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Phenotypic Correlations in Broiler Breast Meat Quality and some Welfare Criteria: Implications of Photoperiod Length and Light Intensity

Research Article

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ABSTRACT

The goals of this research were to estimate the phenotypic correlations among various meat quality traits, carcass parts weight, some blood parameters, and eye dimensions from a male broiler line and to describe the relation among these variables. Two photoperiod length groups and two light intensity groups of commercial meat-type broilers were used as treatments. A total of 272 1 day-old male broiler chicks (Ross 308) were randomly assigned to four treatment groups based on the photoperiod length and light intensity, with four replicates. Eight broilers from each group were used for colour measurement (CIE L*a*b*), pH, cooking loss, and water holding capacity at the age of 42 days. The pH at 24 hours after postmortem (pHu) was capable of directly interfering with the attributes of the meat, since this trait was inversely related with a*, water holding capacity and pH 15 mins postmortem (pH_{15}) in the dim, reducing (DRLI) group, indicating an effect of pHu decrease during 24h postmortem on protein denaturation. This study demonstrates that the variables of poultry meat quality are related and that there is a phenotypical association between a* value, water holding capacity (WHC) and the other attributes of the meat. The pHu, a* value and WHC could be efficient meat quality indicators in this broiler line. Corticosterone (CORT) level had a significant positive correlation ($r=0.323$, $P<0.05$) with glucose level in the bright light (BLI) group. Eye weight had a significant correlation with all eye dimensios in increasing photoperiod length group.

KEY WORDS blood parameters, carcass, correlation, eye health, meat quality.

INTRODUCTION

Artificial control of day length for poultry has two primary aims. First, it prevents birds from maturing too early, at too low a body weight. This is avoided by use of a constant but short day length during rearing, which has no obvious welfare implications. Secondly, light control is used to bring birds into breeding condition and to keep them in this state for an extended period (Appleby *et al.* 2004). Therefore, recent studies have focused on limited lighting programs (such as increasing photoperiod), as an alternative to the continuous lighting program, to provide for the well-being of the birds. Light intensity plays an important role in the health status of broilers (Blatchford *et al.* 2012). Studies showed that low light intensity has negative effects on broiler carcass traits, early uniformity and meat tenderness, and is related to incidence of disease, eye defects, dystrophy, skeletal disorders and poor foot pad health (Blatchford *et al.* 2009; Rault *et al.* 2017). High light intensity can improve activity, benefit bone health, increase growth and breast muscle percentage, and provide comfort behaviors for broilers (Blatchford *et al.* 2009; Blatchford *et al.* 2012;

Deep *et al*. 2013, Rault *et al*. 2017). However, too high a light intensity may enhance attack behavior of broilers and is not in accordance with broiler welfare (Kjaer and Vestergaard, 1999).

Welfare has been assessed from eye health, blood serum corticosterone (CORT), glucose, triglyceride, lactate, cholesterol, and total protein, lactate dehydrogenase (LDH) and aspartate aminotransferase (AST) levels, and carcass characteristics (Deep *et al*. 2010). It has been reported that the hypothalamic-pituitary-adrenocortical axis is activated by stress and increases plasma CORT concentration in poultry (Jones *et al*. 1988).

Environmental conditions, such as photoperiod length and housing conditions, may affect meat quality. Meat quality is defined by the combination of many factors; however, consumers attach a special importance to colour and texture (Dadgar, 2010). The visual appraisals for the determination of meat colour are time-consuming, colour is frequently measured by reflectance colourimetry and reported as Commission International d'Éclairage (CIE) L*a*b* coordinates. With this method, the color of poultry breast has been evaluated from the data of the lightness (L*), redness (a*), and yellowness (b*) of the meat (Mothershaw *et al*. 2009). In poultry, color variations in meat have received considerable attention from researchers because of their direct influence on consumer acceptance and high correlation with the functional characteristics of meat. Fresh raw breast meat is expected to have a pale pink color. Also, sustaining birds in good health, with high welfare and health standards, results in good quality meat products (Sundrum, 2001). Producers should be concerned with factors that may negatively affect these important meat quality traits attributes (Qiao *et al*. 2002). Soares *et al*. (2009) have indicated the following criteria for classification of breast meat into quality categories: L* ≥ 53 for pale, soft, exudative (PSE), L ≤ 44 for dark, firm, dry (DFD) like and 44 < L* < 53 for normal meat. Meat colour is associated with pH in a way that lighter muscles (L*>50) have higher pH values than darker (L*<45) ones (Allen *et al*. 1998). Polidori *et al*. (1999) have reported the correlation between pH after 24 h post mortem, lightness and PSE problems for poultry meat, confirming the importance of correct measurement of colour parameters. Fletcher *et al*. (2000) have established a significant correlation between pH and extreme colour variations, while Salakova *et al*. (2009) indicated that negative correlations existed between chicken breast meat lightness (L*), yellowness (b*) and pH values, whereas positive correlations existed between breast meat L*, b* and redness (a*). Allen *et al*. (1998) have found a negative correlation between colour and pH of chicken breast meat. Dereli Fidan *et al*. (2015) reported that negative correlations existed between chicken breast meat pH_{15} and a* values; between breast meat pHu and L* values; and between breast meat pHu and DL values in male and female broilers (Dereli Fidan *et al*. 2015).

