



ISSN: 2456-2912

NAAS Rating (2026): 4.61

VET 2026; 11(5): 320-324

© 2026 VET

www.veterinarypaper.com

Received: 13-02-2026

Accepted: 21-03-2026

All authors' names and
affiliations are given below, after
the references.

Comparative study on pH, R- value, colour and sensory characteristics of commercially available and cold slaughtered buffalo meat

Jahana Sherin Mambulliyalil, VN Vasudevan, Ashika EL, Sunil Kumar NS, Irshad A, Silpa Sasi, Uma R, Thulasi K, Akhila VV and Hridya Vijay C

DOI: <https://www.doi.org/10.22271/veterinary.2026.v11.i5e.3289>

Abstract

The present study was undertaken to evaluate the quality differences between meat obtained from cold slaughtered animals and commercially available buffalo meat, as concerns exist regarding the safety and acceptability of such meat. Samples of commercially available meat were collected at different post-slaughter intervals, while cold slaughtered samples were obtained within twelve hours of death. The experimental approach included analysis of physicochemical parameters such as pH and R-value, instrumental colour measurements, and sensory evaluation of colour and odour. The results revealed significantly higher pH and R-value in cold slaughtered meat, indicating altered post-mortem biochemical changes. Colour evaluation showed variations in redness, while sensory scores were comparatively lower in cold slaughtered samples. These findings indicate compromised quality characteristics in cold slaughtered meat. The study provides scientific evidence for differentiating such meat from properly slaughtered meat and highlights the need for strict monitoring to ensure meat quality and consumer safety.

Keywords: Buffalo meat, Cold slaughter, pH, R-value, Colour, Sensory quality

1. Introduction

Buffalo meat is an important component of the Indian meat industry due to its high nutritional value, economic significance, and export potential. It is rich in high-quality protein, essential amino acids, and vital micronutrients such as iron, zinc, and B-complex vitamins, while containing relatively lower fat and cholesterol compared to other red meats. In India, buffalo meat contributes significantly to food security, rural livelihoods, and foreign exchange earnings.

Meat quality is strongly influenced by slaughter practices and subsequent post-mortem biochemical changes in muscle. Improper slaughter conditions, particularly in cases where meat is derived from animals that die prior to exsanguination (cold-slaughtered meat), result in inadequate bleeding and altered muscle metabolism. These changes lead to significant variations in physicochemical characteristics such as pH, R-value, and colour attributes, ultimately affecting sensory quality and consumer acceptability.

Among the key quality indicators, pH reflects the extent of post-mortem glycolysis and meat stability, while R-value indicates ATP degradation and rigor mortis progression. Instrumental colour parameters (CIE L*, a*, b*) provide objective evaluation of meat appearance, which is closely associated with consumer preference. Sensory attributes such as colour and odour serve as practical indicators of freshness and overall meat quality.

Despite increasing concerns regarding the safety and marketability of cold-slaughtered meat, systematic scientific studies differentiating such meat from properly slaughtered buffalo meat using physicochemical and sensory parameters remain limited, particularly under Indian conditions. Therefore, the present study was undertaken to evaluate and compare pH, R-value, instrumental colour (L*, a*, b*), and sensory attributes (colour and odour) between cold-slaughtered and commercially available buffalo meat.

Corresponding Author:

Jahana Sherin Mambulliyalil

Department of Livestock
Products Technology, College of
Veterinary and Animal Sciences,
Mannuthy, Thrissur, Kerala,
India

2. Materials and Methods

2.1 Study Area / Sample Collection

The study was conducted to compare the physicochemical and sensory characteristics of cold slaughtered (CS) and commercially available (CA) buffalo meat.

Commercially available buffalo meat samples were procured from retail meat outlets where animals were slaughtered by conventional exsanguination without prior stunning. Approximately 200 g of meat samples were collected from the round muscle, packed in low-density polyethylene (LDPE) pouches, and designated as CA samples. A total of eighteen samples were collected at post-slaughter intervals of 1-3 h, 4-6 h, and 7-9 h ($n = 6$ per interval). The time of slaughter was confirmed through enquiry with butchers and traders.

