Bangladesh Journal of Animal Science
Journal homepage: http://www.banglajol.info/index.php/BJAS

Comparative evaluation of physical quality attributes of broiler meat under fresh and chilled conditions

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ARTICLE INFO

Article history:
Received: 6 November 2025
Revised: 3 December 2025
Accepted: 24 December 2025
Published:31 December 2025

Keywords:
Fresh broiler meat, Chilled broiler meat, Meat Quality, Color, pH, Temperature

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ISSN: 0003-3588

OPEN ACCESS

ABSTRACT

The current study evaluated the impact of storage conditions after slaughter on the physicochemical characteristics of broiler breast meat, contrasting fresh carcasses assessed within 3 hours post-mortem with chilled carcasses maintained at 4 °C for 24 hours. Thirty broilers (1800 ± 50 g) were processed at the Meat Research Unit under the department of Animal Science at Bangladesh Agricultural University, and breast muscles (Pectoralis superficialis) underwent quality evaluations encompassing pH, color (*L*, a*, b**), internal temperature, water-holding capacity (WHC), cooking loss, drip loss, and shear force. The findings indicated a notable decrease in pH and internal temperature in chilled meat when contrasted with fresh samples ($p < 0.001$), highlighting the usual post-mortem glycolytic acidification and thermal reduction processes. Chilled meat exhibited markedly reduced shear force values ($p < 0.001$), indicating enhanced tenderness after rigor resolution. The cooking loss was significantly higher in fresh samples ($p = 0.004$), while chilled meat demonstrated enhanced water-holding capacity (WHC) ($p < 0.001$). The color values exhibited slight differences across treatments, with no notable effects detected for *L** and *a**. However, the chilled meat displayed a minor decrease in yellowness (*b**, $p = 0.048$). The reduction in drip loss was significantly greater in chilled samples ($p < 0.001$), underscoring improved moisture retention throughout the storage period. In summary, chilled broiler breast meat demonstrated favorable textural and functional attributes while preserving visual appeal, indicating that brief chilling is an advantageous post-slaughter method for boosting meat tenderness, ensuring color stability, and enhancing processing yield. The results indicate a strong inclination within the industry towards chilled poultry meat, positioning it as a superior option compared to the immediate post-slaughter sale of fresh meat.

Introduction

Chicken meat, especially from fast-growing commercial broilers, is one of the most commonly eaten animal proteins around the world. Chicken meat is termed as white meat, which is becoming more and more popular as a result of its high protein and low cholesterol content (Akter *et al.,* 2022; Azad *et al.,* 2021; Das *et al.,* 2022). This is also cheap and can be used in many different ways in cooking (Rathod *et al.,* 2017). In Bangladesh and many other South Asian countries, broiler meat is a big part of communal meals and celebrations. The demand for broiler chicken goes up a lot during big events like weddings, religious festivals, and social gatherings. For one event, 300 to 400 birds are often needed to make a variety of traditional dishes. In these situations, keeping the quality of the meat is important not only to meet customers' expectations for taste, tenderness, and juiciness but also to make sure that large-scale preparations are safe and consistent.

How to Cite

S Nahar, JF Juthi, MM Mahbub, MMR Raihan and MAK Azad (2025). **Comparative evaluation of physical quality attributes of broiler meat under fresh and chilled conditions**. *Bangladesh Journal of Animal Science* 54 (4): 74-80. https://doi.org/10.3329/bjas.v54i4.86820

The physicochemical and sensory properties of meat depend a lot on how it was stored before cooking. For example, it could be fresh (about three hours after slaughter) or chilled (kept at refrigeration temperatures, usually 0–4 °C, for a set amount of time). Fresh meat shortly after slaughter is still undergoing postmortem biochemical processes, including ATP depletion, lactic acid accumulation, pH decline, and the onset of rigor mortis. These changes have a direct effect on the ability to hold water, the color, and the tenderness, which are all important for how people see the food and how well it cooks (Debut *et al.,* 2005; Mir *et al.,* 2017). In contrast, chilling is a common way to keep food fresh that slows the growth of microbes, lowers the activity of enzymes, and makes food last longer. However, chilled storage can also cause proteins to break down, drip loss, oxidative changes, and small changes in color, all of which can affect the meat's taste and cooking performance (Sams, 2000; Rathod *et al.,* 2017).

