IJAS Iranian Journal of Applied Animal Science

Relationship in Broiler Breast Meat Quality and some Blood Parameters: Implications of Different Colours Clothes and Visual Human Contact

Research Article

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Received on: 5 Apr 2018
Revised on: 18 May 2018
Accepted on: 31 May 2018
Online Published on: Jun 2019

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Online version is available on: www.ijas.ir

ABSTRACT

The goals of this research were to estimate the phenotypic relationship among various breat meat quality traits, blood parameters and tonic immobility from a broiler and to describe the relation among these variables. Broiler chicks were devided into different groups: (1) colour clothing groups represented four different colours as red, blue, green, and gray and (2) the chicks that were subjected to visual human contact for 60 and 300 sec. A total of 192 chicks, one day-old, were randomly assigned to eight treatment groups according to the colour clothing and visual human contact. Hatching weights for red, blue, green and gray clothing colour groups were found as 47.10, 48.35, 46.67, and 47.05 g, and for 60 and 300 sec visual human contact groups were determined as 47.34 and 47.24 g, respectively. Cooking loss had a significant negative relationship with pH at 15 minutes after slaughter (pH_{15}) in the red clothes group. Water holding capacity had a negative correlations (r=-0.355 and -0.489) with pH at 24 hours after slaughter (pH_u) in the 60 and 300 sec groups, respectively. Total protein level had a high degree and positive correlation (r=0.675) with cholesterol level in the red clothes group. Tonic immobility (TI) duration had significant relationship with TI induction in the green clothes group. The a* colour value of breast meat showed a moderate negative and significant correlation with the variables L* value of breast meat (-0.574 ($P<0.01$) and -0.373 ($P<0.05$), respectively) in gray clothing and 300 sec visual contact group. These finding have a lot of implications on the use of gray colour clothing and 300 s visual contact to improve meat quality for welfare in broilers.

KEY WORDS blood parameters, meat quality, relationship, tonic immobility, visual contact.

INTRODUCTION

Broiler breeding in intensive management systems may expose human eye contact (Zulkifli *et al*. 2002). Human factors affect fear of poultry which may lead to a reduction in the productivity of poultry performance. Normally, since the routine rearing procedure, poultry fears humans because of (Vasdal *et al*. 2018) different kinds of stressors (e.g. stockpersons, noise, and lighting) (Waiblinger *et al*. 2006). However, poultry can easily adapt to human presence and human visual and physical contact. Studies have demonstrated that human contact has a positive effect in reducing fear in poultry (Hemsworth *et al*. 2002; Zulkifli and Siti Nor Azah, 2004; Bassler *et al*. 2013; Edwards *et al*. 2013), and this causes to improve the production and immune function, which are two indicators for determining reduced stress response (Hemsworth *et al*. 2002; Zulkifli *et al*. 2002; Zulkifli and Siti Nor Azah, 2004; Lentfer *et al*. 2015). There is also a study reporting the evidence that poultry are somewhat sensitive to visual contact with humans (Hemsworth, 2009). Vision is important to bird, and this reflected in the fact that the avian eye is particularly large in relation to both the head and the brain. Studying the visual perception of birds have shown that they respond to

visual stimuli very much like human beings. The color preference is important in the domestic chickens (Zhang *et al*. 2012). Studies on this subject are usually on stockpersons' clothing, coloured feeders and food, water, enrichment devices, illuminated targets, and imprinting objects. Kovach and Kabai (1993) reported that birds are adjudged via long wavelengths, giving colours that they see as red, yellow or orange and this condition is responce spectra of visual markers. Welfare has been assessed from blood glucose, triglyceride, lactate, cholesterol, and lactate dehydrogenase (LDH), total protein, and meat quality traits (Zhang *et al*. 2009; Deep *et al*. 2010). In poultry, color variations in meat have received considerable attention from researchers because of their direct influence on consumer acceptance and high relationship with the functional characteristics of meat (Alkan *et al*. 2010; Narinç *et al*. 2013; Narinç *et al*. 2015). Fresh raw breast meat has 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 characteristics (Qiao *et al*. 2002). Fletcher *et al*. (2000) established a marked relationship between pH and extreme colour variations, while Salakova *et al*. (2009) reported that negative relationship between breast meat yellowness (b*), lightness (L*), and pH values, but there were positive relationship between breast meat L*, b* and redness (a*). The aim of this study was to determine relationships between breast meat quality traits, some blood parameters, and TI in broilers under the regular visual contact by the stockperson wearing clothes in different colours.