Cold slaughtered buffalo meat samples were collected from carcasses of animals that died due to natural causes and were presented for post-mortem examination at veterinary institutions. Approximately 200 g of round muscle samples were collected, packed in LDPE pouches, and designated as CS samples. A total of six samples were collected within 12 h of death after confirming the time of death with farmers or veterinarians. It has to be noted that though CS samples were collected from the field veterinary institutions between 2-12 h post-mortem, the samples were brought to the laboratory in chilled form in insulated boxes and analysis for pH took place about 18-24 h after the death of animal.

Immediately after collection, samples were subjected to physicochemical and sensory evaluation.

2.2 Experimental Procedures

2.2.1 pH Measurement

The pH of meat samples was determined using a digital pH meter as described by O'Halloran *et al.* (1997) [1]. The electrode was inserted approximately 2 inches into the muscle at multiple points, and readings were recorded after rinsing the probe with distilled water between measurements.

2.2.2 Colour Measurement (L^* , a^* , b^*)

Instrumental colour was measured using a calibrated colourimeter with diffuse illumination. The instrument was standardized using black and white tiles, and L^* , a^* , and b^* values were recorded at three different points on each sample.

2.2.3 R-Value Determination

R-value was determined following the method of Honikel and Fischer (1977) [2]. Meat samples were homogenized in perchloric acid, filtered, and diluted with phosphate buffer. Absorbance was measured at 250 nm and 260 nm using a spectrophotometer, and R-value was calculated as the ratio of absorbance at 250 nm to 260 nm.

2.2.4 Sensory Evaluation

Sensory evaluation of raw meat samples was conducted using an 8-point hedonic scale (AMSA, 1995) [3]. A panel of six semi-trained members evaluated colour, appearance, and odour. Samples were coded with random numbers and presented in a randomized order under controlled laboratory conditions. Mean scores were calculated for each attribute.

2.3 Instruments and Chemicals

The instruments used included a digital pH meter (Systronics, India), colourimeter (Lovibond LC 100 Spectro), and a single-beam spectrophotometer (Systronics, India). Standard buffer solutions (pH 4.0 and 7.0) were procured from Merck Life

Science Pvt. Ltd., Mumbai. Perchloric acid and phosphate buffer were used for R-value estimation.

2.4 Statistical Analysis

The experimental data were analyzed using one-way analysis of variance (ANOVA). Differences among means were considered statistically significant at $p < 0.05$. Sensory scores were expressed as mean $\pm$ standard deviation.

3. Results and discussion

3.1 Results

3.1.1 pH

The mean pH values of commercially available (CA) and cold slaughtered (CS) buffalo meat are presented in Table 1 and Table 3.

The overall mean pH of CS buffalo meat (6.32 ± 0.13) was significantly higher ($p < 0.01$) than that of CA buffalo meat (5.97 ± 0.04), indicating a clear difference between the two slaughter conditions.

Among the different groups, a highly significant difference ($p < 0.01$) in pH was observed. The highest mean pH was recorded in CS samples (6.32 ± 0.13), followed by CA samples at 1-3 h (6.14 ± 0.05). The lowest pH was observed in CA samples at 4-6 h (5.86 ± 0.07), while CA samples at 7-9 h (5.91 ± 0.03) showed slightly higher values than the 4-6 h group.

Overall, the results indicate that CS and early post-mortem CA samples maintain higher pH, whereas CA samples at later post-mortem intervals exhibit lower pH values.

3.1.2 R-value

The mean R-values of CA and CS buffalo meat are presented in Table 1 and Table 3.

The overall mean R-value of CS buffalo meat (1.30 ± 0.04) was significantly higher ($p < 0.05$) than that of CA buffalo meat (1.15 ± 0.03), indicating a statistically significant difference between the two groups.

A highly significant difference ($p < 0.01$) in R-values was observed among the different groups. The lowest mean R-value was recorded in CA samples at 1-3 h (1.00 ± 0.05), followed by CA samples at 4-6 h (1.18 ± 0.02) and 7-9 h (1.28 ± 0.03). The highest R-value was observed in CS samples (1.30 ± 0.04).

Overall, a progressive increase in R-value was observed with increasing post-mortem interval in CA samples, with CS samples consistently showing the highest values.

3.1.3 Instrumental colour values

The instrumental colour parameters (L^* , a^* , b^*) are presented in Table 1 and Table 3.

The L^* value (lightness) was significantly higher ($p < 0.01$) in CS buffalo meat (37.52 ± 1.01) compared to CA buffalo meat (30.76 ± 1.71). Among groups, higher L^* values were observed in CS and CA (4-6 h), while the lowest value was recorded in CA (1-3 h).