These quality differences have been shown in comparative studies. For instance, Rathod *et al.* (2017) showed that fresh poultry meat had more moisture and fewer microbes than chilled and frozen samples, even though chilled meat lasted longer. Dey *et al.* (2020) found that differences in how wet markets handle, transport, and store meat affected lipid oxidation (TBARS values) and protein degradation (tyrosine values). This shows how important post-slaughter handling is for determining the final quality of meat.

When there are dozens of cooks working with hundreds of broiler carcasses for big feasts, these differences in quality become very important. Even small differences in how much water each bird holds, how it feels, or how it tastes can add up to big effects on how much food you get from cooking, how consistent it tastes, and how happy customers are overall. Furthermore, food safety hazards necessitate meticulous management in mass catering environments, as inadequate chilling or prolonged exposure of fresh meat can elevate the risk of microbial contamination, potentially resulting in foodborne illness outbreaks (Fletcher, 2002; Mir *et al.,* 2017).

Consequently, a methodical comparison of fresh (3 hours post-slaughter) versus chilled broiler meat is essential in the context of feast preparation and bulk culinary operations. Such research enables caterers, event planners, and meat suppliers to make evidence-based decisions by understanding how postmortem handling influences key physicochemical properties, including pH, water-holding capacity, color, drip loss, cooking loss, and tenderness. Therefore, the objective of this study was to monitor changes in pH, temperature, and color of broiler meat during the first three hours post-slaughter, and to evaluate the physicochemical quality attributes of broiler breast meat in fresh (0 h) versus chilled (24 h at 4 °C) conditions. This approach aimed to determine which condition offers superior technological and visual quality for consumer purchase and processing applications.

MATERIALS AND METHODS

Ethical approval

The experiment was conducted at the Meat Research Unit, Bangladesh Agricultural University, Mymensingh, under the certification number AWEEC/BAU/2025(2)/44(a).

Experimental Site

This experiment was conducted at the Meat Research Unit, Bangladesh Agricultural University and Animal Science Laboratory, Department of Animal Science, Bangladesh Agricultural University, Mymensingh.

Sample Collection and Preparation

A total of 30 broilers of 1800±50 g live weight was taken from Meat Research unit of Meat Research Unit farm. After taking the live weight of the birds, the birds were slaughtered, bled, and defeathered. Then, after evisceration of the carcasses; head, and shank were removed. Then the experiment is divided in 2 parts. In the first part, the carcass's pH and color were measured in fresh condition and in chilled condition (24 hours) at different time intervals (control, 20 min, 40min, 60 min, 120min, 180 min). And in the second part of the experiment, all the meat quality parameters were again compared between fresh and chilled (24 hours) conditions of carcasses.

Measurement of quality parameters pH

The pH of the meatball samples was determined by the direct method using a pre-calibrated portable pH meter (HI98163, HANNA Instruments, Australia). The tip of the above pH meter was inserted into the meat sample until a stable reading was obtained.

Determination of Color

Instrumental color (CIE *L* a* b**) was taken from breast muscles samples at different time intervals after postmortem. Then the meat samples were refrigerated for 24 hours at 4°C temperature and the color of breast meat was individually measured using Konica Chroma

Meters CR- 22 410 (Konica Minolta Inc., Tokyo, Japan). For each reading, 3 measurements were performed, and the final value for each sample was the average of those readings. Breast meat color were expressed in the CIE LAB dimensions of lightness (*L**), redness (*a**), and yellowness (*b**).