MATERIALS AND METHODS

The following procedures related to animal handling and sample collections were approved by the ADU Animal Experiments Local Ethic Council (No:64583101/2014/049). A total of 192 male broiler chicks, one-day old (Ross 308) were purchased from a commercial hatchery. On day one, broiler chicks were housed in floor pens covered with wood shavings.

Broilers reared at 12 broilers/m^2. Hatching weights for red, blue, green, and gray clothing colour groups were 47.10, 48.35, 46.67, and 47.05 g, respectively. In addition, the hatching weights were 47.34 and 47.24 g in both visual human contact groups (60 and 300 sec). Feed and water were given *ad libitum* throughout the study. The broiler chick ration given between days 1-21 contained 22% of crude protein and 3100 kcal/metabolic energy/kg, while the broiler chicken ration given between days 22-42 contained 21% of crude protein and 3250 kcal/metabolic energy/kg.

The ambient temperature was gradually decreased from 32 ± 1 ˚C on d 1 to 23 ± 1 ˚C untill end of the study (day 42) (NRC, 1994).

The study was conducted as 4 × 2 factorial experimental design: (i) clothing groups including four different colours (red, blue, green and gray). (ii) two visual human contact groups at a duration of 60 and 300 s. Each group consisted of 2 replicates of 12 broilers per pen. The size of pen was 110 × 103 cm. The chickens were subjected to regular visual human contact once a day by the same stockperson who wore the different colour clothings from day 15 to end of the study.

In the visual contact procedure, the stockperson wearing clothes with different colours entered the pens slowly with the minimal noise and standed up in the centre of the pens without any physical contact with chickens. On day 41, 13 broilers of each group (N=104 broilers in total) were randomly selected to perform TI test. Chickens was gently carried to a quiet room. Each chicken was carefully restrained for 15 s by covering the head with one hand, while placing the other hand on the sternum. A chronometer was used to record latencies until the chicken righted itself. If the chicken righted itself in < 10 s, the procedure was repeated.

If TI test was not happened after three trials the TI duration was noted as zero. The maximum duration of TI allowed was 10 minutes (Jones and Faure, 1981). On day 42, blood samples were obtained between 08:00 am and 09:00 am by brachial vein of 11 birds from each group. Blood parameters were measured using commercial reagents by a spectrophotometry (Shimadzu UV-1601, Germany). To determine meat quality traits, on day 42, 11 birds from each group (total 88) were slaughtered by exsanguination through a neck cut. Meat quality analysis was done using breast muscle (pectoralis major). The pH value was measured with a portable pH meter 15 min (initial pH, pH_{15}) and 24 hours (ultimate pH, pH_u) after the right pectoralis major was collected. Meat colour of skinless breast meat samples were determined using a Minolta CR 400 colorimeter. The cooking loss (CL) was evaluated in the meat samples according to Honikel (1998). The water holding capacity (WHC) was calculated 24 h after slaughter, using the methodology as previously described by Barton-Gade *et al*. (1993). Statistical analyses were done by using SPSS 22.0 (SPSS, 2013).

General lineer model (GLM) was designed to reveal the effects of the colour of clothing and duration of visual contact on blood variables, meat and carcass traits, and TI durations. The relationship between meat and carcass traits, blood parameters and TI durations were determined using Person's correlation coefficients.

Table 1 Pearson correlation coefficients and correlation significance among quality measurements of pectoralis major muscle samples and blood parameters from Ross 308 broiler carcass within different colours clothes