A similar relationship between breast meat pHu and L* values has also been reported, with decreasing pHu associated with increasing L* values (Berri *et al*. 2007; Salakova *et al*. 2009). Abdominal fat was reported to be highly correlated with pH_u with estimates of -0.54 and -0.76 reported by Le Bihan-Duval *et al*. (1999) and Le Bihan-Duval *et al*. (2001), respectively. Meat lightness (L*) was reported to be moderately correlated with abdominal fat with estimates of 0.41 and 0.50 (Le Bihan-Duval *et al*. 1999; Le Bihan-Duval *et al*. 2001). Also, in this study, when the pH value was higher, meat was darker, less yellow and redder. Thus, as the pH increased, the values of lightness and yellowness decreased but that of redness increased (Allen *et al*. 1997). Allen *et al*. (1998) also reported that the L* value of poultry breast meat was positively correlated with cooking loss (CL). The objectives of this study were to determination correlations between breast meat quality traits (L*, a*, b*, CL, water holding capacity (WHC), carcass part weights, pH_{15} and pHu) some blood parameters (CORT, glucose, triglyceride, lactate, cholesterol, total protein, LDH and AST levels), eye dimensions (eye weight (EW), corneal diameter (CD), mediolateral diameter (ML), dorsoventral diameter (DV), and anterioposterior size (AP)) in broilers.

MATERIALS AND METHODS

Birds and husbandry

The following procedures related to animal handling and sample collections were approved by the Adnan Menderes University Animal Experiments Local Ethic Council (Decision Number:64583101/2013/088). The trial was conducted at the Poultry Research Unit of Animal Science Department, Faculty of Veterinary Medicine, Adnan Menderes University, Turkey. A total of two hundred and seventy two day-old male broiler chicks of Ross 308 were obtained from a commercial hatchery. Feed and water were provided *ad libitum* throughout the experiment. The broiler chick ration given between days 1-21 contained 23% of crude protein (CP) and 3060 kcal/ME/kg, while the broiler chicken ration given between days 22-42 contained 21.5% of CP and 3200 kcal/ME/kg.

Experimental design

Broiler chicks were placed in four environmentally controlled houses in floor pens at day of hatch in a completely randomized design with 4 treatment, 4 replicates and 17 chicks in each replicate. Photoperiod length and light intensity were the two factors that varied according to the experimental design.

Four replicate rooms were then subjected to the following photoperiod length and light intensity treatments in a 2 × 2 factorial arrangement: photoperiod lengths were either near-continuous (CPL) (23L:1D from 1 to 42 d) or increasing photoperiod (IPL) (23L:1D from 1 to 8 d, 14L:10D from 9 to 15 d, 16L:18D from 16 to 22 d, 18L:6D from 23 to 29 d, 20L:4D from 30 to 36 d, followed by 23L:1D from 37 to 42 d) and light intensity was either bright light (BLI) (20 lux from d 1 to 42 d) or dim, reducing (DRLI) (5 lux from d 1 to 8, 2.5 lux from d 9 to 15, and 1.25 lux from d 16 to 42). It should be noted that 23L was applied for the last 6 d before slaughter in the increasing photoperiod group. This was done because it is common industry practice to maximize photoperiod length for three to seven day before slaughter, and is provided for by recent EU guidelines (European Union, 2007).

