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## Effect of transportation and holding period on broiler meat quality

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#### Abstract

The purpose of this study was to determine the effects of stress of transportation and holding periods before marketing on meat quality of broilers brought into urban areas from far off production points for marketing. The meat quality parameters like breast and thigh muscle pH, shear force value for tenderness and water holding capacity (WHC) were studied among broilers transported over long (>300 km) and short (100-200 km) distances and also during holding period. Distance of transport of broilers was found to influence shear force value significantly ( $P \leq 0.01$ ) and muscle pH (breast and thigh muscle) and WHC were not affected by the same. Comparatively, long distance transport of > 300 km resulted in less tender meat than short distance transport for 100-200 km. The live shrink loss (%) increased upto day-2 of holding and the birds were found to recoup body weight and reverse the trend after that. The breast muscle pH also rose upto day-2 and came down afterwards. The broiler meat was found to be the most tender on day-2 of holding, while WHC was the highest on day-4. Microbial quality of drinking water and litter at the holding pens were very poor. Long distance travel and holding periods before marketing influenced the meat qualities of the broilers.

**Keywords:** Broiler, meat quality, transportation, holding, stress

#### Introduction

Meat quality of domesticated animals can be affected by several antemortem stress factors (Kannan *et al.*, 1997) [1], one of which is pre-slaughter transportation. Transport alters both the metabolism and psychological state of animals, which may produce undesirable changes in meat quality (Owens and Sams, 2000; Pérez *et al.*, 2002; Leheska *et al.*, 2003) [2, 3, 4]. As broiler production activity under the widely popular and the mostly adopted integrated or contract system is located in villages far away from the major consumption centres, the live broilers are transported over long distances before they are ultimately sold to consumers through retail market units and the duration of transport varies from three to 12 hours. During transport the birds are often exposed to a number of stress factors that can affect meat quality such as improper temperature, adverse microclimate, vibration, motion, impacts, shocks, lack of feed and water, social disruption and noise. Feed withdrawal, catching, loading, transport, unloading, shackling and stunning are standard procedures used. The metabolic state of the animal at the time of slaughter determines the initial metabolic state of the muscle postmortem and, as a result, affects the final meat quality (Savenije *et al.*, 2002) [5]. By considering the above facts, the present study was designed to study the effect of transport and holding periods of live broilers before marketing on the meat quality.

#### Materials and Methods

##### Duration of transport

Live broilers transported by whole sale dealers operating in Chennai were involved in the city. They were lifted and transported from broilers farms located far off ie. Different districts and accordingly, they were classified as long distance (> 300 km) and short distance (100-200 km) groups and subjected to study.

##### Holding period

Most of the retail marketing units ordered and received live broilers from the whole sales two times in a week and hence, the broilers were accommodated in holding space of retail units for a maximum of four days. Accordingly, the meat of the birds held over a maximum period of four days were subjected to meat quality studies at 0, 1, 2, 3 and 4<sup>th</sup> day of holding period.

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### Meat quality parameters

Broiler meat quality as influenced by distance of transport and length of holding period at the retail shops was assessed by breast and thigh muscle pH, shear force value (tenderness) and water holding capacity (WHC) by slaughtering six broilers (3 males + 3 females) every day as per the method of Arumugam and Panda (1970)<sup>[6]</sup>.

#### pH

The pH of the meat was assessed by the use of a digital pH meter using a combination probe electrode.

#### 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 centre of the breast muscle were subjected to the shear test at three points and the average was recorded.

#### Water holding capacity (WHC)

The estimation of water holding capacity was carried out by adopting the filter paper press method recommended by Hamm (1971)<sup>[7]</sup> with modification in the method of applying pressure. About 0.3 g of breast meat sample was placed in a folded Whatman's No.41 filter paper between two glass slides and subjected to a pressure of 100 g. After waiting for three minutes, the resultant impression means of expressed water on the filter paper were measured and expressed in per cent.

#### Coliform count

Microbial quality of drinking water and litter at the holding point of broiler retail shops was assessed by collecting

samples and making coliform count.

#### Preparation of MacConkey agar

For preparing the medium, 4.7 g of MacConkey agar was suspended in 100 ml of distilled water. The suspension was boiled and autoclaved at 15 lbs pressure per square inch for 15 minutes to sterilize the media.

