Bangladesh Journal of Veterinary and Animal Sciences
Journal home page: www.bjvas.com
pISSN 2227-6416
eISSN 2709-2542

Research article

Effect of transport stress and pre-slaughter practices on the meat quality of cattle and buffalo

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ARTICLE INFO

Article history:

Received: 08/09/2024

Accepted:02/04/2026

Keywords:

Beef, carabeef, meat quality, pre-slaughter practices, transport stress

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ABSTRACT

Pre-slaughter practices significantly affect the meat quality. The present study was conducted to investigate the effect of transport stress and pre-slaughter practices on the meat quality of cattle (beef) and buffalo (carabeef). A total of 20 meat samples (cattle: 10 and buffalo: 10) were collected from Firingi Bazar Slaughterhouse of Chattogram City Corporation, Chattogram, Bangladesh, along with the different animal information related to pre-slaughter resting at lairage, feeding, watering and fasting. The meat quality was measured based on moisture content, pH, water holding capacity (WHC), extract release volume (ERV), tyrosine value (TV) and total viable count (TVC).Results indicated that the transport duration did not affect the beef quality between the two groups (≤2 hours and >2 hours). However, significant variation ($p<0.05$) between the two groups was found in carabeef in terms of pH. Again, ERV and TVC values in beef varied significantly ($p<0.05$) for the difference in resting period between the two groups (≤12 hours and >12 hours), whereas all parameters of carabeef quality were not significantly different ($p>0.05$) between the groups. The feed withdrawal period (groups: ≤12 hours and >12 hours) and water withdrawal period (groups: ≤6 hours and >6 hours) did not affect the beef and carabeef quality ($p>0.05$). Overall, the study revealed that the transport duration in buffalo and the resting period in cattle affect the meat quality significantly. To ensure better meat quality the pre-slaughter management of the animals should be efficient.

To cite this paper: *A. Dutta, B. Halder, K. Adhikary, P. Bhowmik, B. Aich and M. Alam, 2025.Effect of transport stress and pre-slaughter practices on the meat quality of cattle and buffalo. Bangladesh Journal of Veterinary and Animal Sciences, 13(1& 2):01-07.*

1. INTRODUCTION

Numerous aspects of the nutritional composition of meat vary in a complex way depending on different intrinsic and extrinsic factors. Several extrinsic factors related to slaughter and post-slaughter are blood loss, freezing, preservation, ageing, commercialization and consumption (Guerrero et al. 2013). Besides these, two other important factors affecting meat quality are transportation and pre-slaughter practices. Transport stress and pre-slaughter practices are critical factors in animal welfare and determining the quality of meat obtained from food animals (Alamet al. 2010; Alamet al. 2018). During the transportation of animals, numerous microbial, physical and environmental hazards can potentially negatively affect the health and meat quality of the animals (Southern et al. 2006). Moreover, the types of animals, feed and water deprivation, ambient temperature, air or water quality, stocking density, etc., play a vital role regarding animal welfare and meat quality during transport (Rakib et al. 2016). Exposure of an animal to those stressors results in the release of catecholamines and glucocorticoids in the blood. The secretion of catecholamines leads to significant changes in energy metabolism, including glycogenolysis and gluconeogenesis (Barth et al. 2007). Significant depletion of muscle glycogen reserves has a crucial effect on key parameters of meat quality such as pH, tenderness, ageing potential, colour and water-holding capacity (Gregory and Grandin 2007). Commercially, the ultimate pH is used as the main indicator of meat quality (Gregory and Grandin, 2007). Ultimate pH is related to tenderness, colour, flavour, acceptability, water-holding capacity and storage quality of meats. In the case of food animal practice, pre-slaughter management after transport includes resting, feeding, watering and fasting. Adequate resting at lairage with other practices facilitates the rehydration and recovery from transport stress. Thus, feeding and watering prior to slaughter are important factors that affect the meat quality in food animals. Finally, fasting before slaughter, at least for 12 hours, is the ultimate practice offered to the food animals, which helps in hygienic meat production.

However, there is limited published information in Bangladesh describing how meat quality is affected due to different field-level pre-slaughter practices. To address that, we designed this study to determine the effect of transport stress and pre-slaughter practices on the meat quality of cattle and buffalo in Bangladesh.

