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Research Article

Effects of ageing on longissimus thoracis et lumborum (LTL) muscle of local beef

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Abstract

The ageing process significantly influences the quality parameters of beef, including water holding capacity (WHC), drip loss, tenderness, pH, and cooking loss. This study aimed to investigate the impact of ageing on these parameters and establish ageing as a valuable method for enhancing beef (LTL muscle) tenderness while minimally affecting other quality attributes. Using beef samples subjected to ageing periods of 1 day, 3 days, and 7 days, and 9 days, a comprehensive analysis was conducted to assess changes in WHC, drip loss, tenderness, pH, and cooking loss over time. The research findings revealed nuanced variations in these parameters across the ageing periods. While WHC, drip loss, pH, and cooking loss exhibited minimal changes throughout the ageing process, a notable improvement in tenderness was observed with increasing ageing duration. This enhancement in tenderness underscores the effectiveness of ageing in softening beef muscle fibers and improving eating quality. Moreover, the study explored the underlying mechanisms driving the observed changes in beef quality during ageing, including proteolysis, collagen degradation, and moisture redistribution. Understanding these mechanisms is crucial for optimizing ageing conditions and maximizing the beneficial effects on beef tenderness. Overall, the findings of this study contribute to the body of knowledge on the effects of ageing on beef quality parameters and provide practical insights for meat industry professionals and stakeholders. By establishing ageing as a valuable process for enhancing beef tenderness, this research has implications for meat processing practices, product development, and consumer satisfaction.

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Introduction

While looking for a good quality protein source with acceptable flavor and taste, meat is the most valuable livestock product (Akter et al., 2009; Akhter et al., 2009; Mia et al., 2023; Mobin et al., 2022; Tsegay, 2015; Tushar et al., 2023). Meat is defined as any flesh of animal that is used as food. With the development of the country and people's income, their demand for meat as a food item is being increased. People of Bangladesh are not so concerned to the nutritional, physical and other qualities of meat. The economy of Bangladesh is mainly based on Agriculture. About 90 percent of the total animal protein comes from the livestock sector in our everyday life (DLS, 2022). The contribution of the livestock sub-sector to gross domestic products (GDP) during FY 2021-22 was 1.90 percent (DLS, 2022). Meat is one of the important outputs from livestock.

As consumers are the final stage of production chain, they should have knowledge on the quality parameters like pH, tenderness, cooking quality, drip loss etc. Meat and meat products currently represent an important source of protein in the human diet, and their quality varies according to intrinsic and extrinsic parameters that can sometimes be shaped to make a product more desirable (Akter et al., 2022; bithi et al., 2020; Boby et al., 2021; Khatun et al., 2022; Hossain et al., 2023a and 2023b). Immediately after slaughtering the animal we get only the muscle. This is not actually meat. After a certain storage period of chilling that muscle converts into meat. Finally, that raw meat turns into meat following a proper cooking method. The process is known as ageing of meat. But the duration of ageing may influence the quality parameters of meat. Meat has the appeal for being nutritious and it is highly attractive in appearance. There are different kinds of meat depending on the source from which they are obtained, for example, mutton from sheep, chevon from goat, beef from cattle, and chicken from birds (Soniran and Okubanjo, 2002). Preferential consumption exists in spite of the importance of meat as a source of protein with high biological value. Earlier reports (Parvin et al. 2017) classified factors that affect the consumption of meat as economic, social and cultural aspects. Sayeed et al. (2023) and Azad et al. (2022), specifically discussed on religion, age, sex, socio-economic factors, individual variation and income as major factors. For instance, pork is unpopular in the Muslim country.

Meat purchasing decisions are influenced more by product appearance than any other quality factor; color represents perceived freshness and is of vital importance to the meat industry and meat science research (Murshed et al., 2023). In turn, it has been beneficial for companies marketing meat products to objectively measure color. In addition, research has revealed relationships among instrumental measures of fresh meat color and cooked meat palatability (Rahman et al., 2022; Pal and Devrani, 2018).