#### Collection of sample

Litter material sample was collected from different parts of the holding area in the retail shops like corner, centre and near the feeder and waterer. One gram of litter material was mixed with nine ml of distilled water and serial dilution made. The samples were plotted onto MacConkey agar for coliform count. Each sample was inoculated according to the procedure prescribed by Barker and Breach (1980)<sup>[8]</sup>. The plates were incubated aerobically at 37 °C for 48 hrs. Lactose fermenting colonies were counted and expressed as cfu/ml of sample by multiplying the counted colonies with the reciprocal of the dilution. Water samples were analysed similarly as like that of the litter sample.

### Results and Discussion

#### Transportation and broiler meat quality

Broiler meat quality parameters like breast and thigh muscle pH, shear force value for tenderness and water holding capacity (WHC) were studied among broilers transported over long (>300 km) and short (100-200 km) distances and respective means ( $\pm$  M.E.) are presented in Table 1. Mean transit live shrink loss (%) values differed significantly ( $P \leq 0.01$ ) between the two groups reinforcing the earlier findings (Aral *et al.*, 2014; Arikan *et al.*, 2017)<sup>[9,10]</sup>.

**Table 1:** Broiler meat quality parameters as influenced by distance of transport (Mean  $\pm$  S.E.)

Distance	Live shrink loss (%)	pH		Shear force value	WHC (%)
		Breast	Thigh		
Long (>300 km)	4.78 <sup>b</sup> $\pm$ 0.12	5.95 $\pm$ 0.03	6.55 $\pm$ 0.06	1.79 <sup>b</sup> $\pm$ 0.05	72.0 $\pm$ 0.91
Short (100-200 km)	3.65 <sup>a</sup> $\pm$ 0.13	5.96 $\pm$ 0.04	6.11 $\pm$ 0.05	1.51 <sup>a</sup> $\pm$ 0.06	73.3 $\pm$ 0.78
't' value	6.68**	0.49 <sup>NS</sup>	1.85 <sup>NS</sup>	2.76*	0.13 <sup>NS</sup>

Means within each column carrying different superscripts differ significantly

\*( $P \leq 0.05$ ) \*\* ( $P \leq 0.01$ ) <sup>NS</sup> -Not Significant ( $P \geq 0.05$ )

#### Breast muscle pH

Breast muscle pH did not seem to vary significantly ( $P \geq 0.05$ ) irrespective of whether the broilers were transported over a short distance (5.96  $\pm$  0.04) or long distance (5.95  $\pm$  0.03). The findings indicated that the breast muscle was not affected or stressed that much because of variations in length of transport and consequent stress, vibration or fatigue. Depletion in breast muscle glycogen reserves during transportation might not have been proportionate to the distance of transport and consequently variations in the same were not perceptible. However, the same were found to be marginally higher than those reported by Lyon *et al.* (1991)<sup>[11]</sup> and Musa *et al.* (2006)<sup>[12]</sup>. As muscle pH values in this study were recorded after transportation over some distance and depletion of muscle glycogen would have resulted in reduced lactic acid production and consequent higher pH (Gregory, 1994; Radhakrishnan, 2000 and Oba *et al.*, 2009)<sup>[13, 14, 15]</sup>.

#### Thigh muscle pH

Mean values for thigh muscle pH showed comparatively higher variations with the same for long distance being 6.55  $\pm$

0.06 compared to 6.11  $\pm$  0.05 for short distance. However, the difference so noticed was also not found to be statistically significant ( $P \geq 0.05$ ). Thigh muscle pH proved to be less acidic than breast muscle pH. Comparatively higher pH values for thigh muscle over breast muscle and wider variation over long and short distances indicated that the glycogen reserves in thigh muscles were comparatively lower or exhausted more than the breast muscle. It is apparent that during vibration and motion during transportation, thigh muscles are more often employed in the balancing act. Consequent depletion in thigh muscle glycogen reserves might have led to lower production of lactic acid (Lawrie, 1998 and Radhakrishnan, 2000)<sup>[16, 14]</sup>.

#### Tenderness/Shear force value

Mean shear force values indicated that there was significant difference ( $P \leq 0.05$ ) in tenderness of muscles of broilers transported over short or long distances, for, the respective values were 1.51  $\pm$  0.06 and 1.79  $\pm$  0.05, which indicate that the broilers transported over long distance had comparatively tough muscles with less tenderness. Similarly, Lyon *et al.* (1992)<sup>[17]</sup> also reported that accelerated glycolysis as a result of struggling would result in less tender meat. Kotula and

Wang (1994) [18] observed that shear value of breast muscle increased as feed withdrawal time increased and feed withdrawal periods in excess of 6 h resulted in a significant ( $P \leq 0.05$ ) decrease in tenderness of the breast muscle. As broilers were deprived of feed during transportation and the duration of deprivation depended on distance of transport, broilers transported over long distance might have had comparatively less tender meat over short distance transported birds. Contrarily, Dos Santos *et al.* (2017) [19] found that the shear force, seasons and distances had no significant influence on tenderness of the meat.