Quality measurements[1]	Red colours clothes											
	pH_{15}	pHu	WHC	CL	L*	a*	b*	Glucose	Cholesterol	Triglyceride	Total protein	LDH
pH_{15}	-	-	-	-	-	-	-	-	-	-	-	-
pHu	-0.357	-	-	-	-	-	-	-	-	-	-	-
WHC	-0.097	-0.232	-	-	-	-	-	-	-	-	-	-
CL	-0.427*	0.109	0.125	-	-	-	-	-	-	-	-	-
L*	0.367	-0.057	0.227	-0.002	-	-	-	-	-	-	-	-
a*	0.098	-0.204	-0.499*	0.176	-0.314	-	-	-	-	-	-	-
b*	-0.114	-0.491*	0.128	-0.011	-0.144	0.159	-	-	-	-	-	-
Glucose	-0.058	-0.138	0.023	0.062	-0.185	0.077	0.251	-	-	-	-	-
Cholesterol	0.225	-0.217	0.121	0.261	0.097	0.155	-0.089	-0.017	-	-	-	-
Triglyceride	0.002	0.062	-0.494*	-0.035	-0.063	0.416	-0.006	0.097	-0.034	-	-	-
Total protein	0.140	0.132	0.092	0.297	0.161	0.146	-0.254	0.059	0.675**	0.287	-	-
LDH	0.081	0.006	0.362	0.063	0.300	-0.241	-0.111	0.024	-0.212	-0.334	0.053	-
	Green colours clothes											
pH_{15}	-	-	-	-	-	-	-	-	-	-	-	-
pHu	0.243	-	-	-	-	-	-	-	-	-	-	-
WHC	-0.583**	-0587**	-	-	-	-	-	-	-	-	-	-
CL	-0.245	-0.269	0.124	-	-	-	-	-	-	-	-	-
L*	0.163	-0.056	0.031	0.227	-	-	-	-	-	-	-	-
a*	-0.405	0.029	0.171	-0.151	-0.366	-	-	-	-	-	-	-
b*	-0.019	-0.359	0.245	-0.171	0.323	-0.316	-	-	-	-	-	-
Glucose	0.070	0.194	0.171	-0.256	0.001	-0.282	0.044	-	-	-	-	-
Cholesterol	0.223	0.262	-0.588	-0.173	-0.128	-0.009	-0.038	0.022	-	-	-	-
Triglyceride	-0.192	0.138	-0.044	-0.100	-0.470*	0.021	-0.103	0.246	0.226	-	-	-
Total protein	0.529*	0.120	-0.317	-0.322	0.369	-0.213	-0.059	0.190	-0.120	-0.164	-	-
LDH	0.105	0.067	-0.056	-0.130	0.157	0.065	0.198	0.069	-0.249	0.103	0.580**	-

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

RESULTS AND DISCUSSION

In study, the variable a* showed a moderate negative and significant correlation with the variables L* (-0.574 (P<0.01) and -0.373 (P<0.05), respectively) in gray clothing and 300 sec visual contact group (Tables 2 and 3). It was showed that a high a* value, probably due to the high heme pigment that may cause a low relationship between L* and meat quality traits in gray clothing and 300 s visual contact group. This correlation agrees with those reported by Barbut (2009), Bianchi *et al.* (2007) who reported that dark broiler breast meat significantly lower L* and higher a* value in breast fillets. Zhuang and Savage (2010) found that for breast fillets pre-sorted according to their L* values, redness of paler fillets was decreased. Qiao *et al.* (2002) reported that increased mean broiler fillet lightness values were associated with decreased a* values among light, normal, and dark categories. Overall, this indicates an inverse relationship between redness and lightness on a given surface. According to these results, it can be said that the broiler breast meat used for the study sensory appereance comparisons had characteristic physical and functional properties for each meat color parameter. A researcher have concluded that selection for rapid growth resulted in a higher L* but a lower a* in broiler breast meat (Narinç *et al.* 2013).

The b* value had a significant negative correlation with pH_u in the red and blue clothes groups (-0.491 and -0.500, respectively) (Tables 1 and 2), and in the 60 and 300 sec visual contact group (-0.371 and -0.444, respectively) (Table 3). The indicated that a high pH_u value would decrease b* value (r=-0.491) in the red clothing group. The inverse relationship between yellowness and pHu, there is evidence for a negative phenotypic correlation between yellowness and ultimate pH. In paralel line with the results presented, negative phenotypic relationship between yellowness and ultimate pH were reported (Nadaf *et al.* 2007).

Some studies (Zulkifli and Siti Nor Azah, 2004; Edwards, 2013) report that regular human contact has an important positive effect on fear and stress. It was thought that there was a decreasing trend in fear and stress level related to human visual contact in broilers. The decline in pH after cessation of the blood flow at slaughter is caused by the accumulation of lactic acid during rigor development. Declining pH induces alterations in the arrangement of myofilaments, thereby expelling fluids. In consequence, reflectance and light scattering could be increased, causing elevated instrumental lightness values due to a decreased light path through meat (Swatland, 2008). We found that relationship between initial and ultimate pH was not significant, probably due to the fact that these two parameters were under the influence of different factors.