Two 40 W incandescent bulbs, which were controlled by a rheostat and automatic timer, were used for lighting. The lights were attached 1.90 m above the floor. Light intensity was monitored at chick head level using a digital illuminometer (Datalogging light meter, Extech HD 450, Extech Instruments, USA) thrice weekly. Walls and ceilings in the rooms were painted white colour to provide high light intensity. The room temperature was set at 34 ˚C for the first day, followed by 32 ˚C over the remainder of the first week, then was reduced by 3 ˚C per week until it reached 23 ˚C. The relative humidity fluctuated between 40 and 70%. Broilers were maintained on fresh wood shavings in floor pens.

Traits measured

On d 42 (at the end of the experiment), blood samples were collected between 0800 and 0900 h from a brachial vein of 10 birds, randomly selected from each replication group. The birds were then returned to the appropriate rooms using a standard handling procedure. Blood samples (5 mL) were collected directly into tubes without anticoagulant. The blood was set at 4 ˚C, then serum was separated by centrifugation at 1500 × g for 15 min. Glucose, triglyceride, lactate, cholesterol, total protein, LDH and AST levels were measured with a biochemical analyzer (Ray Chemray 120) using commercial reagents (Archer Diagnostic Ind. Ltd., Turkey). The CORT concentration was estimated by the ELISA Method using an ELISA kit (Catalog no. ADI-900-097; Enzo Life Science).

Thirty-two chickens from each treatment group (8 birds per pen) were randomly selected at 42 days of age. These 128 birds were slaughtered by severing the jugular vein in the experimental processing unit, 12 h after feed withdrawal. The carcasses were immersed in hot water (53 ˚C for 150 s), mechanically plucked (35 s), and manually eviscerated. Then, the whole carcass (without neck, giblets) was immediately weighed, and hot carcass weight was determined. Cold carcass weights were recorded after the carcasses were stored at +4 ˚C for 24 h. The carcass was cut into parts, and deboned to obtain skinless, boneless breast fillet (pectoralis major) and breast tender (pectoralis minor), wings, legs (thigh and drum) and abdominal fat pads which were weighed to determine carcass parts weight. Breast skin was removed and then weighed.

Meat quality analysis was carried out on breast muscle (pectoralis major). The pH value was measured 15 min (initial pH, pH_{15}) and 24 hours (ultimate pH, pHu) postmortem in the right pectoralis major with a portable pH meter (Hanna Instrument (HI) 9124) equipped with a penetration electrode (Hanna FC-200) calibrated in standard buffers at pH 4.00 and 6.96 at ambient temperature. The surface colour of left breast was separated with their skin on and the color values of these skinless breast meat samples were determined according to the CIELAB method (International Commission on Illumination, 1978) using a Minolta CR 400 colorimeter (Konica Minolta Sensing, Inc., Osaka, Japan). Lightness, redness, and yellowness values, L*, a*, and b*, respectively, were assessed according to this method. Measuring area of 8 mm, illuminant D65 and 10˚ standard observer were used. The instrument was standardized using a standard white plate.

The cooking loss (CL) was evaluated all carcass (total 128 birds) according to Honikel (1998), and was determined with the formula CL(%)= [(raw weight piece-cooked weight piece) / (raw weight piece)] × 100. Water holding capacity (WHC) was evaluated 24 h after slaughter, using the methodology described by Barton-Gade *et al.* (1993). The right eye was collected from 10 birds in each replication group (a total of 160 birds) at 42 days of age and eye weight and dimensions (CD, ML, DV, and AP) were noted immediately after extirpation, using a digital caliper.

Statistical analyses

Statistical analyses were performed by using software package Statistical Package for the social sciences for windows (SPSS) 20.0 (SPSS, 2011). The correlations between meat and carcass traits, blood parameters were calculated using Person's correlation coefficients.

RESULTS AND DISCUSSION

The correlations among breast meat pH values and quality traits within broiler chickens are presented in Table 1. Breast meat pH_{15} had significant positive correlation with lightness and yellowness in the CPL groups. For correlations between meat colour and pH, redness (a*) and WHC were found to correlate negatively to pH_{15}, whereas yellowness (b*) had a positive correlation in IPL.