### Water holding capacity

Water holding capacity was not found to be influenced significantly ( $P \geq 0.05$ ) by distance of transport involved. The finding is in agreement with those of Petracci *et al.* (2001) [20] and Oba *et al.* (2009) [15] who stated that muscle pH influenced the WHC. As breast muscle pH did not vary

between long and short distance transported birds, WHC also did not vary depending on distance of transport. However, WHC values observed in this study were much higher than those reported by Musa *et al.* (2006) [12]. Dos Santos *et al.* (2020) [21] also found that carcasses quality was not affected by the interaction between season and distance during transport.

### Holding conditions

#### Holding Period

After the live broilers were delivered at retail shops, they were held under restricted area over a period of time varying from zero to four days before they were sold to the ultimate consumers. Influence of length of holding time on live shrink loss (%) and various other meat quality parameters like muscle pH, shear force value and water holding capacity were assessed and respective mean values ( $\pm$  S.E.) are presented in Table 2.

**Table 2:** Live shrink loss (%) and meat quality parameters of broilers as influenced by holding time at retail shops (Mean  $\pm$  S.E.)

Days of holding	Live shrink loss (%)**	Muscle pH		Shear force value**	WHC** (%)
		Breast*	Thigh <sup>NS</sup>		
0	0.38 <sup>a</sup> $\pm$ 0.18	5.70 <sup>a</sup> $\pm$ 0.04	5.78 $\pm$ 0.06	1.22 <sup>a</sup> $\pm$ 0.04	78.5 <sup>b</sup> $\pm$ 1.02
1	9.17 <sup>cd</sup> $\pm$ 0.33	5.95 <sup>ab</sup> $\pm$ 0.04	5.99 $\pm$ 0.05	1.72 <sup>cd</sup> $\pm$ 0.06	75.5 <sup>b</sup> $\pm$ 0.74
2	11.32 <sup>d</sup> $\pm$ 0.56	6.03 <sup>b</sup> $\pm$ 0.03	5.95 $\pm$ 0.04	1.45 <sup>ab</sup> $\pm$ 0.05	83.0 <sup>b</sup> $\pm$ 0.89
3	6.87 <sup>bc</sup> $\pm$ 0.28	5.77 <sup>a</sup> $\pm$ 0.03	5.87 $\pm$ 0.02	1.78 <sup>d</sup> $\pm$ 0.08	80.2 <sup>b</sup> $\pm$ 0.68
4	4.37 <sup>b</sup> $\pm$ 0.26	5.75 <sup>a</sup> $\pm$ 0.03	5.85 $\pm$ 0.02	1.50 <sup>bc</sup> $\pm$ 0.04	94.0 <sup>a</sup> $\pm$ 0.51

Means within each column carrying atleast one common superscript do not differ significantly

\* ( $P \geq 0.05$ ) \*\* ( $P \geq 0.01$ )

<sup>NS</sup>-Not Significant ( $P \geq 0.05$ )

### Live shrink loss

After broilers were delivered at the retail shops, live shrink loss continued for two more days in spite of provision of water and feed during holding. It increased initially from 0.38  $\pm$  0.18 at 0-day to 11.32  $\pm$  0.56 on day-2. Afterwards, the broilers seemed to start recouping and the loss came down to 4.37  $\pm$  0.26% on day-4. Analysis of variance revealed that the above loss on day-2 was significantly ( $P \leq 0.01$ ) higher than that on day-0, 3, or 4 of holding. It has to be noted that even after four days of feeding and watering, broilers have not recovered their original body weight recorded at the time of delivery. Lyon *et al.* (1991) [11] and Buhr *et al.* (1998) [22] also noticed live shrink losses among broilers during holding. The findings in this study are also in agreement with those of Taylor *et al.* (2002) [23] who stated that following a feed outage, broilers consumed more feed and gained in weight.

### Breast muscle pH

Mean values for breast muscle pH during different days of holding also followed a similar trend like live shrink loss (%). The same became the least acidic on day-2 (6.03  $\pm$  0.03) and then started (day- 4: 5.75  $\pm$  0.03) falling. Glycogen reserves in breast muscle might have continued to be depleted in proportion to live shrink loss upto day-2 and thereafter, once the birds started gaining in weight, the reserves might have gone up leading to comparatively more post-mortem lactic acid production and fall in pH (Lawrie, 1998 and Radhakrishnan, 2000) [16, 14].

