samples were weighed to determine the final value. Cooking loss (CL) = (A-B)/A x 100%, where; A = weight before cooking; B = weight after cooking.

Water holding capacity (WHC) [6]. The WHC test method follows the Hamm Method with a sampling pattern as presented in Fig 1. Test equipment using Filter Paper Press (modification). The sample was weighed as much as 0.3 grams. The sample was placed between 2 filter papers. Filter paper was placed between 2 plates and then pressed with a load of 35 kg for 5 minutes. Furthermore, the calculation of the meat and wet area formed on the filter paper (as shown in the example image) is carried out. WHC = Ma/Wa x 100%; where Ma = meat area (cm^2); Wa = wet area (cm^2)

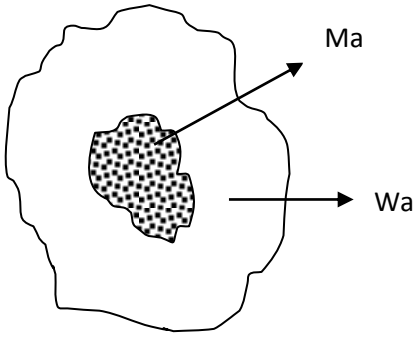

Fig.1. Data collection patterns on meat samples for testing the WHC

RESULTS AND DISCUSSION

Based on the test results obtained data related to the physical characteristics of the Longissimus dorsi (LD) muscle as presented in Table 1.

Table 1. Physical characteristics of the meat of the Longissimus dorsi (LD) muscle part were marinated using different marinating times and levels of ingredients (collagen extract)

Treatments	pH	Meat Shear Force (MSF) (kg/cm^2)	Cooking Loss (CL) (%)	Water Holding Capacity (WHC) (%)
Marination Time (MT) (days)	Sig: p<0.01	Sig: p<0.01	Sig: p<0.01	Sig: Ns
0	6.39±0.36^a	0.61±0.17^a	33.72±1.33^a	52.97±2.51
4	6.61±0.34^a	0.68±0.30^a	30.78±2.64^b	58.46±4.12
8	7.63±0.05^b	0.34±0.12^b	34.67±1.39^a	59.19±4.60
Level of Collagen Extract (LCE) (%)	Sig: Ns	Sig: p<0.01	Sig: Ns	Sig: Ns
0	6.90±0.55	0.71±0.26^a	33.39±3.17	56.08±5.11
1	6.86±0.65	0.53±0.26^b	33.56±1.24	54.62±9.41
2	6.87±0.72	0.39±0.11^b	32.22±2.67	58.91±3.84
Interaction of MT*LEC	Ns (P>0.05)	p<0.05	p<0.01	p<0.01

Note : ^{a,b} different superscripts in each treatment showed significant differences

Ns = Non significant (p>0.05)

pH

The pH value of meat is an important characteristic. Changes in pH value can be caused by various factors, including stress on livestock, slaughtering methods and rest periods. The ultimate pH value of normal meat ranges from 5.4 to 5.8 at 6 hours postmortem and the color of the meat will be bright red [7]. The effect of marination on meat on the pH value has not been widely explained, so it is a very interesting study based on the ANOVA data in Table 1. It shows that the application of different marination times has a very significant effect ($p<0.01$) on the pH value of the meat marinated with bone collagen extract. However, the difference in the level of use of collagen extract as a marination ingredient in meat did not show a significant effect ($p> 0.05$). The test results showed no interaction ($p>0.05$) between the time of marination and the level of use of collagen extract, which could affect pH changes during the marinance process. The addition of the MT from 0 days to 8 days increased the pH value significantly from pH 6.39±0.36 to pH 7.63±0.05. The graph comparing the pH value resulting from the interaction between MT and the LCE was presented in Fig 2.

