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Physiological effects of transport duration on meat quality of Indian broiler chickens

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Abstract
Pre-slaughter transport affects the meat yield, and meat quality, but little is known about the effect of transport on medium-growing broiler chickens. This study aimed at evaluating stress effects due to different durations of transport (0, 1, 2, and 3 h) and meat quality of medium-growing broiler chickens. One hundred feathered broilers aged 45 days (marketing age), of 1.52 kg average BW, were allotted into five groups; each group contained five replicates (five birds/replicate or cage). Each transport cage with dimensions 75 × 54 × 27 cm (length × width × height) was loaded with six birds. The tested transport durations increased BW loss (linear, $P<0.01$), drip loss of breast muscle increased (linear, $P<0.01$), whereas shear force, pH at 24 h post-mortem, and breast meat colour lightness, redness, and yellowness scores were not affected. In conclusion, the tested transport durations (from 1 to 3 h) increased BW loss and affect the meat quality in 45-day-old broiler chickens.

Keywords: broiler, transport, meat analysis, pre-slaughter handling

Introduction
Pre-slaughter transport of broilers results stress which has a significant impact on meat yield, and meat quality, which cause major economic losses in poultry enterprises (Barbut, 2015) [1]. The transport stressors are categorized into mental, physical, and mixed factors. The physical stressors include catching, crating, and the environment during transport, such as hot or cold temperatures, wind, vehicle vibration, and air flow, which cause physical injuries. Mental stressors include social mixing, fear and pain, food and water deprivation, promoting exhaustion of the bird (Jayaprakash *et al*., 2016) [2]. The ante-mortem stress on animals increases the production and consumption of epinephrine and glucocorticoids (Arikan *et al*., 2017) [3]. These stressors promote alterations in the biochemical and physiological status of the bird's cells, disturbing their normal homeostasis, reducing the quality and quantity of meat. The reserves of muscle glycogen in birds are consumed during transport which induces significant alterations in carcass meat pH and colour. Adzitey and Nurul (2011) [4] reported that brief transport times lead to pale-soft-exudative meat, and long durations lead to dark-firm-dry meat. Among the meat quality attributes, meat colour has a major role in consumer decision to accept or reject the product in supermarket shelves (Droval *et al*., 2012) [5]. Other traits such as water loss and meat tenderness can be detected only after cooking. Present study is hypothesized that transport duration is expected to exert negative effects on the meat quality of broiler chickens. This study, therefore, evaluated the effects of different transport durations (0, 1, 2, and 3 h) on meat quality of Indian medium-growing broiler chickens.

Material and Methods
Experimental design
One hundred 45-day-old broilers with consistent BW (1.52 ± .23 kg) were allotted to four group. Each group consisted 5 replicates, total of 25 birds/group), and each replicate was transported in a single birdcage. Birds in the first group were not transported and were considered as controls, but the others were transported in one truck, for total durations of 0, 1.0, 2.0, and 3.0 h. All shipments occurred at 11:00 AM under 32 °C temperatures and 65% relative humidity. The speed of transportation was between 30 and 40 km/h (Xing *et al*., 2015) [6]. The individual BWs were recorded before and after transport. During the preceding growth phase, all birds received a corn-soybean-meal-based balanced mash diet and drinking water ad libitum. Feed was withdrawn 10 h before shipping, but water was available ad libitum until shipping time. Drinking water was not supplied during transport in this study. So, birds can be transported to slaughter house without feed and water.

All bird cages were put at random locations on the truck. The truck was an opened truck designed for shipment of broiler chickens. All birds went on the truck at the same time and pre-selected cages were quickly removed after the designated transportation times then transportation continued to the next designated time.

Sample collection

The birds were slaughtered to obtain internal organs and tissues. Left and right deboned breast and thigh muscles were dissected. Left pectoral samples were used for determining the biochemical contents; pH, drip loss, and segments of the right pectoral samples were used for determining meat colour and shear force.

Assessment of carcass traits and meat quality indices

Breast muscle (%), thigh muscle (%), and abdominal fat (%) were expressed as weight percentages of final BW. Meat colour, pH, and shear force of breast muscle were measured according to the methods described by Jiang *et al*. (2007) [7]. Readings of pH of the left pectoralis major were measured in triplicate at different locations, 45 min and 24 h after slaughter using a portable pH meter. At the same times, scores of meat colour, the redness, yellowness, and lightness values were measured. About 10 g samples of breast muscle cut parallel to muscle fiber direction were used to measure drip loss during storage at 24 h at 4 °C. Formula for Drip loss (%) = (initial weight of sample − final weight of sample) /initial weight of sample × 100%. Finally, the cross-sectional shear force of cooked breast muscles was measured 10 times with 10 sub-samples cut parallel to muscle fiber direction.