### Thigh muscle pH

Thigh muscle pH (Mean  $\pm$  S.E.) increased from 5.78  $\pm$  0.06 at 0-day to 5.99  $\pm$  0.05 on day-1, but subsequently declined to reach 5.85  $\pm$  0.05 (Figure 2). However, the changes in thigh muscle pH over length of holding period were not found significant ( $P \geq 0.05$ ). This indicate that both breast and thigh muscle pH turned more acidic as the holding period is

prolonged beyond two days because of re-feeding and replenishment of muscle glycogen as discussed for muscle pH. Zhang *et al.*, (2009) [24] revealed that pH of was not affected by transport time, recovery time, or their interaction. However, breast pH values were higher than those of thigh muscle, which might be due to higher lactate concentrations or glycogen reserves in breast muscle.

### Tenderness/Shear force value

Tenderness of broiler meat did not seem to follow a trend during holding period as mean shear force values for 0-day (1.22  $\pm$  0.04) and day-2 (1.45  $\pm$  0.05) were significantly ( $P \geq 0.01$ ) lower than those for day-1 (1.72  $\pm$  0.06) and day-3 (1.78  $\pm$  0.08). The muscle was the most tender on day-0 under holding and afterwards it became significantly less tender to varying levels in the following period. Findings of Khan and Nakamura (1970) [25] that voluntary and involuntary struggling resulted in less tender meat might offer partial explanation as broilers under holding at retail shops are repeatedly disturbed every day due to frequent catching as per retail demand. Better tenderness on day-3 might be attributed to comparatively higher pH value (Ali *et al.*, 1996) [26].

### Water holding capacity

Water holding capacity of broiler meat was found to increase with the time of holding beyond day-1 and was the highest (94.0  $\pm$  0.51) on day-4. The mean WHC on day-4 was significantly ( $P \leq 0.01$ ) higher than the means for earlier days. It indicated that cooking losses would be the highest if broilers held for four days are used (Owens and Sams, 2000) [2]. No correlation between breast muscle pH and WHC was evident as observed by Petracci *et al.* (2001) [20] and Musa *et al.* (2006) [12] and this factor requires further study.

### Microbial quality of drinking water and litter

Live broiler holding conditions at broiler retail shops were

also assessed by subjecting drinking water provided for the birds and the litter material in the holding pens to coliform count (Table 3). The coliform count in drinking water for birds varied from  $1.0 \times 10^2$  to  $2.8 \times 10^5$  per ml among the eight broiler retail shops surveyed. The same in litter material in holding pens ranged from  $2.5 \times 10^5$  to  $3.8 \times 10^5$ .

**Table 3:** Coliform count in holding pens at broiler retail shops

Shop / Area	Coliform count	
	Water (per ml)	Litter (per g)
1	$2.5 \times 10^5$	$3.0 \times 10^5$
2	$1.5 \times 10^5$	$2.5 \times 10^5$
3	$3.0 \times 10^2$	$3.0 \times 10^5$
4	$1.0 \times 10^2$	$3.2 \times 10^5$
5	$2.0 \times 10^2$	$3.6 \times 10^5$
6	$1.5 \times 10^2$	$3.8 \times 10^5$
7	$2.3 \times 10^5$	$3.6 \times 10^5$
8	$2.8 \times 10^5$	$3.2 \times 10^5$

This study indicated that the values were much higher compared to the minimum level of sanitary conditions anticipated (Prabakaran, 1999) [27]. It might have resulted because of constant and repeated contamination of the litter with the droppings of the broilers and the water with the litter material.

### Conclusion

It is concluded that the distance of travel affected tenderness of broiler meat and the length of holding period at retail marketing units significantly influenced breast muscle pH, tenderness and anticipated cooking loss of broiler meat. An awareness campaign is required targeting the broiler retail shop owners to ensure provision of sanitised drinking water and adoption of routine disinfection procedures at the broiler holding pens to ensure supply of quality meat to consumers.