Water Holding Capacity

WHC was measured by centrifuging each 1 g sample at 10,000 rpm for 10 minutes at 4℃. WHC was expressed as the ratio of the sample's weight after centrifugation to it's initial weight (Szmańko *et al.,* 2021).

$$WHC\ (\%) = \frac{sample\ weight\ after\ centifugation(\%)}{sample\ weight\ before\ centifugation(\%)} \times 100$$

Drip loss

Samples were stored in a refrigerator at 4 °C for 48 hours to measure drip loss. Broiler breast samples were suspended in tightly sealed plastic containers and kept at 4 °C for 48 hours following the method described by Honikel (1998). Drip loss was calculated as the percentage of weight loss after suspension. Drip loss was estimated by using the following calculation:

$$Drip\ loss\ (\%) = \frac{initial\ weight\ of\ the\ sample\ -\ final\ weight\ of\ the\ sample}{initial\ weight\ of\ the\ sample} \times 100$$

Cooking loss

Cooking loss was determined by collecting 50-60 g sample from the upper breast muscle (W1) and sealed in a polythene bag, then tagged and double-sealed in another bag. The water bath was filled two-thirds and heat the meat until the internal temperature reached to 72℃. Cooking loss was calculated as a percentage of weight loss during cooking (Vujadinović *et al.,* 2014).

$$Cooking\ loss\ (\%) = \frac{(wt.before\ cooking - wt.after\ cooking)}{wt.before\ cooking} \times 100$$

Statistical model and analysis

Data were analyzed using Minitab 17. A One-Way ANOVA was performed to assess significant differences between the brands. Post-hoc comparisons were conducted using the Tukey test at ($p < 0.05$) to identify pairwise differences. Results are presented as mean ± standard error (SE).

Results and Discussion

The study assessed the effect of storage conditions (fresh vs. chilled) on the physical quality attributes of Broiler breast meat weighing approximately 1800 ± 50g. Parameters measured include pH, cooking loss, drip loss, water holding capacity (WHC), and meat color attributes (*L*, a*, b**).

Table 1: Pectoralis superficialis muscle of broiler breast meat at fresh condition

Variable	T0	T1	T2	T3	T4	T5	P-value
L*	58.79±0.39^{a}	58.78±0.33^{a}	58.91±0.52^{a}	58.56±0.87^{a}	60.74±0.58^{a}	61.06±0.57^{a}	**0.012**
a*	8.20±0.29^{a}	7.64±0.30 ^{ab}	7.18 ±0.43^{ab}	7.64 ±0.21^{ab}	6.81 ±0.37^{ab}	6.81 ±0.37^{ab}	**0.032**
b*	15.27±0.16^{b}	15.39±0.24^{b}	15.38±0.54^{b}	17.49±0.39^{a}	17.66±0.29^{a}	17.15±0.73^{ab}	**<0.001**
c	16.04±0.66^{c}	16.52±0.39^{bc}	18.70±.67^{ab}	18.33±0.49^{abc}	19.57±0.64^{a}	18.75±0.66^{ab}	**0.002**
h	60.70±0.36^{b}	63.17±0.37^{ab}	64.80±1.08^{a}	65.16±0.62^{a}	63.47±1.42^{ab}	65.90±1.17^{a}	**0.009**
P^{H}	6.21±0.06^{a}	6.10±0.05^{a}	5.96±0.13^{ab}	5.49±0.15^{c}	5.49±0.15^{c}	5.55±0.10^{bc}	**<0.001**
Temp	32.46±0.31^{a}	30.96±0.29^{a}	31.26±0.32^{a}	31.44±0.60^{a}	28.70±0.53^{b}	28.68±0.44^{b}	**<0.001**

Data are Mean ± SEM. Mean ± SEM in each row having different superscript varies significantly at values p<0.05. Here, T0: 0 min; T1: 20 min; T2: 40 min; T3: 60 min; T4: 120 min; T5: 180 min.