Table 1 Pearson correlation coefficients and correlation significance among quality measurements of P. Major muscle samples from Ross 308 broiler carcass within photoperiod length and light intensity groups

Item	Photoperiod treatment													
	Near-continuous photoperiod length							Increasing photoperiod length						
	L*	a*	b*	CL	WHC	pH15	pHu	L*	a*	b*	CL	WHC	pH15	pHu
L*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a*	-0.227	-	-	-	-	-	-	-0.167	-	-	-	-	-	-
b*	0.596***	-0.237	-	-	-	-	-	0.273*	-0.211	-	-	-	-	-
CL	-0.007	0.045	-0.096	-	-	-	-	-0.061	-0.070	0.035	-	-	-	-
WHC	-0.065	0.081	-0.112	0.315*	-	-	-	-0.020	0.326*	-0.001	0.048	-	-	-
pH15	0.263*	-0.197	0.289*	-0.039	-0.253*	-	-	0.087	-0.498***	0.278*	0.085	-0.301*	-	-
pHu	-0.026	-0.026	0.171	-0.233	-0.343**	-0.020	-	-0.042	-0.191	0.103	-0.124	-0.501***	0,389**	-
Item	**Light intensity treatment**													
	Bright light							Dim, reducing light						
L*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a*	-0.185	-	-	-	-	-	-	-0.260*	-	-	-	-	-	-
b*	0.525***	-0.174	-	-	-	-	-	0.714***	-0.300*	-	-	-	-	-
CL	-0.006	-0.014	-0.006	-	-	-	-	-0.053	0.007	-0.168	-	-	-	-
WHC	-0.027	0.176	-0.017	0.175	-	-	-	-0.131	0.270*	-0.139	0.168	-	-	-
pH15	0.156	-0.199	0.292*	0.006	-0.297*	-	-	0.253*	-0.526***	0.374**	0.017	-0.300*	-	-
pHu	0.081	0.053	0.205	-0.141	-0.344**	0.203	-	-0.102	-0.302*	-0.024	-0.221	-0.494***	0.257*	-

pH_{15}: initial pH value measured 15 min post mortem; pHu: pH value measured 24 h post mortem; L*: lightness; a*: redness; b*: yellowness; CL: cooking loss and WHC: water holding capacity. * (P<0.05); ** (P<0.01) and *** (P<0.001).

Negative correlations existed between chicken breast meat pHu and WHC values in CPL, IPL, BLI, and DRLI groups (-0.343, -0.501, -0.344, and -0.494, respectively). Lightness (L*) and yellowness (b*) were found to correlate positively to pH_{15}, whereas redness (a*) and WHC had a negative correlation in DRLI groups. The correlations among live weight and carcass part weights within broiler chickens are presented in Tables 2 and 3. Live weight resulted in significant positive correlation with carcass part weights, except for abdominal fat pad (AFP) weight in photoperiod length and light intensity groups (Tables 2 and 3). Whole breast weight tended to be negatively related to AFP weight in CPL, IPL, BLI, and DRLI groups (-0.076, -0.096, -0.106, and -0.083, respectively) although these correlations were not statistically significant. Generally, strong positive and statistically significant correlations were determined between hot carcass and carcass part weights, except for AFP weight, in CPL, IPL, BLI, and DRLI birds. Moderate negative correlations of -0.347 and -0.383 (P<0.05) were observed between triglyceride and LDH concentration in the IPL and DRLI group birds, respectively (Table 4). A moderate positive correlation of 0.323 (P<0.05) was observed between glucose and CORT concentration in the BLI groups birds (Table 4). Table 5 indicates that eye weight was highly significantly (P<0.001) and positively correlated with dorsoventral diameter, mediolateral diameter and anterioposterior size in photoperiod length and light intensity groups.

In this study, breast meat pH_{15} was significantly correlated with L* (0.263) in CPL groups. This correlation agrees with those reported by Anadon (2002) who observed that the positive correlation between breast meat pH at 0.25 hours postmortem was significant in male.

The determined that a* values were higher in fillets exhibiting lower L* values and lower ultimate pH in DRLI birds similar with result of Anadon (2002) who reported a significant negative correlation between ultimate pH and a* values (r=-0.16), and differ from results of Qiao *et al.* (2001) who reported a significant positive correlation between ultimate pH and a* value.