Table 2 Pearson correlation coefficients and correlation significance among quality measurements of pectoralis major muscle samples and blood parameters from Ross 308 broiler carcass within different colours clothes

Quality measurements	Blue colours clothes											
	pH_{15}	pHu	WHC	CL	L*	a*	b*	Glucose	Cholesterol	Triglyceride	Total protein	LDH
pH_{15}	-	-	-	-	-	-	-	-	-	-	-	-
pHu	0.031	-	-	-	-	-	-	-	-	-	-	-
WHC	0.084	-0.476*	-	-	-	-	-	-	-	-	-	-
CL	-0.258	0.109	-0.246	-	-	-	-	-	-	-	-	-
L*	0.336	-.0.190	0.105	0.105	-	-	-	-	-	-	-	-
a*	0.136	0.237	-0.075	-0.061	0.109	-	-	-	-	-	-	-
b*	0.149	-0.500*	0.458*	-0.164	0.232	-0.335	-	-	-	-	-	-
Glucose	-0.329	0.164	-0.373	-0.141	0.153	0.249	-0.392	-	-	-	-	-
Cholesterol	0.231	0.271	-0.345	-0.123	-0.178	-0.115	-0.329	-0.105	-	-	-	-
Triglyceride	0.016	0.252	-0.059	0.072	-0.159	-0.187	0.233	-0.039	-0.067	-	-	-
Total protein	-0.423	-0.125	0.086	0.248	0.045	-0.297	0.232	0.129	-0.012	-0.128	-	-
LDH	-0.046	0.176	-0.132	-0.116	0.026	0.056	-0.218	0.143	-0.271	0.058	-0.212	-
	Gray colours clothes											
pH15	-	-	-	-	-	-	-	-	-	-	-	-
pHu	0.211	-	-	-	-	-	-	-	-	-	-	-
WHC	-0.187	-0.445*	-	-	-	-	-	-	-	-	-	-
CL	-0.030	0.086	-0.030	-	-	-	-	-	-	-	-	-
L*	-0.122	0.122	0.221	-0.229	-	-	-	-	-	-	-	-
a*	-0.051	-0.262	0.145	0.268	-0.574**	-	-	-	-	-	-	-
b*	-0.162	-0.390	-0.035	-0.058	-0.299	0.197	-	-	-	-	-	-
Glucose	0.318	-0.298	0.027	-0.004	-0.578**	0.287	0.149	-	-	-	-	-
Cholesterol	0.421	-0.054	-0.176	0.093	-0.549*	0.590*	0.201	0.356	-	-	-	-
Triglyceride	-0.089	0.214	0.017	-0.129	0.004	-0.136	-0.117	-0.176	-0.165	-	-	-
Total protein	0.031	0.063	-0.385	0.193	-0.306	-0.030	0.050	0.071	-0.020	0.059	-	-
LDH	-0.026	-0.365	0.339	-0.480*	-0.007	0.060	0.146	0.447	-0.007	-0.340	-0.193	-

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

Table 3 Pearson correlation coefficients and correlation significance among quality measurements of pectoralis major muscle samples and blood parameters from Ross 308 broiler carcass within visual human contact groups

Quality measurements	60 second visual human contact											
	pH_{15}	pHu	WHC	CL	L*	a*	b*	Glucose	Cholesterol	Triglyceride	Total protein	LDH
pH_{15}	-	-	-	-	-	-	-	-	-	-	-	-
pHu	-0.204	-	-	-	-	-	-	-	-	-	-	-
WHC	-0.183	-0.355*	-	-	-	-	-	-	-	-	-	-
CL	-0.313*	0.125	0.010	-	-	-	-	-	-	-	-	-
L*	0.175	-0.097	0.285	0.041	-	-	-	-	-	-	-	-
a*	-0.001	0.003	-0.083	0.074	-0.226	-	-	-	-	-	-	-
b*	-0.004	-0.371*	0.216	0.015	0.017	-0.001	-	-	-	-	-	-
Glucose	0.026	-0.088	0.079	0.007	-0.044	0.137	0.038	-	-	-	-	-
Cholesterol	0.263	0.022	-0.226	-0.132	-0.185	0.317	0.138	0.203	-	-	-	-
Triglyceride	0.055	0.055	-0.146	-0.034	-0.185	-0.169	0.128	-0.008	-0.100	-	-	-
Total protein	-0.145	-0.186	-0.062	0.109	-0.061	-0.158	0.295	0.131	-0.051	-0.016	-	-
LDH	-0.048	0.031	0.206	-0.195	-0.046	0.057	-0.121	0.135	0.017	-0.344*	-0.199	-
	300 second visual human contact											
pH15	-	-	-	-	-	-	-	-	-	-	-	-
pHu	0.150	-	-	-	-	-	-	-	-	-	-	-
WHC	-0.210	-0.489**	-	-	-	-	-	-	-	-	-	-
CL	-0.179	-0.188	-0.051	-	-	-	-	-	-	-	-	-
L*	0.059	0.046	0.040	-0.152	-	-	-	-	-	-	-	-
a*	0.016	-0.070	0.025	0.132	-0.373*	-	-	-	-	-	-	-
b*	-0.054	-0.444**	0.244	-0.206	0.263	-0.244	-	-	-	-	-	-
Glucose	-0.016	0.028	-0.044	-0.070	-0.039	-0.013	0.084	-	-	-	-	-
Cholesterol	0.197	0.173	-0.225	0.366*	-0.133	0.030	-0.205	0.086	-	-	-	-
Triglyceride	-0.110	0.147	-0.131	0.013	-0.066	0.186	-0.036	0.045	-0.019	-	-	-
Total protein	-0.228	0.222	-0.166	0.289	0.025	-0.096	-0.130	0.112	0.052	0.020	-	-
LDH	-0.041	0.057	-0.005	-0.429**	0.277	-0.052	-0.084	0.059	-0.362	-0.052	-0.083	-