### References

- Kannan G, Heath JL, Wabeck, CJ, Souza MC, Howe JC, Mench JA. Effects of crating and transport on stress and meat quality characteristics in broilers. *Poultry Science* 1997;76:523-529.
- Owens CM, Sams AR. The influence of transportation on turkey meat quality. *Poultry Science* 2000;79:1204-1207.
- Perez MP, Palacio J, Santolaria MP, Acena MC, Chacon G, Gascon M *et al.* Effect of transport time on welfare and meat quality in pigs. *Meat Science* 2002;61:425-433.
- Leheska JM, Wulf DM, Maddock RJ. Effects of fasting and transport on pork quality development and extent of postmortem metabolism. *Journal of Animal Science* 2003;81:3194-3202.
- Savenije B, Lambooi E, Gerritzen MA, Venema K, Korf J. Effect of feed deprivation and transport on pre-slaughter blood metabolites, early postmortem muscle metabolites and meat quality. *Poultry Science* 2002;81:699-708.
- Arumugam MP, Panda B. Processing and Inspection of Poultry. Indian Veterinary Research Institute, Izatnagar, U.P, 1970.
- Hamm R. Interactions between phosphates and meat proteins. The AVI Publishing Company, Inc. Westport, Connecticut, 1971.
- Barker FJ, Breach MR. Total and viable counts In: Medical microbial techniques. First ed. Butterworths Co. Ltd., U.K. 1980; 419-425.
- Aral Y, Arian MS, Akin AC, Kuyulu CY K, Guloglu SC, Sakarya E. *Ankara Univ Vet Fak Derg* 2014;61:205-210.
- Arian MS, Akin AC, Akcay A, Aral Y, Sariozkan S, Cevrimli MB. Effects of transportation distance, slaughter age, and seasonal factors on total losses in broiler chickens. *Brazilian Journal of Poultry Science* 2017;19:421-428.
- Lyon CE, Papa CM, Wilson JR. Effect of feed withdrawal on yields, muscle PH, and texture of broiler breast meat. *Poultry Science* 1991;70:1020-1025.
- Musa HH, Cheng GH, Shuiep ES, Bao WB. Breed and Sex effect on meat quality of chicken. *International Journal of Poultry Science* 2006;5(6):566-568.
- Gregory NG. Preslaughter handling, stunning and slaughter. *Meat Science* 1994;36:45-56.
- Radhakrishnan KTR. Factors affecting meat quality Proc. of XX Annual Conference and Symposium of Indian Poultry Science Association, Chennai 2000,192-197.
- Oba A, Almeida AD, Pinheiro JW, Ida EI, Marchi DF, Soares AL. The effect of management of transport and lairage conditions on broiler chicken breast meat quality and DOA (Death on Arrival). *Brazilian archives of biology and technology* 2009;52:205-211.
- Lawrie RA. The conversion of muscle to meat. Lawrie's meat science. 6<sup>th</sup> ed. Woodhead publishing Ltd., Cambridge, England 1998,96-118.
- Lyon CE, Robach MC, Papa CM, Wilson RL. Effect of wing restrains on the objective texture of commercially processed broiler breast meat. *Poultry Science* 1992;71:1228-1231.
- Kotula, KL, Yi Wang. Characterization of broiler meat quality factors as influence of withdrawal time. *Journal of Applied Poultry Research* 1994;3:103-110.
- Dos Santos VM, Dallago BSL, Racanicci AMC, Santana AP, Bernal FEM. Effects of season and distance during transport on broiler chicken meat. *Poultry Science* 2017;96:4270-4279.
- Petracci M, Fletcher DL, Northcutt JK. The effect of holding temperature on live shrink, processing yield and breast meat quality of broiler chickens. *Poultry Science* 2001;80:670-675.
- Dos Santos VM, Dallago BSL, Racanicci AMC, Santana AP, Cue RI, Bernal FEM. Effect of transportation distances, seasons and crate microclimate on broiler chicken production losses. *PLoS ONE* 2020;15(4):e0232004. <https://doi.org/10.1371/journal.pone.0232004>.
- Buhr RJ, Northcutt JK, Lyon CE, Rowland GN. Influence of time off feed on broiler viscera weight, diameter and shear. *Poultry Science* 1998;77:58-764.
- Taylor NL, Northcutt JK, Fletcher DL. Effect of a short-term feed outage on broiler performance, live shrink, and processing yields. *Poultry Science* 2002;81:1236-1242.
- Zhang LH, Yue HY, Zhang HJ, Xu L, Wu SG, Yan HJ *et al.* Transport stress in broilers: I. Blood metabolism, glycolytic potential, and meat quality. *Poultry Science* 2009;88:2033-2041.
- Khan AW, Nakamura R. Effect of pre and post-mortem glycolysis of poultry tenderness. *Journal of Food Science* 1970;35:266-267.
- Ali ASA, Harrisson P, Jensen JF. Effect of some antimortem stressors on perimortem and post mortem biochemical changes and tenderness in broiler breast muscle. *World's Poultry Science Journal* 1999;55:403-414.
- Prabakaran R. Commercial Chicken Production. 1<sup>st</sup> Edn. Saranya Publication, Chennai, 1999.