The a^* value (redness) was significantly lower ($p < 0.05$) in CS buffalo meat (11.56 ± 0.84) compared to CA buffalo meat (13.35 ± 0.37). The highest redness was observed in CA samples at 7-9 h, whereas CS samples showed comparatively lower values.

The b^* value (yellowness) did not differ significantly ($p > 0.05$) between CA and CS buffalo meat. However, among groups, CA samples at 7-9 h showed relatively higher b^* values compared to other groups.

3.1.4 Sensory attributes

The sensory scores for colour, appearance, and odour are presented in Table 2 and Table 4.

The mean colour and appearance score of CA buffalo meat (6.57 ± 0.14) was significantly higher ($p < 0.01$) than CS buffalo meat (5.47 ± 0.21). A gradual decline in scores was observed in

CA samples with increasing post-mortem interval, with the highest score in CA (1-3 h) and lowest in CS samples.

Similarly, the odour score of CA buffalo meat (6.48 ± 0.17) was significantly higher ($p < 0.01$) than CS buffalo meat (4.63 ± 0.20). Odour scores decreased progressively with time in CA samples, while CS samples exhibited the lowest scores.

Table 1: Mean $\pm$ SE pH, R-value and instrumental colour (L^* , a^* , b^*) of CA and CS buffalo meat

Parameters	CA buffalo meat	CS buffalo meat	t-value	P-value
pH	5.97 ± 0.04	6.32 ± 0.13	3.353**	0.003
R-Value	1.15 ± 0.03	1.30 ± 0.04	2.373*	0.027
L^*	30.76 ± 1.71	37.52 ± 1.01	3.402**	0.003
a^*	13.35 ± 0.37	11.56 ± 0.84	2.249*	0.035
b^*	9.72 ± 0.25	10.42 ± 0.53	1.329 ^{ns}	0.198

CA - commercially available; CS - cold slaughtered. ** Significant at 0.01 level; * Significant at 0.05 level; ns - non-significant.

Table 2: Mean $\pm$ S.E sensory colour and appearance, and odour scores of CA and CS buffalo meat

Parameters	CA buffalo meat	CS buffalo meat	Z-value	P-value
Colour and appearance	6.57 ± 0.14	5.47 ± 0.21	3.401**	0.002
Odour	6.48 ± 0.17	4.63 ± 0.20	3.602**	<0.001

CA- Commercially available; CS- Cold slaughtered

** Significant at 0.01 level

Table 3: Mean $\pm$ S.E pH, R-value and Instrumental Colour (L^* , a^* , b^*) of CA buffalo meat collected at different post-mortem time intervals and CS buffalo meat

Parameters	Time of collection of CA samples (post-mortem)			CS buffalo meat	F-value (P-value)
	1-3 h	4-6 h	7-9 h		
pH	$6.14^{ab} \pm 0.05$	$5.86^c \pm 0.07$	$5.91^{bc} \pm 0.03$	$6.32^a \pm 0.13$	6.718** (0.003)
R-Value	$1.00^c \pm 0.05$	$1.18^b \pm 0.02$	$1.28^{ab} \pm 0.03$	$1.30^a \pm 0.04$	12.923** (<0.001)
L^*	$26.89^b \pm 4.01$	$35.30^a \pm 0.83$	$30.08^{ab} \pm 2.43$	$37.52^a \pm 1.01$	3.962* (0.023)
a^*	$12.26^b \pm 0.51$	$12.91^b \pm 0.35$	$14.88^a \pm 0.51$	$11.56^b \pm 0.84$	6.082** (0.004)
b^*	$9.28^b \pm 0.19$	$9.25^b \pm 0.41$	$10.63^a \pm 0.41$	$10.42^{ab} \pm 0.53$	3.285* (0.042)

CA- Commercially available; CS- Cold slaughtered

** Significant at 0.01 level. * Significant at 0.05 level.

Means bearing different lower-case alphabets as superscript differ significantly within a row

Table 4: Mean $\pm$ S.E sensory colour and appearance and odour scores of CA buffalo meat collected at different post-mortem time intervals and CS buffalo meat