2. MATERIALS AND METHODS

Collection of meat samples

A total of 20 meat samples (cattle: 10 and buffalo: 10), preferably meat of longissimus dorsi, were collected from the Firingi Bazar Chattogram City Corporation Slaughterhouse, Chattogram, Bangladesh. After collection, samples were immediately transferred to the Department of Animal Science and Nutrition laboratory at Chattogram Veterinary and Animal Sciences University. During the study period, the samples were preserved in a freezer (Esco®, Model: UUs-4398-1, USA).

Meat quality determination

Moisture content

The moisture content was determined by using the oven-dry method (AOAC, 2005). Five grams of meat were taken in a petridish and placed in a hot oven at a temperature of 105ºC for heating until constant weight. Finally, moisture content was calculated using the formula: (weight of wet sample – weight of dry sample)/weight of wet sample, and it was expressed as a percentage.

pH

The pH of meat was determined by following the method of Pippen et al. (1965). For pH determination, 15 g of the meat sample was taken and homogenized (Model: SR-30, Medline Scientific Ltd., UK) with 30 ml of distilled water. The slurry was filtered using Whatman No. 1 filter paper, and the pH of the filtrate was measured using a pH meter (Orion StarTM Model: A211, USA).

Water holding capacity (WHC)

The water holding capacity was measured following the filter paper press technique (Grau and Hamm, 1953). For this,300 mg of the meat sample was placed on a Whatman No. 1 filter paper and placed between two glass slides. A 100-gram weight was placed on the top of the upper slide for 3 min. The area was measured using a compensation polar planimeter (Placom Planimeter®, Model: KP 90N), and WHC was reported in cm^2.

Extract release volume (ERV)

ERV is the volume of aqueous extract released by a homogenate of meat (meat: extraction solution in a1:4 ratio). Fifteen grams of the meat sample was homogenized with 60 ml of extraction reagent, and the extract release volume of meat was estimated by the folded filter paper method described by Pearson (1967).

Tyrosine value (TV)

TV was estimated by using the modified method of Pearson described by Strange et al. (1977). A 2.5 ml trichloroacetic acid extract of meat was diluted with an equal amount of distilled water. After mixing 3 ml of diluted folinciocalteu phenol reagent, it was kept for 15 min. The absorbance of the colour was taken at 660 nm wavelength using a spectrophotometer (Model: U-2900, Hitachi® Ltd, Japan).

Total viable count (TVC)

The TVC was detected following the plate count method of ISO (2003). For meat extract preparation, 5 grams of the meat sample was added to 45 ml of PBS, blended and centrifuged at 10,000 rpm for 2 min. Using the centrifuged supernatant (meat extract), a 10-fold serial dilution was made up to a dilution factor of 10^{10} in PBS. One ml of meat extract from each dilution was spread on a petri-dish containing 20 ml of plate count agar and incubated at 35ºC for 48 hours. The bacterial colonies were then counted using a colony counter to get TVC and expressed in CFU/ml.

Statistical analysis

All data were input into Microsoft Office Excel2010 and transferred to the software STATA/IC-11 for analysis. Descriptive statistics were done by using the STATA software, and an unpaired t-test was performed to compare the data. To conduct the t-test, samples of the same species were grouped into two categories, and finally, mean values were compared. Groups were made for each pre-slaughter practice, namely, transport duration (TD), resting period (RP), feed withdrawal period (FWP) and water withdrawal period (WWP). Differences between the variables were accepted as being significant if $p<0.05$.

3. RESULTSAND DISCUSSION

This study evaluated the meat quality of animals in the context of variations in different pre-slaughter practices offered to them before slaughtering. The general information about the animals slaughtered, such as species, breed, sex, and BCS, is summarized in Table 1.

The effects of transport duration, feed and water withdrawal and resting period on the meat quality of cattle and buffalo are given in Table 2 and Table 3, respectively. Moisture content, WHC values and ERV of both beef and carabeef were unaffected ($p>0.05$) by transport duration. Notably, the TVC value showed no difference in beef and carabeef ($p>0.05$).