The Pectoralis major muscle between pHu and WHC correlation value (-0.343) were lower in CPL birds when compared to those of IPL birds. In the study, the estimates of significant correlations found between L* and b* was of high magnitude (0.596, 0.525, and 0.714, respectively) in CPL, BLI, and DRLI groups, and moderate magnitude (0.273) in IPL birds.

The L* correlated well with b* meat quality traits and this explains the darker color and higher yellowness of DRLI birds due to higher pHu compared to CPL and IPL groups. The variable a* showed a moderate negative and significant correlation with the variables L* (-0.260) in DRLI groups. According to Salakova *et al.* (2009), Dadgar (2010) and Silva *et al.* (2011), the redness and yellowness of chicken are linked, such that meat with higher redness tends to present higher levels of yellowness, similar to the association found in this study. Le Bihan-Duval *et al.* (1999), Barbut *et al.* (2005) and Bianchi *et al.* (2007) reported that dark broiler breast meat significantly lower L* value, higher a* value, and lower b* values than light broiler breast fillets. The significant correlation between a* and b* was negative and of moderated intensity (-0.300) in DRLI groups. Similarly, Qiao *et al.* (2001) indicated that breast meat a* values were negatively correlated with b* values, thus as meat redness increases yellowness decreases in broilers.

Table 2 Pearson correlation coefficients and correlation significance among broiler carcass part weights within photoperiod length groups

Item	Near-continuous photoperiod length											
	LW	Hot carcass	Cold carcass	Breast skin	Fillets	Tenders	Whole breast	Thighs	Drums	Whole leg	Wings	AFP
LW	-	-	-	-	-	-	-	-	-	-	-	-
Hot carcass	0.981***	-	-	-	-	-	-	-	-	-	-	-
Cold carcass	0.979***	0.997***	-	-	-	-	-	-	-	-	-	-
Breast skin	0.354**	0.348**	0.366**	-	-	-	-	-	-	-	-	-
Fillets	0.647***	0.667***	0.667***	0.361**	-	-	-	-	-	-	-	-
Tenders	0.564***	0.557***	0.560***	0.190	0.613***	-	-	-	-	-	-	-
Whole breast	0.671***	0.688***	0.688***	0.351**	0.989***	0.722***	-	-	-	-	-	-
Thighs	0.778***	0.790***	0.787***	0.355**	0.580***	0.488***	0.599***	-	-	-	-	-
Drums	0.791***	0.776***	0.773***	0.322**	0.684***	0.590***	0.709***	0.814***	-	-	-	-
Whole leg	0.816***	0.819***	0.816***	0.359**	0.640***	0.543***	0.661***	0.981***	0.911***	-	-	-
Wings	0.731***	0.737***	0.743***	0.346**	0.684***	0.502***	0.692***	0.722***	0.768***	0.768***	-	-
AFP	0.136	0.174	0.176	0.205	-0.063	-0.109	-0.076	0.312*	0.035	0.233	0.017	-
Item	**Increasing photoperiod length**											
LW	-	-	-	-	-	-	-	-	-	-	-	-
Hot carcass	0.972***	-	-	-	-	-	-	-	-	-	-	-
Cold carcass	0.972***	0.998***	-	-	-	-	-	-	-	-	-	-
Breast skin	0.352**	0.366**	0.380**	-	-	-	-	-	-	-	-	-
Fillets	0.811***	0.866***	0.863***	0.262*	-	-	-	-	-	-	-	-
Tenders	0.728***	0.756***	0.744***	0.141	0.684***	-	-	-	-	-	-	-
Whole breast	0.835***	0.888***	0.883***	0.253*	0.992***	0.771***	-	-	-	-	-	-
Thighs	0.922***	0.911***	0.914***	0.383**	0.673***	0.642***	0.700***	-	-	-	-	-
Drums	0.907***	0.905***	0.904***	0.331**	0.697***	0.600***	0.713***	0.856***	-	-	-	-
Whole leg	0.947***	0.940***	0.941***	0.378**	0.704***	0.649***	0.728***	0.984***	0.934***	-	-	-
Wings	0.673***	0.654***	0.655***	0.274*	0.483***	0.382**	0.488***	0.633***	0.732***	0.688***	-	-
AFP	0.064	0.054	0.061	-0.009	-0.127	0.084	-0.096	0.102	0.013	0.075	-0.163	-

LW: live weight and AFP: abdominal fat pad.
* (P<0.05); ** (P<0.01) and *** (P<0.001).