Parameters	Time of collection of CA samples post-mortem			CS buffalo meat	χ^2 -value (P-value)
	1-3 h	4-6 h	7-9 h		
Colour and appearance	$7.22^a \pm 0.07$	$6.62^{ab} \pm 0.07$	$5.87^{bc} \pm 0.06$	$5.47^c \pm 0.21$	20.147** (<0.001)
Odour	$7.37^a \pm 0.09$	$6.35^{ab} \pm 0.08$	$5.71^{bc} \pm 0.10$	$4.63^c \pm 0.20$	21.628** (<0.001)

** Significant at 0.01 level

Means having different lower-case alphabets as superscripts differ significantly within a row

3.2 Discussion

3.2.1 pH

The significantly higher pH observed in cold slaughtered (CS) buffalo meat compared to commercially available (CA) meat indicates altered post-mortem biochemical processes. This elevation in pH may be attributed to reduced post-mortem glycolysis due to depletion of muscle glycogen reserves prior to death, resulting in lower lactic acid accumulation. Pre-slaughter stress, hypoxia, and metabolic exhaustion are known to limit glycogen availability and thereby restrict the normal decline in pH (Kandeean *et al.*, 2009) [4]; (Mahros *et al.*, 2022) [5]. It is also important to note that CS samples were analysed 18-24 h post-mortem, during which post-mortem acidification would have progressed closer to ultimate pH values, potentially influencing the observed pH differences. However, some studies have reported no significant differences in pH under varying slaughter and bleeding conditions, indicating that the effect may vary depending on species and handling practices (Öztekin and Candoğan, 2025) [6].

The pH values of CA buffalo meat in the present study fall within the normal range reported for buffalo meat, whereas the elevated pH in CS samples suggests DFD-like conditions. Similar findings have been reported where stress and inadequate bleeding resulted in higher ultimate pH and inferior meat quality traits (Mia *et al.*, 2023) [7]; (Ahmad *et al.*, 2015) [8]. Thus, the higher pH in CS meat reflects disturbed muscle metabolism associated with stress and death-related physiological changes.

3.2.2 R- value

The significantly higher R-values observed in cold slaughtered (CS) buffalo meat compared to commercially available (CA) samples indicate advanced post-mortem biochemical changes. The R-value reflects ATP degradation and the formation of inosine monophosphate (IMP), and is considered a reliable indicator of rigor mortis progression (Honikel and Fischer, 1977) [2].

It is also important to note that CS samples were analysed 18-24 h post-mortem, which may have contributed to the higher

R-values due to advanced post-mortem metabolic progression. Despite the higher pH observed in CS samples, the elevated R-values suggest that ATP depletion may have occurred rapidly at earlier stages post-mortem.

The progressive increase in R-values across CA post-mortem intervals confirms normal post-mortem metabolism, whereas the consistently higher values in CS samples suggest accelerated or altered ATP depletion. Similar trends have been reported in buffalo muscle where R-values increased with post-mortem time, reflecting the advancement of rigor mortis (Rao *et al.*, 2009) ^[9]. Additionally, R-value has been reported to be more sensitive than pH in detecting early biochemical changes during rigor development (Khan and Frey, 1971) ^[10].

3.2.3 Instrumental colour

The significantly higher L* values observed in CS buffalo meat indicate a paler appearance compared to CA samples. Changes in lightness are associated with protein denaturation, structural alterations, and increased light scattering. Stress-related metabolic disturbances can accelerate these changes, resulting in paler meat (Kim *et al.*, 2014) ^[11].

The significantly lower a* values in CS samples indicate reduced redness, which may be due to altered myoglobin chemistry and reduced oxygenation state. Meat colour is primarily influenced by myoglobin concentration and its chemical state, with limited contribution from residual blood (Naveena and Kiran, 2014) ^[12]. Stress conditions and high pH are known to alter myoglobin stability, thereby reducing redness (Mia *et al.*, 2023) ^[7].

In contrast, b* values did not show significant differences between CA and CS samples, suggesting that yellowness is less affected by slaughter conditions and is more influenced by lipid oxidation and surface characteristics. Similar findings have been reported where b* values remained relatively stable across different slaughter and storage conditions (Sohaib *et al.*, 2020) ^[13].

3.2.4 Sensory attributes

The significantly higher sensory scores for colour, appearance, and odour in CA buffalo meat indicate superior acceptability compared to CS meat. Sensory colour is closely associated with myoglobin oxidation and visual perception of freshness, making it a reliable indicator of meat quality (Sen *et al.*, 2012) ^[14].