The pH value of carabeef was significantly ($p<0.05$) higher in animals transported for more than 2 hours. Buffaloes experience more stress than other animals due to their low heat regulation mechanism (Mishra. 2021). In stress, glycogen breaks down into glucose. Moreover, higher transport duration leads to the depletion of glycogen in plasma (Zhang et al. 2014). Due to less glycogen in muscle, post-mortem pH increases because of the formation of less lactic acid (Immonen et al. 2000). A study by Gallo et al. (2003) found that 16 hours of transportation results in higher muscle pH than 3 hours of transportation in steers. Bonou et al. (2018) reported a significant increase in the ultimate pH of chicken meat when transported for a longer time. Ådnøy et al. (2005) found no significant differences in meat pH between lambs that did or did not undergo a long, double transport. Neath et al. (2007) stated that there is a decline in ultimate pH in buffaloes experiencing a long journey, which is opposite to the result of the current study. A study on suckling lambs reported that WHC was reduced with higher transport duration (De la Fuente et al. 2010).

Table 1. Characteristics of the slaughtered animals

Variables	Categories	Cattle (N=10)	Buffalo (N=10)
Breed	Haryana Cattle)	70% (7)	-
	RCC (Cattle)	30% (3)	-
	Murrah (Buffalo)	-	100% (10)
Sex	Male	90% (9)	80% (8)
	Female	10% (1)	20% (2)
BCS	2	10% (1)	10% (1)
	3	30% (3)	50% (5)
	4	60% (6)	40% (4)
Injury due to transport	Yes	50% (5)	30% (3)
	No	50% (5)	70% (7)
Abnormal nasal discharge	Yes	30% (3)	10% (1)
	No	70% (7)	90% (9)
Clinical sign(s)	Yes	30% (3)	10% (1)
	No	70% (7)	90% (9)

The resting period (≤12 hours and >12 hours) on either species did not affect the moisture content, WHC and pH value between beef and carabeef. Marıa et al. (2003) and Miranda-de la Lama et al. (2009) showed that resting time in lairage did not affect colour and ultimate meat pH significantly. The ERV was higher ($p<0.05$) in cattle rested for >12 hours compared to those rested for ≤12 hours. ERV value of meat was affected by spoilage resulting from increased microbial contamination (Pearson, 1968). The current study found that a higher microbial load is associated with a lower ERV.H ere, cattle resting ≤ 12 hours had higher TVC values than those resting >12 hours ($p<0.05$). The transportation stress results in the release of catecholamine hormones, particularly noradrenaline, which sometimes enhances the growth of bacteria and their virulence (Lyte, 2004; Lyte and Ernst 1992). The resting period in lairage helps replenish muscle glycogen, reduces weight loss, rehydrates the body tissue and assists in minimizing other effects of transport stress (Mounier et al. 2006). The study also stated that the ability to withstand stress may vary from animal to animal, explaining the unaffected result in carabeef. Notwithstanding, a longer lairage period (overnight) led to higher pH, WHC, lower drip loss and darker meat in comparison to the shorter duration in lairage (2 hours) (Costa et al. 2002). Hence, adequate rest in lairage was suggested to reduce the meat quality defects by Wesley et al. (2005).

The feed withdrawal (≤12 hours and >12 hours) before slaughter showed no significant difference in the meat quality of beef and carabeef. Deprivation of food and water before slaughter reduces gut content and prevents microbial contamination (Adzitey, 2011). Again, feed withdrawal for a longer period will reduce the dressing percentage. Studies found increased meat pH and WHC of animals experiencing fasting prior to slaughter (Karaca et al. 2016; Leheska et al. 2002). It is hypothesized that gut emptying of animals for a longer duration leads to increased intestinal pH (due to reduced volatile fatty acid), which ultimately affects the meat quality (Harvey et al. 2001).

In the present study, meat quality parameters of both beef and carabeef showed no statistically significant differences between the two groups for water withdrawal and fasting for ≤6 hours and >6 hours. D'Souza et al. (1998) found that fasting or deprivation of feed and water before slaughter for 16 to 24 hours increased food safety by reducing microbial contamination and improved meat colour and ultimate p^H.