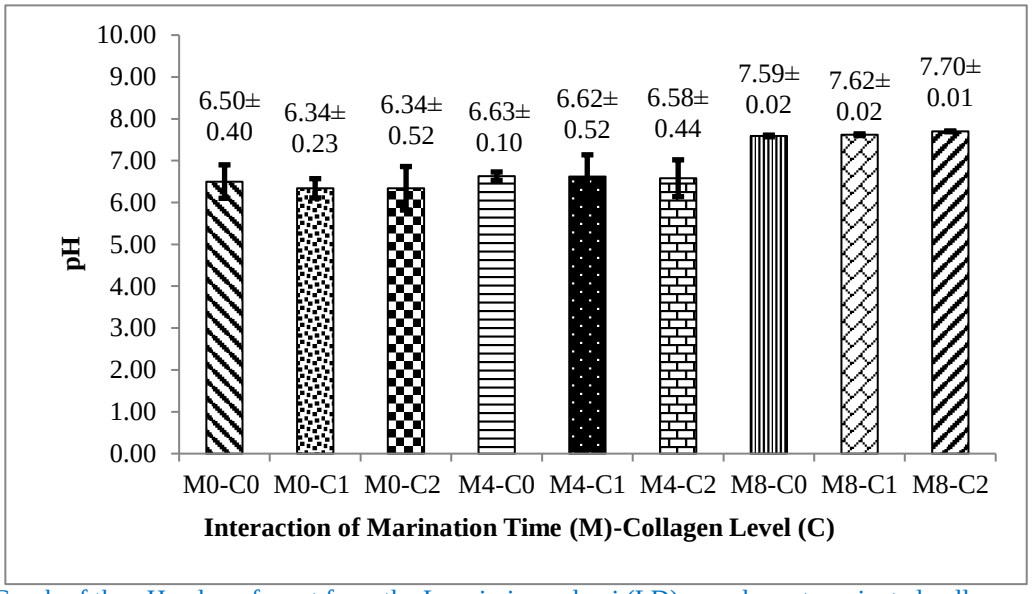

Fig 2. Graph of the pH value of meat from the Longissimus dorsi (LD) muscle part marinated collagen extract at the time of marination with different levels of marination

Note:

M0-C0 = Marination time 0 day - collagen level 0%; M0-C1 = Marination time 0 day - collagen level 1%; M0-C2 = Marination time 0 day - collagen level 2%; M4-C0 = Marination time 4 days - collagen level 0%; M4-C1 = Marination time 4 days - collagen level 1%; M4-C2 = Marination time 4 days - collagen level 2%; M8-C0 = Marination time 8 days - collagen level 0%; M8-C1 = Marination time 8 days - collagen level 1%; M8-C2 = Marination time 8 days - collagen level 2%.

Based on Fig. 2, it can be seen that, on average, the pH value of the meat using 8 days of marination time for the use of 3 types of collagen extract levels (0%; 1% and 2%) (M8-C0; M8-C1 and M8-C2) higher than the 0 and 4 day marination times (M0 and M4) of 7.59±0.02-7.70±0.01. On average, all treatment combinations resulted in the interaction pH value of 6.34±0.23-7.70±0.01.

Meat Shear Force (MSF)

Based on the ANOVA results (Table 1), it was shown that the application of MT and the LCE as a marination material had a very significant effect ($p<0.01$) on the MSF value of meat. Likewise, the two treatments also showed a significant interaction ($p<0.05$). The increase in MT and the increase in the LCE significantly decreased the MSF of meat. On average, the lowest MSF value was the 8-days MT with 2% LCE of 0.34±0.12 kg/cm^2 and 0.39±0.11 kg/cm^2, respectively. The highest was the 0-day marination time with 0% collagen levels of 0.61±0.17 kg/cm^2 and 0.71±0.26 kg/cm^2, respectively. The graph of the interaction between MT and the level LCE was presented in Fig 3.

