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Effect of Egg Weights on Hatching Results, Broiler Performance and Some Stress Parameters

Author(s)

Duman M[I]
Şekeroğlu A[II]

[I] Ömer Halisdemir University, Bor Vocational School, Department of Laboratory and Veterinary Health, Bor, Niğde – Turkey

[II] Ömer Halisdemir University, Ayhan Sahenk Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies, Niğde – Turkey

Mail Address

Corresponding author e-mail address
Dr. Mustafa Duman
Ömer Halisdemir University, Bor Vocational School, Dept. of Laboratory and Veterinary Health, Bor, Niğde-Turkey
Tel: +90 388 311 45 27
Email: mustafa.duman@ohu.edu.tr

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ABSTRACT

The present study was conducted to investigate the effect of hatching egg weight of broiler parent stocks on hatching results, chick performance, carcass characteristics, internal organ weights and some blood stress parameters. Eggs were divided into 3 egg weight groups (55.0 to 60.0 g (light), 60.1 to 65.0 g (medium) and 65.1 to 70.0 g (heavy)) for the experiments. After incubation, mixed-gender broiler chicks from the hatcher were placed into 27 grower pens (2x1 m) with 9 replications for 3 weight groups by using randomized block design. Each pen had 25 broiler chicks. Therefore, 225 chicks were used for each group and 675 chicks in total. The experiment was designed with nine replicates. Chi-square test, variance analysis test and Duncan multiple range test were used during statistical analysis. Hatching egg weight significantly affected egg shell thickness (p=0.042), egg weight loss on 18th day of incubation (p<0.001), number of healthy chick (p=0.001) and deformed chicks (p=0.003), hatchability (p=0.003), hatchability yield (p=0.002), hatching weight and 7 day chick body weight (p=0.001), fresh carcass yields (p=0.002), and cooled carcass yields (p<0.001), blood triglyceride level (p=0.031), back toe relative asymmetry (p=0.032) and back toe fluctuating asymmetry (p=0.038). It was concluded in the present study that medium-weight eggs yielded better hatching results and the chicks of medium-weight eggs also yielded better outcomes with regards to other investigated parameters.

INTRODUCTION

Hatching results and broiler performances are mostly affected by genetic and environmental factors. These factors include storage duration of eggs, genetic characteristics, egg internal and external quality parameters, feeding, bodyweight and age of breeder hens, season, housing system and health conditions (Roberts & Nolan, 1997). Egg weight is also a significant quality parameter and has an impact on broiler performance (Ulmer-Franco *et al.,* 2010). There are significant relationships between poultry egg weights and hatching results. Egg weight directly effects hatchability, hatching duration, embryonic mortality, hatching weights and subsequent performance of chicks (Witt de & Schwalbach, 2004; Alkan *et al.,* 2008; Çağlayan *et al.*, 2009; Alabi *et al.,* 2012). Therefore, relatively heavier or lighter eggs are not preferred as hatching eggs (Abiola *et al*., 2008). Some researchers (Elibol & Brake, 2008; Hesna Sahin *et al.*, 2009; Ulmer-Franco *et al.,* 2010; Alabi *et al.,* 2012) observed that egg size within the intermediate range would hatch better than small eggs. While lower egg weights usually increase hatchability, heavier weights reduce hatchability. However, hatching weights and survival rate of chicks from lighter eggs are usually at low levels. Furthermore, there are positive correlations between chick weights and further growth performances of hens (Jiang & Yang 2007).

Rapid growth capacity and environmental factors may reduce the meat quality and result in some negative cases like ascites, destruction in fear level and body symmetry. Tonic immobility is a welfare indicator to be used to measure and evaluate the poultry fear levels (Gallup, 1979). Under ideal conditions, right and left side of a characteristic are symmetric. Deviations from full symmetry are called fluctuating asymmetry (Van Nuffel *et al*., 2007). Fluctuating asymmetry is the most common welfare parameter used to assess the physical characteristics of broilers. It is a significant parameter for optimum flock performance (Van Poucke *et al*., 2007). Effects of egg weight on pullet performance have been widely studied (Witt de & Schwalbach, 2004; Alkan *et al.,* 2008; Jiang & Yang 2007; Ulmer-Franco *et al.,* 2010; Egbeyale *et al.,* 2011; Iqbal *et al.,* 2016). However, such studies do not gather growth, carcass parameters, internal organ weights, blood parameters, asymmetry and tonic immobility in a single study.

This study was concluded to determine of the best egg weight group in term of effects of hatching egg weights on hatching results, broiler performance, carcass parameters, internal organ weights, asymmetry, tonic immobility duration and some blood parameters.

MATERIAL AND METHOD

Broiler chicks, hatched from the eggs supplied from a commercial broiler facility housing 32 weeks old broiler breeder flock (*Ross-308),* were used as the animal material of the experiments. The criteria set by NIH (National Institute of Health Guide for the Care and Use of Laboratory Animals) were strictly obeyed during the experiments. Eggs were weighed with a balance (0.01 g accuracy) and divided into 3 groups as of light (55.0 to 60.0g), medium (60.1 to 65.0g) and heavy (65.1 to 70.0g). A total of 1080 eggs, 360 eggs for each weight group, were placed into the incubator. Before placing into incubator, pre-heating treatment was applied to eggs in a room with 25 °C temperature and 80% relative humidity.

During the incubation period, temperature was set at 99.68 °F (37.6 °C) and relative humidity was set as 85 °F wet-bulb temperature. Fertility checks were performed on the 18th day of incubation in a dark room. 30 eggs from each replication were randomly selected and they were weighed and fertile eggs of each replication were then transferred to hatching unit in separate trays. In the hatching unit, the temperature was set as 97.88 °F (36.6 °C) and relative humidity was set as 90 °F wet-bulb temperature. Infertile eggs and the eggs with a dead embryo were transferred to the laboratory to determine the time of death. Following the complete hatching, available healthy and deformed chicks from each egg-weight group were counted and recorded.