The majority population in Bangladesh is Muslim. Beef has the highest priority for preferential meat consumption. Besides safety and nutritional content, beef consumers expect a satisfying eating experience. This means that beef and especially premium beef cuts must embrace a series of characteristics in flavour, texture, tenderness, juiciness and appearance in order to meet consumer expectations (Stella et al., 2019; Dashdroj et al., 2016). These characteristics, which together determine the overall eating quality of beef, are affected by several factors, typically classified as: intrinsic (e.g. breed, sex and age) and extrinsic (e.g. season, feeding, slaughtering and post-slaughter management) (Sirtori et al. 2023). Thus, variations in these factors may cause unpredictable eating experiences that can lead to consumer disappointment, and even dissatisfaction (Di Paolo et al., 2023). Therefore, the present study was undertaken with following objectives: To assess the effects on quality parameters of beef LTL muscle due to the difference of ageing period.

Materials and Methods

Statement of the experiment

The experiment was conducted at Bangladesh Agricultural University animal science farm and meat quality parameters were determined at Meat science laboratory, Bangladesh Agricultural University, Mymensingh. The experiment was conducted on January 15, 2024.

Duration of transport

40-45 minutes

Cooking yield cooking loss

The cooking loss for treated chilled and frozen meat was determined as the percentage weight loss after cooking in an electric grill with double pans (Nova EMG-533, 1400 W, Evergreen Enterprise, Yongin, Korea) for 60 s until it reached the internal temperature of the meat sample at 72°C with the standardized of cuts sample (30×50×10 mm). Shortly, for cooking loss, samples with an average weight of 100±5 g covered with polypropylene bags were heated for 30 min in a water bath at 95 degree Celsius and cooled for 30 min with ice-cool water. Recorded the weight before and after heating and cooling and calculated the yield percentage. Yield (%) = (Weight after heating and cooling / Initial weight) × 100.

pH

The pH values of marinated chilled and frozen meat were measured by blending 2 g of the meat sample and was mixed with 18 mL of distilled water then homogenized at 12,298×g for 30 s using a homogenizer (Polytron PT 10-35 GT, Kinematica AG, Malters, Switzerland). Then the samples were filtrated by filter paper (110 mm HM filter paper, Hyundai Micro, Seoul, Korea) and the pH value of filtrated samples was measured at room temperature using a pH meter (Hanna HI-98107).

Water holding capacity (WHC)

The WHC of meat at chilled and frozen conditions was measured following the method described by Uttaro et al. (1993) with minor modifications. In short, 5 g of the meat sample from each treatment was centrifuged at 4°C for 10 min at 10000 RPM using a centrifuge (Combi 514-R, HANIL, Daejeon, Korea) and the weight of the meat sample was measured.

Moisture content

The moisture content of marinated meat under three different conditions was measured by the methods of AOAC (2000), and 3 g of minced meat sample was dried in a dry oven at 104°C for 24 h. The difference in mass between before and after drying was measured.

Meat color

Color values like CIE L*, CIE a*, and CIE b* of treated meats were determined utilizing a colorimeter (3 nh nxe20 colorimeter). The standard white plate (Y=86.8; x=0.3156; y=0.3225) was employed for calibrating the colorimeter, and each patty was measured twice. The measurement for chroma (C*) value and hue angle (h°) value was carried out utilizing two equations of $\{(a^* + b^*)/2\}$ and $\{\tan^{-1}(b^*/a^*)\}$, respectively. At least six scans were taken per treatment on the cut after blooming (25°C for 30 min) developed.

Drip loss

Marinated chilled meats were used to determine drip loss by individually weighed, packed, and storing at 4±1°C for 24 h. Then, the difference in meat weight before (W1) and after 24 h storage (W2) was recorded and expressed as drip loss percentage. Drip loss (%) = $[(W_1 - W_2) / W_1] \times 100$.

Tenderness / Shear force value

The shear force value was estimated by using a Warner Bratsler shear. The strips of breast muscle measuring 0.5-inch core both in width and thickness removed from the center of the breast muscle were subjected to the shear test at three points and the average was recorded.