The decline in sensory scores with increasing post-mortem interval in CA samples reflects progressive quality deterioration due to oxidative changes and surface dehydration. Surface desiccation and pigment oxidation have been reported to reduce colour acceptability during storage (Ledward, 1971) ^[15].

Odour is a critical indicator of meat freshness and is closely linked to biochemical and microbial changes. The significantly lower odour scores in CS samples suggest early onset of spoilage-related changes, reducing consumer acceptability (Ruiz-Capillas *et al.*, 2021) ^[16]. Increase in undesirable odours with time due to microbial activity and biochemical breakdown has also been reported in meat products (Putra *et al.*, 2019) ^[17].

4. Conclusion

Cold slaughtered (CS) buffalo meat showed significantly higher pH and R- values compared to commercially available (CA) meat, indicating altered post-mortem metabolism. CS samples also exhibited higher lightness and lower redness,

along with reduced sensory acceptability. Overall, CA meat demonstrated superior quality attributes, while CS meat showed characteristics associated with deterioration. These parameters can be effectively used to differentiate between CA and CS buffalo meat.

Acknowledgement

The authors gratefully acknowledge the Department of Animal Husbandry and Dairying, Government of India, for funding support under the National Livestock Mission. The authors also thank the concerned institutions and staff for their assistance during sample collection and analysis.

References

1. O'Halloran GR, Troy DJ, Buckley DJ. The relationship between early post-mortem pH and the tenderisation of beef muscles. *Meat Sci.* 1997;45:239-251.
2. Honikel KO, Fischer C. A rapid method for the detection of PSE and DFD pork. *J Food Sci.* 1977;42(6):1633-1636.
3. American Meat Science Association. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Chicago (IL): American Meat Science Association and National Livestock and Meat Board; 1995. 105 p.
4. Kandeepan G, Anjaneyulu ASR, Kondaiah N, Mendiratta SK, Lakshmanan V. Effect of age and gender on the processing characteristics of buffalo meat. *Meat Sci.* 2009;83(1):10-14.
5. Mahros AM, *et al.* Effect of preslaughter stress on meat quality traits. *J Anim Physiol Anim Nutr.* 2022.
6. Öztekin DC, Candoğan K. Influence of different bleeding times on structural and physicochemical characteristics of beef from Halal-slaughtered cattle. *Turk J Agric Food Sci Technol.* 2025;13(8):1618-1624.
7. Mia MM, *et al.* Impact of heat stress on muscle metabolism and meat quality in ruminants. *Animals.* 2023;13(1):1234.
8. Ahmad RS, *et al.* Influence of bleeding efficiency on meat quality. *J Food Sci Technol.* 2015.
9. Rao VA, *et al.* Changes in biochemical properties of buffalo muscle during post-mortem storage. *Meat Sci.* 2009.
10. Khan AW, Frey AR. A simple method for following rigor mortis development. *J Food Sci.* 1971.
11. Kim YHB, *et al.* Effect of post-mortem metabolism on meat colour. *Meat Sci.* 2014;98(3):520-528.
12. Naveena BM, Kiran M. Buffalo meat quality, composition and processing characteristics. *Food Rev Int.* 2014.
13. Sohaib M, *et al.* Effect of slaughtering methods on meat quality. *J Food Process Preserv.* 2020.
14. Sen AR, *et al.* Effect of storage on colour and sensory properties of meat. *J Food Sci.* 2012.
15. Ledward DA. Post-mortem changes in meat colour. *J Food Sci.* 1971.
16. Ruiz-Capillas C, *et al.* Sensory evaluation of meat products. *Foods.* 2021;10(5):1047.
17. Putra AA, *et al.* Effect of storage time on meat odour and quality. *Food Control.* 2019.

Author name and affiliation

Jahana Sherin Mambulliyalil

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala,

India

VN Vasudevan

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Ashika EL

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Sunil Kumar NS

Department of Veterinary Anatomy, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Irshad A

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Silpa Sasi

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Uma R

Department of Veterinary Biochemistry, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Thulasi K

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Akhila VV

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

Hridya Vijay C

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, India

How to Cite This Article

Mambulliyalil JS, Vasudevan VN, Ashika EL, Kumar NSS, Irshad A, Sasi S, *et al.* Comparative study on pH, R- value, colour and sensory characteristics of commercially available and cold slaughtered buffalo meat. International Journal of Veterinary Sciences and Animal Husbandry 2026; 11(3): xx-xx.

Creative Commons (CC) License

This is an open-access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.