Table 3 Pearson correlation coefficients and correlation significance among broiler carcass part weights within light intensity groups

Item	Bright light											
	LW	Hot carcass	Cold carcass	Breast skin	Fillets	Tenders	Whole breast	Thighs	Drums	Whole leg	Wings	AFP
LW	-	-	-	-	-	-	-	-	-	-	-	-
Hot carcass	0.975***	-	-	-	-	-	-	-	-	-	-	-
Cold carcass	0.974***	0.999***	-	-	-	-	-	-	-	-	-	-
Breast skin	0.300*	0.321*	0.330**	-	-	-	-	-	-	-	-	-
Fillets	0.657***	0.700***	0.701***	0.329**	-	-	-	-	-	-	-	-
Tenders	0.570***	0.558***	0.556***	0.099	0.605***	-	-	-	-	-	-	-
Whole breast	0.681***	0.716***	0.717***	0.308*	0.990***	0.710***	-	-	-	-	-	-
Thighs	0.802***	0.805***	0.807***	0.369**	0.686***	0.589***	0.709***	-	-	-	-	-
Drums	0.784***	0.782***	0.778***	0.312*	0.700***	0.641***	0.731***	0.863***	-	-	-	-
Whole leg	0.821***	0.822***	0.823***	0.362**	0.712***	0.624***	0.738***	0.986***	0.934***	-	-	-
Wings	0.726***	0.748***	0.751***	0.391**	0.743***	0.551***	0.754***	0.762***	0.795***	0.796	-	-
AFP	0.083	0.076	0.089	0.282*	-0.103	-0.086	-0.106	0.221	0.067	0.178	-0.045	-
Item	**Dim, reducing light**											
LW	-	-	-	-	-	-	-	-	-	-	-	-
Hot carcass	0.984***	-	-	-	-	-	-	-	-	-	-	-
Cold carcass	0.982***	0.996***	-	-	-	-	-	-	-	-	-	-
Breast skin	0.417**	0.404**	0.428***	-	-	-	-	-	-	-	-	-
Fillets	0.793***	0.805***	0.803***	0.308*	-	-	-	-	-	-	-	-
Tenders	0.711***	0.723***	0.723***	0.265*	0.664***	-	-	-	-	-	-	-
Whole breast	0.819***	0.832***	0.830***	0.316*	0.990***	0.762***	-	-	-	-	-	-
Thighs	0.894***	0.900***	0.891***	0.367**	0.564***	0.551***	0.592***	-	-	-	-	-
Drums	0.904***	0.892***	0.891***	0.349**	0.694***	0.575***	0.708***	0.801***	-	-	-	-
Whole leg	0.941***	0.940***	0.934***	0.378**	0.637***	0.586***	0.661***	0.977***	0.910***	-	-	-
Wings	0.678***	0.650***	0.655***	0.236	0.452***	0.338**	0.454***	0.620***	0.708***	0.681***	-	-
AFP	0.136	0.180	0.175	-0.010	-0.095	-0.002	-0.083	0.253*	0.008	0.178	-0.082	-

LW: live weight and AFP: abdominal fat pad.
* (P<0.05); ** (P<0.01) and *** (P<0.001).

Castellini *et al.* (2002) reported that a low pHu reduces the importance of myoglobin in selectively absorbing green light, resulting in meat that appears less a* value and more b* value. Live weight was strongly and positively correlated to, except for AFP weight, carcass part weights in photoperiod length and light intensity group.

Table 4 Pearson correlation coefficients and correlation significance among blood parameters within photoperiod length and light intensity groups