Postmortem Changes in pH and Color of Fresh Broiler Meat in Ambient Temperature

Table 1 demonstrates that postmortem time had a notable influence on several physicochemical characteristics of broiler breast meat. Lightness (*L**) remained relatively stable from T0 to T3; however, a marked increase was observed at 120 and 180 minutes (T4 and T5), where L* values reached 60.74 and 61.06, respectively. This significant rise ($p > 0.05$) suggests that the meat surface became progressively brighter as postmortem time advanced. Redness (*a**) was initially highest at T0 and exhibited a gradual decline, while yellowness (*b**) and chroma (*c**) increased significantly from T3 onward. These changes indicate enhanced color saturation and a more vivid appearance in later postmortem stages. The concurrent shift in hue angle (*h**) further reflects subtle modifications in the overall visual tone of the meat. Collectively, these color attributes suggest that meat sampled at later time points appeared brighter and more visually appealing due to ongoing biochemical modifications, consistent with pigment behaviors described by Mancini & Hunt (2005).

The pH of the breast muscle exhibited a declining pattern across treatments, reaching its lowest values at T3 and T4. Although not statistically significant ($p > 0.05$), the downward trend is characteristic of early postmortem glycolysis, during which glycogen is converted to lactic acid. This behavior aligns with the findings of Le Bihan-Duval *et al*. (1999), who reported that broiler meat undergoes predictable physicochemical transitions as rigor mortis develops. The simultaneous decline in muscle temperature, particularly at T4 and T5, reflects normal carcass cooling and contributes to slowing microbial activity and enzyme-driven degradation, thereby supporting short-term preservation.

The variations observed in color parameters (*L*, a*, b**) across time intervals are consistent with expected postmortem biochemical changes. Similar observations were made by Augustyńska-Prejsnar *et al.* (2019), who reported that short-term handling and processing conditions have minimal impact on overall color stability in broiler meat. Thus, although numerical fluctuations occurred, the fresh meat maintained generally stable physicochemical characteristics within the first three hours post-slaughter.

Overall, the data illustrate that early postmortem biochemical reactions such as pH decline, pigment shifts, and temperature reduction contribute to subtle but progressive changes in meat appearance and quality. These findings reflect typical muscle-to-meat conversion processes in broilers and emphasize the importance of early post-slaughter handling in determining final product quality.

Effect of Chilled Temperature on the Postmortem pH and Color Characteristics of Broiler Breast Meat

Table 2 shows that chilled storage had a pronounced influence on the physicochemical attributes of broiler breast meat, particularly its color profile, pH, and internal temperature. Lightness (*L**) values were significantly higher at T4 and T5 compared with earlier intervals ($p > 0.05$), indicating that the meat surface became progressively paler as chilling progressed. This increase in lightness is typically associated with moisture redistribution and structural protein changes that enhance light scattering, as described in Lawrie & Ledward (2006).

Table 2: Pectoralis superficialis muscle of broiler breast meat at chilled condition

Variable	T0	T1	T2	T3	T4	T5	P value
L*	55.77±1.17^{bc}	53.69±1.02^{c}	54.59±1.03^{bc}	54.32±1.00^{bc}	58.14±0.64^{ab}	59.84±0.27^{a}	**0.012**
a*	5.34±0.10^{c}	5.70±0.16^{c}	6.11±0.08^{c}	7.78±0.52^{b}	10.29±0.40^{a}	9.37±0.40^{a}	**<0.001**
b*	8.73±0.39^{d}	9.23±0.38^{cd}	10.75±0.28^{bc}	11.46±0.45^{ab}	12.75±0.40^{a}	11.75±0.36^{ab}	**<0.001**
c	9.65±0.44^{b}	9.39±0.36^{b}	11.31±0.45^{b}	13.80±0.52^{a}	15.38±0.86^{a}	15.35±0.63^{a}	**<0.001**
h	61.34±0.54^{a}	57.89±0.64^{b}	57.89±0.55^{b}	57.22±0.64^{b}	53.22±0.68^{c}	56.31±1.02^{b}	**<0.001**
P^{H}	6.15±0.04^{a}	6.19±0.06^{a}	6.04±0.03^{ab}	6.00±0.07^{ab}	5.76±0.11^{bc}	5.64±0.06^{c}	**<0.001**
Temp	35.31±0.49^{a}	32.01±0.72^{b}	31.44±0.29^{b}	29.89±0.40^{bc}	27.75±0.51^{c}	25.53±0.51^{d}	**<0.001**