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

The pH_{15} which is an indicator for the rate of pH decline, had an opposite correlation with L* and a* values compared with pHu.

However, similar results were reported by Berri *et al.* (2005). The pectoralis major muscle between pH_u and WHC correlation value (-0.355) were lower in 60 sec birds

when compared to those of 300 sec birds (-0.489). WHC had a significant moderately negative correlation with pH_u in the blue, green, and gray clothes groups, respectively. This relationship agrees with those reported by Silva *et al.* (2011) who observed that the negative, moderate correlation between breast meat pH at 24 hours postmortem and WHC was significant in poultry.

The determined that WHC values were higher in fillets exhibiting lower pH_u in birds similar with result of Silva *et al.* (2011) who reported a significant negative correlation between pH_u and a* values (r=-0.25). The results presented that broiler breast meat with higher ultimate pH is often characterised by increased tenderness, while not tenderness in the blue, green, and gray clothes groups, because it was negative correlation between pH_u and WHC value. Le Bihan-Duval *et al*. (2001) reported that the drip loss of raw meat, a measure of WHC, was highly correlated with pH_u (−0.83) and also with L* (0.80). Increasing pH_u (or decreasing L*) should contribute to the improvement of the WHC of broiler breast meat.

Increased levels of LDH level were correlated with lower CL (r =-0.480 and -0.429, respectively) in gray clothing and 300 sec visual contact group.

As in this study, increase in lactate concentration is correlated with stress, which indicated a detrimental effect of stress on meat quality (Edwards *et al*. 2010; Dokmanovic *et al*. 2015).

These results supported that the statement that LDH level can be used as a marker of meat quality. In study, cholesterol level had a positive correlation with CL in the 300 sec visual contact groups (r=0.366). It was found that the b* value was negatively correlated with the pH_u value in 60 and 300 sec visual contact group. A positive correlation can be found between blood total protein level and pH_{15} in green clothing group (0.529). Dokmanovic *et al.* (2015) indicated that negative, moderate correlation between breast meat pH at 60 minute postmortem and lactate level (-0.34) in broiler. The correlations between TI duration and induction were found as -0.122, -0.150, 0.398 and -0.049 for red, blue, gren, and gray clothing groups, respectively. The correlations between TI duration and induction were found as -0.108 and 0.167 for 60 and 300 sec visual contact groups, respectively. A significant correlation of 0.398 was observed between TI duration and induction in green clothing group. It has been reported a positive correlation between antecedent fear state and the duration of TI (Hemsworth, 2009).

CONCLUSION

There are correlations among the meat colour parameters (L*, b*, and a* colour value) and the other meat quality traits in broilers. Higher LDH level was associated with lower CL suggesting that lactate could be a marker of both meat quality. It can be said that this welfare indicators can be positively affected by the gray clothing and 300 sec visual contact used. This positive effect can be attributed to the impairement of the vision contact duration of the birds by the gray colour clothing and increase in the animal welfare. Triglyceride affected meat quality in red clothing group, so higher levels of triglyceride was associated with decreased WHC. In other words, stress parameters triglyceride had increased in red clothing group as parallel to decrease in WHC. The pHu was capable of directly interfering with the characteristics of the meat, since this trait was inversely related with WHC in the blue, green, and gray clothes groups. Cholesterol affected meat quality in 300 s visual contact group, so higher levels of cholesterol was associated with decreased CL. 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 hybrits. Further studies are needed to investigate the relations between human and chicken in terms of visual contact.

ACKNOWLEDGEMENT

The author would like to thank all staff of Adnan Menderes University, Department of Animal Science for technical support.

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