Statistical analysis

Each replicate (n = 5) served as the experimental unit. The effects of transport durations (n = 4) were examined for each variable by GLM when all data conform to normality and homogeneity (JMP Ver. 8.0.2, 2009; SAS Institute Inc., Cary, NC, USA). Analysis of covariance was used to analyze the final BW using initial BW as the covariate (SPSS software version 17.0.1. Chicago, IL, USA). Where appropriate, orthogonal polynomial contrasts were used to estimate the linear and quadratic effects of the transportation durations and a probability level of 0.05 was applied to test significance (SPSS). Data are expressed as means for each group with the SEM derived from the ANOVA error mean square.

Results and Discussion

Body weight loss

The results shown in Table-1 revealed significant effects of the different transport durations, as the final BW decreased and BW loss increased with the duration of transport (linear, $P<0.01$). After arrival of birds transported for 0, 1, 2, and 3 h, the BW loss was 0.07%, 1.59%, 1.86% and 2.96% of the initial BW, respectively.

Table 1: Effects of transport duration on BW loss of 45-day-old yellow-feathered broiler chickens

Variable	Transport duration (h)				SEM	P-values		
	0	1	2	3		Transport	Linear	Quadratic
Mean Initial BW (g)	1.522	1.511	1.509	1.519	11.7	0.824		
Mean Final BW (g)	1.512	1.487	1.481	1.474	11.4	< 0.001	0.002	0.607
Mean BW loss (g)	0.001	0.024	0.028	0.045	0.3	< 0.001	< 0.001	0.906

Breast meat quality

The results of breast meat quality variables are shown in Table-2. The drip loss of breast muscle increased (linear, $P<0.01$; quadratic, $P<0.05$) with increased duration of transport, and the pH at 45 min post-mortem showed a quadratic response ($P<0.01$). Drip loss of birds transported for 2 h or 3 h was both greater than that of other three treatments. Birds transported for 3 h had the greatest drip loss vs the control (4.6% vs 3.61%), increased by 27.4%. The shear force, pH at 24 h post-mortem, the breast meat colour, redness, yellowness, and lightness scores, either measured at 45 min or 24 h post-mortem, were not affected by transport.

Table 2: Effects of transport duration on breast meat quality of 45-day-old Yellow-feathered broiler chickens

Variables	Transport duration (h)					SEM	P-values
	0	1	2	3		Transport	Linear
Drip loss (%)	3.1	3.2	3.29	3.59	4.1	0.122	< 0.001
Shear force (N)	37.9	34.6	35.5	31.9	31.1	3.26	0.598
pH 45 min	5.15	5.45	5.5	5.23	5.25	0.064	0.003
pH 24 h	5.05	5.1	5.07	5.07	5.05	0.019	0.423
Breast meat colour (After 45 min of slaughter)							
Lightness	56.8	56.7	56.7	57	58.8	0.922	0.382
Redness	13.3	13.7	13.4	13	12.5	0.365	0.243
Yellowness	8.74	11.11	9.98	9.28	8.85	0.743	0.177
Breast meat colour (After 24 h of slaughter)							
Lightness	59.3	60.7	60.4	60.5	60.6	0.805	0.756
Redness	12.5	11.6	11.5	11.8	11.8	0.475	0.627
Yellowness	12	12.8	11.8	12.2	11.9	0.462	0.571

The breast meat quality, pre-slaughter transport up to 3 h did not adversely affect breast muscle shear force, pH at 24-h post-mortem, or the meat colour redness, yellowness, and lightness values either at 45 min or 24 h after slaughter, but drip loss increased with duration of transport and pH at 45 min post-mortem changed quadratically. The pH45 min increased relatively in birds transported for 1 and 2 h, vs controls (0h) and those transported for longer times. However, reports on the effect of transport on meat quality are sometimes contradictory, ranging from no differences to decreased muscle glycogen and increased final pH after transport (Savenije *et al*., 2002) [8]. There is an inverse

relationship between pH and carcass loss, that is, the increase in pH leads to decreased carcass loss (Caldara *et al*., 2012) [9]. In contrast, the results here showed that the pH at 45 min post-mortem increased in birds transported for 1 h while those transported for 2 and 3 h did not differ from the controls. Drip loss, however, increased linearly with longer transportation, regardless of pH. The present results did not demonstrate negative effects of duration of transport on breast muscle shear force. Similar conclusions were reported by Dos-Santos *et al*. (2017) [10], who found that meat tenderness was not affected by the long- and short-transport distances. The present study suggests that transporting broiler chickens for up to 3 h had no adverse effects on the main meat quality variables affecting consumer acceptance, as the meat colour and shear force were not significantly affected. Meat tenderness is one of the most important quality factors contributing to consumer acceptance (Hong and Lee, 2012) [11].

Conclusion

Transporting market-aged Indian broiler chickens for 0, 1, 2, or 3 h results increased body weight loss and negatively affected the drip loss. But not cause any mortality, meat colour and shear force, were not affected. This study clearly revealed that the meat quality of broiler chickens was affected by transport stress indicated by increased drip loss in muscle. This study concluded that the broiler transport durations (from 1 to 3 h) increased body weight loss and affect the meat quality in 45-day-old broiler chickens.

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