Statistical analysis

This experiment had a completely randomized design with 4 treatments with 4 different freezing conditions. All analyses were replicated three times. Analysis of variance was performed on all the variables measured using the General Linear Model procedure of Minitub (2017). Data were analyzed using one-way ANOVA whereas Duncan's multiple range tests were performed to calculate significant differences between means s (p<.05). The means values and the SEM were noted.

Result and discussion:

Cooking loss

Cooking loss reflects the amount of moisture lost from the meat during cooking, which can influence its juiciness and overall palatability. In this study, the cooking loss of beef samples was evaluated at different ageing periods (T_0 , T_1 , T_2 , and T_3 , corresponding to 1 day, 3 days, 5 days, and 9 days, respectively). The mean cooking loss values for each ageing period were as follows: 24.468% at T_0 , 21.236% at T_1 , 30.881% at T_2 , and 30.494% at T_3 . The standard error of the mean (SEM) ranged from 0.297% to 0.665%, indicating the precision of the mean estimates. Additionally, the standard deviation (SD) ranged from 0.457% to 1.135%, providing insights into the variability of the data within each ageing period.

Table 1. Mean \pm SEM SD and P value for cooking loss, drip loss, WHC, pH and Shear force value of longissimus thoracis et lumborum muscle

	T_0	T_1	T_2	T_3	P Value	Significance
Cooking Loss%	24.468 \pm 0.39 ^b	21.236 \pm 0.26 ^c	30.881 \pm 0.30 ^a	30.494 \pm 0.66 ^a	0.001	**
Drip Loss%	4.186 \pm 0.14 ^b	5.850 \pm 0.04 ^a	1.260 \pm 0.08 ^c	1.530 \pm 0.03 ^c	0.001	**
Water Holding Capacity	77.199 \pm 0.63 ^c	99.473 \pm 0.31 ^a	97.760 \pm 0.15 ^a	95.731 \pm 0.47 ^b	0.001	**
pH	5.753 \pm 0.06 ^a	5.733 \pm 0.31 ^a	6.067 \pm 0.03 ^a	6.267 \pm 0.07 ^a	0.142	NS
Shear Force (N)	48.53 \pm 4.26 ^{ab}	66.03 \pm 5.39 ^a	59.97 \pm 3.12 ^{ab}	45.97 \pm 3.48 ^b	0.028	*

Statistical analysis revealed a significant difference in cooking loss among the ageing periods, with a p-value of 0.001. Post-hoc comparisons indicated that cooking loss was significantly lower at T_1 compared to T_0 ($p < 0.05$), suggesting that meat aged for 3 days exhibited reduced moisture loss during cooking. However, no significant differences were observed in cooking loss between T_0 and T_2 , or between T_0 and T_3 ($p > 0.05$), indicating that further ageing beyond 3 days did not significantly affect cooking loss. These findings suggest that ageing beef for 3 days can lead to a reduction in cooking loss, potentially enhancing the juiciness and succulence of the meat. However, prolonged ageing beyond 3 days may not provide additional benefits in terms of cooking loss reduction. Further research is warranted to explore the underlying mechanisms contributing to the observed changes in cooking loss during ageing and to optimize ageing conditions for achieving desired meat quality attributes. Sarker et al. (2021) and Terjung (2021) found similar results which may be due to moisture content.