Item	Photoperiod treatment													
	Near-continuous photoperiod length							Increasing photoperiod length						
	Glucose	Choles-terol	Triglyc-eride	Total protein	AST	LDH	CORT	Glucose	Choles-terol	Triglyc-eride	Total protein	AST	LDH	CORT
Glucose	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cholesterol	0.130	-	-	-	-	-	-	0.203	-	-	-	-	-	-
Triglyc-eride	0.152	0.259	-	-	-	-	-	0.245	0.275	-	-	-	-	-
Total protein	0.190	0.273	0.216	-	-	-	-	0.060	0.204	-0.005	-	-	-	-
AST	0.255	-0.013	0.130	-0.022	-	-	-	-0.002	0.287	-0.147	0.055	-	-	-
LDH	0.159	0.127	-0.075	0.094	0.161	-	-	0.062	0.176	-0.347*	-0.038	0.296	-	-
CORT	-0.142	0.228	0.187	-0.037	-0.134	-0.247	-	0.103	-0.157	0.065	-0.295	-0.185	-0.176	-
Item	**Light intensity treatment**													
	Bright light							Dim, reducing light						
Glucose	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cholesterol	0.128	-	-	-	-	-	-	0.056	-	-	-	-	-	-
Triglyc-eride	0.366*	0.244	-	-	-	-	-	-0.063	0.225	-	-	-	-	-
Total protein	0.029	0.195	0.194	-	-	-	-	-0.049	0.114	-0.018	-	-	-	-
AST	-0.147	-0.156	-0.080	0.135	-	-	-	0.305	0.175	-0.030	-0.220	-	-	-
LDH	-0.350*	0.032	-0.205	-0.023	0.003	-	-	0.276	0.058	-0.383*	-0.191	0.248	-	-
CORT	0.323*	-0.086	0.143	-0.263	-0.365*	-0.133	-	-0.239	0.264	0.168	0.035	-0.026	-0.169	-

AST: aspartate aminotransferase; LDH: lactate dehydrogenase and CORT: corticosterone.
* (P<0.05); ** (P<0.01) and *** (P<0.001).

Table 5 Pearson correlation coefficients and correlation significance among eye dimensions from Ross 308 broiler within photoperiod length and light intensity groups

Item	Photoperiod treatment									
	Near-continuous photoperiod length					Increasing photoperiod length				
	EW	CD	DV	ML	AP	EW	CD	DV	ML	AP
EW	-	-	-	-	-	-	-	-	-	-
CD	0.167	-	-	-	-	0.464***	-	-	-	-
DV	0.674***	-0.021	-	-	-	0.738***	0.484***	-	-	-
ML	0.715***	0.075	0.592***	-	-	0.765***	0.380**	0.785***	-	-
AP	0.555***	0.324**	0.116	0.328**	-	0.718***	0.386**	0.537***	0.483***	-
Item	**Light intensity treatment**									
	Bright light					Dim, reducing light				
EW	-	-	-	-	-	-	-	-	-	-
CD	0.089	-	-	-	-	0.234	-	-	-	-
DV	0.843***	-0.004	-	-	-	0.754***	0.253*	-	-	-
ML	0.830***	0.209	0.721***	-	-	0.689***	0.112	0.728***	-	-
AP	0.666***	0.131	0.480***	0.528***	-	0.743***	0.348**	0.451***	0.439***	-

EW: eye weight; CD: corneal diameter; DV: dorsoventral diameter; ML: mediolateral diameter and AP: anterioposterior size.
* (P<0.05); ** (P<0.01) and *** (P<0.001).

The negative association between fillets and AFP weights was also observed in the breast meat in photoperiod length and light intensity group. The between whole breast weight and live weight correlation value were higher in IPL birds (0.835) when compared to those of IPL birds (0.671). CORT had a significant and positive correlation with glucose level in BLI birds. These result suggest that higher in blood CORT level may have a higher influence on glucose level of blood. Eye weight was strongly and positively correlated to eye DV, ML, and AP dimensions in photoperiod length and light intensity group. Increase of eye weight in a rhythmic fashion with higher growth during periods of light and reduced growth during darkness. The lack of this rhythm results in increased eye growth (Summers Rada and Wiechmann, 2006).

Schwean-Lardner *et al*. (2010) reported that birds kept under a long continuous photoperiod (24L:0D) had larger eyes in contrast birds kept under a short photoperiod lengts had tighter eyes.

CONCLUSION

There are phenotypic associations between the L* and b* and a* of meat quality attributes, suggesting that there are relationships among the variables of meat quality in broiler. L* value could be the best meat quality indicator among all the traits studied, since it presents the most easily measurement on the industrial slaughtering line. In conclusion, the variation and measurable differences in all meat quality indicate that these traits can be used in breeding schemes

at the primary level to improve meat quality of commercial broiler lines. However, further research is necessary to elucidate the causes of these variations in muscle quality of broilers.

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