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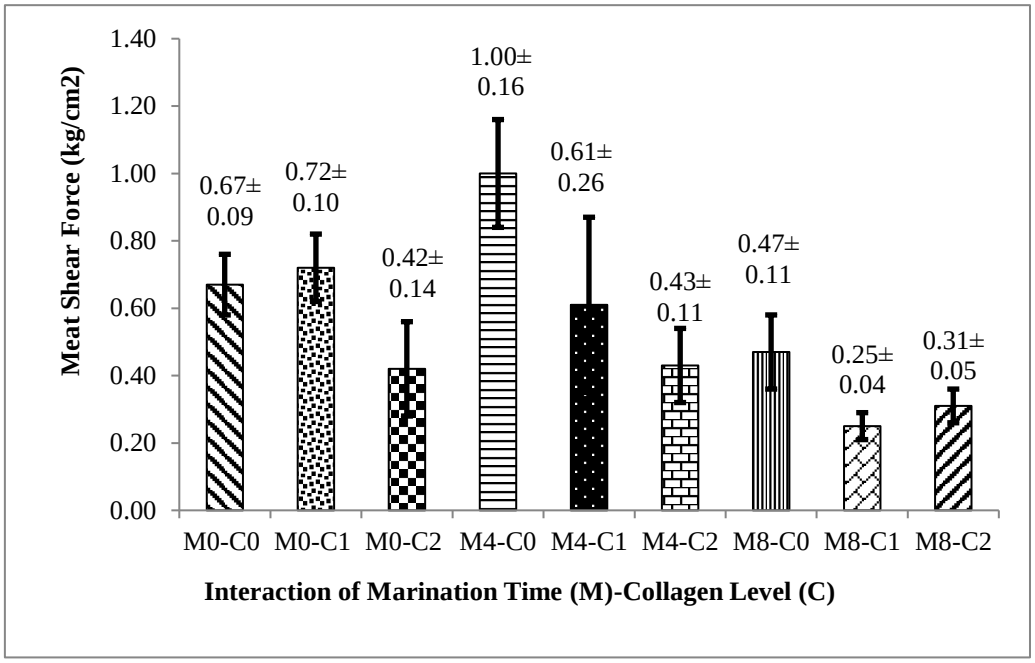

Fig 3.Graph of the meat shear force (MSF)(kg/cm^2) value of meat from the Longissimus dorsi (LD) muscle part marinated collagen extract at the time of marination with different levels of marination

Note:
M0-C0 = Marination time 0 day - collagen level 0%; M0-C1 = Marination time 0 day - collagen level 1%; M0-C2 = Marination time 0 day - collagen level 2%; M4-C0 = Marination time 4 days - collagen level 0%; M4-C1 = Marination time 4 days - collagen level 1%; M4-C2 = Marination time 4 days - collagen level 2%; M8-C0 = Marination time 8 days - collagen level 0%; M8-C1 = Marination time 8 days - collagen level 1%; M8-C2 = Marination time 8 days - collagen level 2%.

Based on Fig. 3, it can be seen that the results of the interaction between the treatment of marination time and the level of collagen extract show quite varied values. The highest MSF value was the combination of 4 days of MT with LCE of 0% (M4-C0)(1.00 kg/cm^2), while the lowest value was 8 days of MT and LCE of 1% (M8C1)(0.25 kg/cm^2).

Cooking Loss (CL)

Fig. 4 shows the average CLvalue of LD muscle using different marination time and collagen extract levels. The results of statistical tests showed that the application of different marination time treatments had a very significant effect ($p<0.01$) on physical properties, especially cooking losses. On the other hand, the application of collagen extract using different levels did not show a significant effect ($p>0.05$) on the value of CL. However, although one of them did not show a significant effect, the results of the interaction test showed a very real interaction ($p<0.01$) between the two treatments applied. The comparison of the CL value of LD muscle using cattle bone collagen extract as a marination material was presented in Figure 4.