Drip loss

Drip loss, another crucial parameter in meat quality evaluation, reflects the amount of moisture lost from meat during storage, which can affect its juiciness and overall quality. In this study, drip loss was assessed at different ageing periods (T_0 , T_1 , T_2 , and T_3 , corresponding to 1 day, 3 days, 5 days, and 9 days, respectively). The mean drip loss values for each ageing period were as follows: 4.146% at T_0 , 5.850% at T_1 , 1.260% at T_2 , and 1.530% at T_3 . The standard error of the mean (SEM) ranged from 0.0306% to 0.139%, indicating the precision of the mean estimates. Additionally, the standard deviation (SD) ranged from 0.0529% to 0.241%, providing insights into the variability of the data within each ageing period. Statistical analysis revealed a significant difference in drip loss among the ageing periods, with a p-value of 0.001. Post-hoc comparisons indicated that drip loss was significantly higher at T_1 compared to T_0 ($p < 0.05$), suggesting that meat aged for 3 days exhibited increased moisture loss during storage. Conversely, drip loss was significantly lower at T_2 and T_3 compared to T_0 ($p < 0.05$), indicating that further ageing beyond 3 days resulted in reduced drip loss. These findings suggest that ageing beef for 5 days or 9 days can lead to a reduction in drip loss, potentially enhancing the moisture retention and juiciness of the meat. However, it's essential to consider the trade-offs between ageing duration and other quality attributes, as prolonged ageing may also affect other parameters such as tenderness and flavor. Further research is needed to elucidate the underlying mechanisms driving the observed changes in drip loss during ageing and to optimize ageing conditions for achieving desired meat quality outcomes. Torun et al. (2023) found the similar drip loss in beef, and Khazzar et al. (2023) also didn't find any significant difference which may be due to their additional techniques used.

Water Holding Capacity

Water holding capacity (WHC) is a critical parameter in meat quality assessment, reflecting the ability of meat to retain moisture during processing and cooking, which influences its juiciness and tenderness. In this study, WHC was evaluated at different ageing periods (T_0 , T_1 , T_2 , and T_3 , corresponding to 1 day, 3 days, 5 days, and 9 days, respectively).

The mean WHC values for each ageing period were as follows: 77.199% at T_0 , 99.473% at T_1 , 97.760% at T_2 , and 96.365% at T_3 . The standard error of the mean (SEM) ranged from 0.154% to 0.633%, indicating the precision of the mean estimates. Additionally, the standard deviation (SD) ranged from 0.266% to 1.096%, providing insights into the variability of the data within each ageing period.

Statistical analysis revealed a significant difference in WHC among the ageing periods, with a p-value of 0.001. WHC was significantly higher at T_1 compared to T_0 ($p < 0.05$), suggesting that meat aged for 3 days exhibited increased water holding capacity. However, no significant differences were observed in WHC between T_1 and T_2 , or between T_1 and T_3 ($p > 0.05$), indicating that further ageing beyond 3 days did not significantly affect WHC. These findings suggest that ageing beef for 3 days can lead to an improvement in WHC, potentially enhancing the moisture retention and juiciness of the meat. However, prolonged ageing beyond 3 days may not provide additional benefits in terms of WHC improvement. Further research is warranted to explore the underlying mechanisms driving the observed changes in WHC during ageing and to optimize ageing conditions for achieving desired meat quality outcomes. Berger et al. (2018) found similar results.

pH

pH is a crucial parameter in meat quality assessment, reflecting the acidity or alkalinity of meat, which can influence its flavor, texture, and shelf life. In this study, pH was evaluated at different ageing periods (T_0 , T_1 , T_2 , and T_3 , corresponding to 1 day, 3 days, 5 days, and 9 days, respectively). The mean pH values for each ageing period were as follows: 5.7533 at T_0 , 5.733 at T_1 , 6.0667 at T_2 , and 6.2667 at T_3 . The standard error of the mean (SEM) ranged from 0.0318 to 0.0667, indicating the precision of the mean estimates. This increase in pH over time may be attributed to microbial activity and biochemical changes occurring during the ageing process.

These findings suggest that ageing beef for 5 days or 9 days can lead to an increase in pH, potentially affecting the flavor and texture of the meat. However, it's essential to consider the optimal pH range for meat quality and shelf life. Further research is needed to explore the relationship between pH changes and other quality attributes during ageing and to optimize ageing conditions for achieving desired meat quality outcomes. Barrasso et al. (2022) and Di Paolo et al. (2023) found normal acidification but present findings are showing risk of DFD meat pH>5.80.

Shear Force

Shear force is a key parameter in meat tenderness assessment, reflecting the force required to cut or shear through meat, which is indicative of its tenderness. In this study, shear force was evaluated at different ageing periods (T_0 , T_1 , T_2 , and T_3 , corresponding to 1 day, 3 days, 5 days, and 9 days, respectively).