Data are Mean ± SEM. Mean ± SEM in each row having different superscript varies significantly at values p<0.05. Here, T0: 0 min; T1: 20 min; T2: 40 min; T3: 60 min; T4: 120 min; T5: 180 min.

Redness (*a**) also increased substantially from T3 onward ($p < 0.001$), suggesting improved oxygenation and stabilization of oxymyoglobin as the muscle temperature decreased. A similar pattern was observed for yellowness (*b**) and chroma (*c**), both of which increased significantly across treatments. These rising values signify greater color saturation and a more vivid appearance, indicating that the chilled muscle developed a brighter red–yellow tone over time. The significant reduction in hue angle (*h**), especially in T4, further confirms a shift toward deeper, more saturated coloration, aligning with typical pigment behavior in post-rigor, chilled poultry muscles.

The pH of the meat declined progressively from T0 to T5 ($p < 0.001$), reaching its lowest value in T5. This decrease reflects the continuation and stabilization of postmortem glycolysis under chilled conditions. Lower pH in chilled meat is often associated with protein denaturation, water-binding changes, and long-term color stability (Honikel, 1998). Internal temperature also dropped significantly across treatments ($p < 0.001$), with T5 showing the lowest temperature. This steady reduction demonstrates effective heat dissipation during chilling, a key factor in minimizing bacterial growth and enzymatic activity while improving meat preservation (Zhou *et al.*, 2010).

Overall, the results indicate that chilled storage not only facilitated normal post-rigor biochemical development but also enhanced color saturation and visual appeal in broiler breast meat. These findings align with previous research demonstrating that controlled chilling contributes to improved color stability and overall quality in poultry meat (Devatkal *et al*., 2019; Faustman *et al*., 2010). Thus, chilling represents an effective strategy for maintaining and enhancing broiler meat quality during early postmortem handling.

Comparative Evaluation of Fresh and Chilled Broiler Physical Quality Attributes

Table 3 illustrates clear differences in quality parameters between fresh (T1) and chilled (T2) broiler breast meat, demonstrating the significant impact of a 24-hour chilling period on muscle physiochemistry and functional properties.

Color

Color measurements showed moderate differences between treatments. Lightness (*L**) and redness (*a**) were numerically higher in fresh meat, whereas yellowness (*b**) and chroma (*c**) were significantly greater in T1 ($p < 0.05$), indicating that fresh samples exhibited a brighter and more saturated color profile. Chilled samples (T2) displayed lower *b** and *c** values, suggesting slight pigment oxidation or reduced color vibrancy during storage. Despite these changes, hue angle (*h**) remained statistically similar between treatments, indicating that overall color tone was largely preserved during chilling. These results are consistent with the findings of Devatkal *et al.* (2019), who reported minimal color deterioration in broiler meat during short-term refrigerated storage.

Table 3: Pectoralis superficialis muscle of broiler breast meat at fresh vs chilled conditions

Variable	T1	T2	P value
L*	59.08±0.57[a]	56.92±0.86[a]	0.052
a*	15.07±7.09[a]	7.15±0.53[a]	0.280
b*	14.66±0.53[a]	12.25±1[b]	0.048
c	18.10±0.22[a]	14.38±0.81[b]	<0.001
h	60.88±0.53[a]	58.15±2.95[a]	0.374
Temp	32.64±0.24[a]	19.21±0.37[b]	<0.001
pH	6.50±0.033[a]	5.83±0.031[b]	<0.001
WHC	62.38±0.82[b]	67.10±0.46[a]	<0.001
Cooking loss	12.55±0.32[a]	10.58±0.50[b]	0.004
Drip loss	7.83±0.26[a]	2.66±0.35[b]	<0.001
Shear force	23.63±0.35[a]	17.29±1.45[b]	<0.001