Fig 4 shows the comparison of CL at various treatment interactions. The interaction between marination time and collagen extract levels showed varying CL. The highest value of CL was the interaction of 8 days of MT with LCE of 0% (M8-C0) (36.17%±0.76), while the lowest value of CL was the result of the interaction of 4 days of marination time with collagen levels of 2% (M4-C2)(28.83%±0.76).

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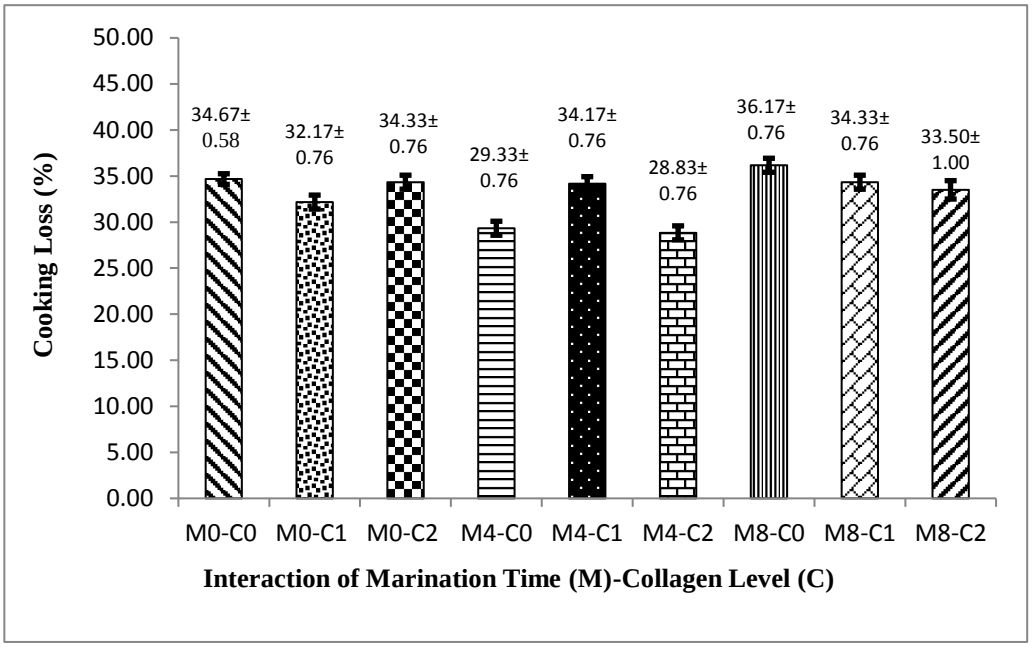

Fig 4. Graph of the cooking loss (CL)(%) value of meat from the Longissimus dorsi (LD) muscle part marinated collagen extract at the time of marination with different levels of marination

Note:
M0-C0 = Marination time 0 day - collagen level 0%; M0-C1 = Marination time 0 day - collagen level 1%; M0-C2 = Marination time 0 day - collagen level 2%; M4-C0 = Marination time 4 days - collagen level 0%; M4-C1 = Marination time 4 days - collagen level 1%; M4-C2 = Marination time 4 days - collagen level 2%; M8-C0 = Marination time 8 days - collagen level 0%; M8-C1 = Marination time 8 days - collagen level 1%; M8-C2 = Marination time 8 days - collagen level 2%.

Water Holding Capacity

WHC is the ability of meat to hold water particles in meat protein. The addition of liquid during the process affects the properties of the meat. Water retention plays a role in determining meat quality. Adding ingredients to the meat will affect the WHC value [8].

Based on the results of statistical tests related to the value of WHC (Table 1), it can be seen that the application of the treatment of marination time and different levels of collagen extract has no significant effect ($p>0.05$) on the WHC value of LD muscle. However, there was a very significant interaction between the two treatments ($p<0.01$). This means that the two treatments are likely to give a real response when applied simultaneously to a process. The graph (Fig. 5) shows that the resulting WHC values varied considerably between treatment combinations.