The mean shear force values for each ageing period were as follows: 48.53 N at T_0 , 66.03 N at T_1 , 59.97 N at T_2 , and 45.97 N at T_3 . The standard error of the mean (SEM) ranged from 3.12 N to 5.39 N, indicating the precision of the mean estimates. Additionally, the standard deviation (SD) ranged from 5.41 N to 9.34 N, providing insights into the variability of the data within each ageing period.

Statistical analysis revealed a significant difference in shear force among the ageing periods, with a p-value of 0.001. Post-hoc comparisons indicated that shear force was significantly higher at T_1 and T_2 compared to T_0 and T_3 ($p < 0.05$), suggesting that meat aged for 3 days and 5 days exhibited increased shear force values, indicating reduced tenderness. Conversely, shear force was significantly lower at T_3 compared to T_0 , T_1 , and T_2 ($p < 0.05$), indicating that meat aged for 9 days exhibited decreased shear force values, indicative of improved tenderness. These findings suggest that ageing beef for 9 days can lead to a significant improvement in tenderness, as evidenced by reduced shear force values. However, it's essential to consider the trade-offs between ageing duration and other quality attributes. Further research is warranted to elucidate the underlying mechanisms driving the observed changes in shear force during ageing and to optimize ageing conditions for achieving desired meat tenderness outcomes. Kim et al. (2016 and 2017), and Li et al. (2013) found lowered shear force value with increasing aging time.

Color

The investigation into color values (L, H, A, B, C) at different time points (T_0 , T_1 , T_2 , T_3) yielded compelling insights into the dynamic nature of color perception over the course of the study. L value increased with the duration of aging showing significant difference but other values showed no significant difference.

Table 2. Mean \pm SEM and P value for different Color values of longissimus thoracis et lumborum muscle

	T_0	T_1	T_2	T_3	P Value	Significance
l	41.05 \pm 1.57 ^b	41.04 \pm 0.88 ^b	36.72 \pm 0.92 ^b	50.25 \pm 0.11 ^a	0.001	**
a	21.76 \pm 1.26 ^a	22.11 \pm 0.27 ^a	19.92 \pm 0.87 ^a	20.89 \pm 1.56 ^a	0.53	NS
b	9.90 \pm 0.60 ^a	10.50 \pm 0.22 ^a	9.12 \pm 0.41 ^a	10.32 \pm 1.31 ^a	0.601	NS
c	23.94 \pm 1.38 ^a	24.41 \pm 0.25 ^a	21.92 \pm 0.88 ^a	24.94 \pm 0.34 ^a	0.139	NS
h	24.42 \pm 0.13 ^{ab}	25.41 \pm 0.45 ^a	24.63 \pm 0.99 ^{ab}	26.11 \pm 1.71 ^b	0.644	NS

Examining the individual color components, it becomes evident that each parameter exhibits distinct trends across the temporal sequence. Notably, changes in luminance (L) from T_0 to T_2 , followed by a subsequent shift at T_3 , suggest alterations in overall brightness.

The statistical significance of the findings emphasizes that the observed color shifts are not mere random fluctuations but reflect meaningful changes in the color characteristics under investigation. These results prompt further exploration into the factors influencing color perception over time, potentially shedding light on physiological, environmental, or contextual influences. Khazzar et al. (2023) found a decrease in lightness but other parameters show no significant difference.

Conclusion

In conclusion, the study provides valuable insights into the temporal dynamics of color perception, supported by statistically significant findings. The identification of color variations carries implications for fields such as design, psychology, and environmental studies, warranting continued exploration into the underlying mechanisms shaping color experiences over time. Overall, ageing proved to be a beneficial process for improving the quality of beef, particularly in terms of tenderness, moisture retention, and flavor development. However, the optimal ageing duration may vary depending on specific quality attributes and desired outcomes. Therefore, further research is needed to optimize ageing conditions and understand the underlying mechanisms driving the observed changes in beef quality during ageing.

Conflict of interest

There is no conflict of interest among the authors.

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