Here, both cattle and buffalo fasted for a short duration, ranging from 4 hours to 10 hours,

Table 2. Effects of transport, resting, feed and water withdrawal period on cattle meat quality

Meat quality traits	Pre-slaughter practices in cattle							
	TD		RP		FWP		WWP	
	≤2 hours (Mn ± SE)	**>2 hours (Mn ± SE)**	**≤12 hours (Mn ± SE)**	**>12 hours (Mn ± SE)**	**≤12 hours (Mn ± SE)**	**>12 hours (Mn ± SE)**	**≤6 hours (Mn ± SE)**	**>6 hours (Mn ± SE)**
Moisture %	70.29±1.95	67.24±5.64	68.93±2.37	71.78±0.28	72.19±0.53	65.63±4.30	69.48±0.81	69.15±2.40
P^H	5.79±0.10	5.33±0.44	5.67±0.17	5.25±0.25	5.83±0.11	5.38±0.31	6.00±0.29	5.61±0.16
WHC (cm^2)	3.88±0.47	3.56±0.83	3.86±0.43	3.30±0.16	4.24±0.37	3.11±0.74	3.18±0.18	3.83±0.43
ERV (ml)	24.42±1.61	21.33±1.27	*19.60±0.40	*23.91±1.25	24.26±1.96	22.30±1.32	24.40±0.40	23.21±1.37
TV (µg)	1.26 ±0.21	1.28±0.45	1.16±0.20	1.19±0.01	1.26±0.21	1.28±0.45	0.89±0.05	1.32±0.22
TVC (CFU)	(4.68±0.78) $\times10^7$	(9.46±1.44) $\times10^7$	*(6.71±1.10) $\times10^7$	*(1.60±0.45) $\times10^4$	(3.82±0.23)$\times10^7$	(9.30±1.45)$\times10^7$	(8.97±0.73)$\times10^7$	(4.33± 0.72)$\times10^7$

Table 3. Effects of transport, resting, feed and water withdrawal period on buffalo meat quality

Meat quality traits	Pre-slaughter practices in buffalo							
	TD		RP		FWP		WWP	
	≤2 hours (Mn ± SE)	**>2 hours (Mn ± SE)**	**≤12 hours (Mn ± SE)**	**>12 hours (Mn ± SE)**	**≤12 hours (Mn ± SE)**	**>12 hours (Mn ± SE)**	**≤6 hours (Mn ± SE)**	**>6 hours (Mn ± SE)**
Moisture %	68.07±5.58	65.84±0.69	65.43±4.30	72.65±0.97	65.96±6.67	68.51±2.71	71.50±1.05	66.47±3.79
P^H	*5.08±0.24	*6.25±0.25	5.63±0.31	5.25±0.25	5.25±0.14	5.75±0.40	5.00±0.29	5.61±0.27
WHC (cm^2)	2.55±0.36	2.51±0.68	2.47±0.41	2.77±0.07	2.62±0.55	2.48±0.44	1.57±0.44	2.69±0.32
ERV (ml)	23.74±1.63	23.50±1.65	23.37±1.38	24.65±1.05	25.03±1.32	22.56±1.59	22.20±0.19	23.81±1.22
TV (µg)	1.52±0.39	0.71±0.22	0.78±0.14	2.11±0.43	1.72±0.47	0.75±0.17	1.15±0.25	1.11±0.26
TVC (CFU)	(2.60±0.08) $\times10^7$	(4.95±1.52) $\times10^8$	(2.67±0.27) $\times10^8$	(2.11±0.55) $\times10^5$	(3.80±0.06) $\times10^7$	(3.31±0.04) $\times10^8$	(1.61±0.55) $\times10^6$	(2.35±0.02) $\times10^8$

*= Statistically significant ($p<0.05$) %= Percentage; TD= Transport duration; RP=Resting period; FWP=Feed withdrawal period; WWP=Water withdrawal period; WHC= Water Holding Capacity; ERV= Extract Release Volume; TVC= Total Viable Count; TV= Tyrosine Value; SE=Standard error.

which may be the cause of the absence of variation between the two study groups. On the other hand, feed and water withdrawal for ≥48 hours increased the risk of microbial growth (Pointon et al. 2012).

This study showed that longer transport duration resulted in an increase in the pH value of carabeef. When rested for a longer period, a decrease in the microbial load in beef was observed. Standards for pre-slaughter practices in relation to species, season, and climatic conditions should be followed to increase the food value and the storage quality of beef and carabeef.

ACKNOWLEDGEMENTS

We acknowledge Chattogram City Corporation's permission to collect samples from the Firingi Bazar slaughterhouse to conduct the study.

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