The highest WHC value is the result of the interaction of 4 days of marination time with 1% collagen level (M4-C1)(63.22%±3.01), while the lowest value is 0 days of marination time with 1% collagen extract level (M0C1)(42.87%±2.76). Protein content of meat affects the WHC value, emulsion capacity and nutritional value of meat [9]. Changes in WHC values are also related to the protein oxidation process [10]. The process of protein oxidation can cause changes in protein solubility and functional properties such as gelation, emulsifying properties and WHC. In addition, the process of protein oxidation is thought to be the cause of the decrease in tenderness and wetness [11].

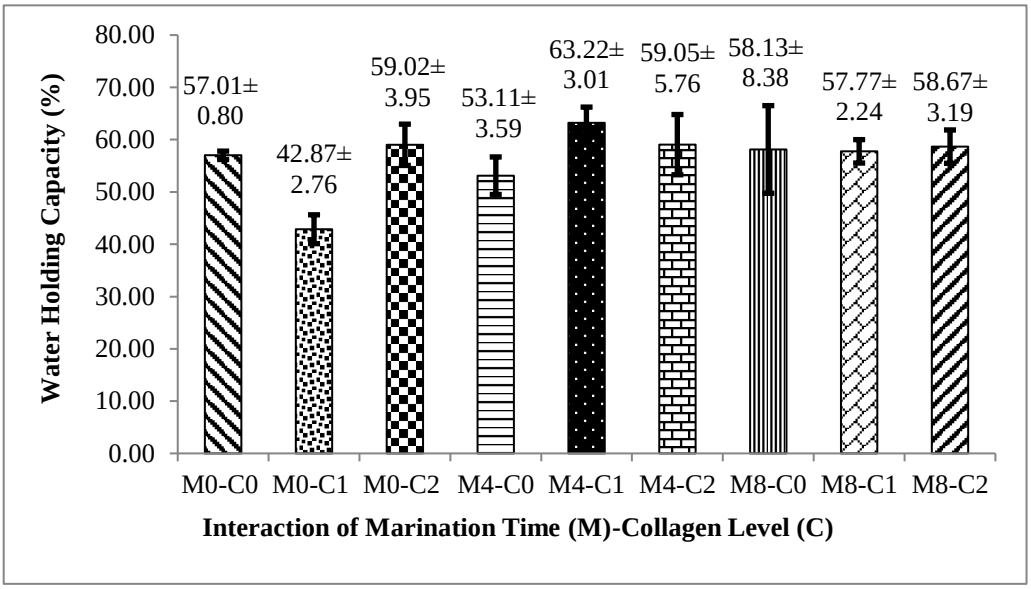

Fig 5. Graph of the water holding capacity (WHC)(%) value of meat from the Longissimus dorsi muscle part marinated collagen extract at the time of marination with different levels of marination

Note:

M0-C0 = Marination time 0 day - collagen level 0%; M0-C1 = Marination time 0 day - collagen level 1%; M0-C2 = Marination time 0 day - collagen level 2%; M4-C0 = Marination time 4 days - collagen level 0%; M4-C1 = Marination time 4 days - collagen level 1%; M4-C2 = Marination time 4 days - collagen level 2%; M8-C0 = Marination time 8 days - collagen level 0%; M8-C1 = Marination time 8 days - collagen level 1%; M8-C2 = Marination time 8 days - collagen level 2%.

CONCLUSION

Increasing the marination time from 0 to 8 days using collagen extract levels from 0% to 2% decreased the value of meat shear force and cooking loss in meat, especially the logissimus dorsi muscle. The application of the 8-day marination time treatment using the 2% collagen extract level (M8-C2) resulted in better physical characteristics of the meat. The application of marination time and the level of use of collagen extract needs to be done simultaneously in a combination form.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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