Data are Mean ± SEM. Mean ± SEM in each row having different superscript varies significantly at values p<0.05. Here, T1: Fresh Carcass; T2: Chilled Carcass (After 24 hours in 4℃).

pH and Temperature

Fresh meat exhibited a significantly higher pH (6.50) than chilled samples (5.83) ($p < 0.001$). This decline reflects the progression of postmortem glycolysis, during which lactic acid accumulates and muscle pH approaches its ultimate level. Such pH reduction is characteristic of rigor completion in broiler meat and has important implications for water-holding capacity (WHC) and tenderness (Honikel, 1998; Zhang *et al.*, 2021).

Internal muscle temperature followed a similar pattern, with fresh carcasses remaining warm (32.64°C) and chilled carcasses cooling substantially to 19.21°C ($p < 0.001$). Rapid cooling limits microbial growth and reduces metabolic activity, contributing to improved storage safety and slowed protein degradation (Zhou *et al*., 2010).

Water-Holding Capacity, Drip Loss, and Cooking Loss

Fresh meat showed significantly higher water-holding capacity (WHC) than chilled meat (67.10% vs. 62.38%; $p < 0.001$). This can be attributed to the higher pH of fresh samples, which keeps muscle proteins farther from their isoelectric point, thereby providing greater net charge and more binding sites for water. As pH decreases toward ultimate values, the muscle structure contracts, reducing available space for intracellular water, an effect well documented in poultry and other meats (Huff-Lonergan & Lonergan, 2005; Purslow *et al*., 2016).

Drip loss differed markedly between treatments, with fresh meat exhibiting substantially higher drip loss (7.83%) than chilled meat (2.66%) ($p < 0.001$). Fresh meat is still in a pre-rigor state, and incomplete protein water binding results in greater fluid exudation. Once rigor mortis is complete during chilling, the muscle structure stabilizes, reducing free water movement.

Cooking loss, however, was significantly higher in chilled samples ($p > 0.05$), likely due to greater protein denaturation during storage, which weakens structural integrity and causes more water to be expelled during heating. This result indicates pattern consistent with heat-induced protein contraction described by Vujadinović *et al.* (2014).

Shear Force

Shear force values revealed that chilled meat (17.29 N) was significantly more tender than fresh meat (23.63 N) ($p < 0.001$). This tenderization results from proteolytic enzyme activity (e.g., calpains) during chilled storage, which breaks down myofibrillar proteins and weakens muscle structure. This process is a hallmark of postmortem aging and is well supported by classical meat science literature (Olson & Stromer, 1976).

Overall, the comparison between fresh (T1) and chilled (T2) broiler meat clearly shows that fresh meat retains brighter color, higher water-holding capacity, and lower cooking loss, although it is tougher and experiences greater drip loss. In contrast, chilled meat becomes more tender and structurally stable with significantly lower drip loss, but exhibits reduced WHC and higher cooking loss. These differences align with previous findings showing that short-term chilling improves tenderness and postmortem structural stability while slightly reducing water-binding properties and color intensity (Fletcher, 2002; Mir *et al.*, 2017).

Conclusion

Inclusive, chilled broiler breast meat demonstrated superior acceptability after 24 hours postmortem, likely due to better consistency, microbiological stability, and desirable textural properties. Therefore, from a meat quality perspective, chilling appears to be a favorable post-slaughter handling method compared to marketing fresh meat straight after slaughter. These insights may be useful for enhancing meat processing protocols and attractive product quality in the poultry industry.

Conflict of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research submitted.

Acknowledgements

The work was funded by Krishi Gobeshona Foundation (KGF), Bangladesh. Subproject Title is "Improvement of broiler meat quality and quantity by prolonging rearing period with cost-effective dietary regime" (Project Code: TF 120-L/23).

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