For hatching results, available healthy chicks were taken into consideration to calculate average fertility rates (FR), hatchability (H) and hatchability yield (HTE) of each egg-weight group. These traits were calculated by using the equations stated by Sahin *et al.* (2009). Also on the 18th day of incubation, egg weight loss (in g and %), embryonic mortality (early, medium and late) and egg shell thickness were determined. Egg weight loss was calculated by subtracting the weights of 90 fertile eggs randomly selected from each group during the egg transfer from the hatching weights of the eggs. During the transfer process (18th day), infertile eggs and the eggs with a death embryo were broken and analyzed under light microscope to determine the time of death. The eggs were marked as infertile, early-period embryo mortality (0 to 6 days), medium-period embryo mortality (7 to 17 days) and late-period embryo mortality (18 to 21 days). Egg shell thickness was measured over the infertile eggs taken out from the incubator on the 18th day. Thickness was measured over the shell pieces (cleared off from the membrane) taken from bump and pointed ends and middle sections of the egg with a micrometer (1/100 mm accuracy) and the average of these three sections were taken as the shell thickness. Healthy chicks of each group on the 21st day were totally weighed and average chick hatching weight of each group was determined.

Mixed-gender broiler chicks from the hatcher were placed into 27 grower pens (2x1 m) with 9 replications for 3 weight groups by using randomized block design. Each pen had 25 broiler chicks. Therefore, 225 chicks were used for each group and 675 chicks in total. All day, 24 hours, lighting was provided during the experiments. Wood shavings were used as bedding material.

An *ad-libitum* feeding program was implemented as; 1st period (23.0% CP, 3100 Kcal/kg ME) chick feed during the days 1 to 10; 2nd period (22.0% CP, 3000 Kcal/kg ME) broiler grower feed during the days 12 to 21; 3rd period (20.0% CP, 3100 Kcal/kg ME) broiler developer feed for the days 22 to 31; 4th period (18.0% CP, 3200 Kcal/kg ME) broiler finisher feed for the days 32 to 39.

Experimental animals were weighed weekly by a balance with 1g accuracy and weekly average body weights (BW) were determined. Weekly feed consumptions were also recorded regularly until the end of experiments and feed conversion ratios corresponding to feed consumption per unit increase in BW (g feed / g BWI) were calculated. Survival rates (%) of each group were also calculated by recording the number of deaths.

At the end of the experiments (39th day), hens were hungered for 8 hours and a total of 108 broilers (36 hens from each group, 4 hens (2 male and 2 female) from each replication) were selected. Initially, tonic immobility (TI) was assessed in selected hens (Gallup, 1979). The selected hens were tested individually for TI by placing it on its back on a U-shaped wooden cradle and restrained for 15 seconds. The duration of TI was recorded the time until the bird stood up. If TI could not be induced after five attempts, the bird was deemed not to be susceptible and its TI duration score was recorded as 0. If the bird did not stand after 10 min, a maximum score of 600 s was recorded for TI duration (Campo & Prieto, 2009; Dávila *et al.*, 2011).

Then, blood samples were taken into vacuum tubes from *V. cutanea ulnaris* of selected hens. Serum was obtained by centrifuging blood samples at 3000 rpm for 10 minutes. Serum samples were preserved at -20 °C and transferred to the laboratory for analysis in a cold-chain (Güneş *et al.*, 2002). *In vitro* enzymatic colorimetric method was employed in glucoses, triglyceride and cholesterol measurements.

The hens that had blood samples taken were transferred to slaughter. Fresh carcass weights were determined right after the slaughter (Bochno *et al.*, 2006). Body parts of right and left sides of fresh carcass were measured with a caliper (Van Nuffel *et al.*, 2007). By using the measurements taken from right (R) and left (L) sides of the hen, fluctuating asymmetry (FA=(½R-L½)) and relative asymmetry (RA= =(½R-L½) / [(R+L)/2].100) were calculated (Menteş, 2008). A general total index was created by adding the calculated fluctuating and relative asymmetries for relevant body parts (Yang, 1998).

Relative weights (g/100g BW) of the heart, liver and spleen were determined by weighing with a balance (0.01 g accuracy) (Yalçınkaya *et al.*, 2010). Measurements of pH from the left side of breast meat were taken from three different sections and the average was taken as the pH value. Breast meat color was evaluated with an ΔE value [$\Delta E=(L^2+a^2+b^2)^{1/2}$] calculated by using L*(lightness) a* (redness) and b* (yellowness) values taken by a chromameter (Konica Minolta Chromameter model CR-300) from three different sections of skinned breast. The average of three ΔE values was taken as breast meat color (Ingram *et al.*, 2008).

Carcasses were aged in cold water for 6 hours, stored at +4 °C for 24 hours and then cooled carcass weights were determined (Bochno *et al.*, 2006). Cooled carcasses were chopped in accordance with Turkish Standards Institution (TSI, 1988). Relative weights (g/100g cooled carcass) of resultant pieces (breast, drumstick, wing, back and neck) were determined with a balance (1 g accuracy).

Chi-square test was used to determine the effects of egg weights on embryo mortalities and survival rate. Other data were compared by variance analysis carried out with SPSS software in accordance with randomized block design. Duncan multiple range test was used to compare treatment means (Özdamar, 1999).

RESULTS

Effects of egg weight on the 18th day, egg weight loss in grams ($p<0.001$), egg shell thickness ($p=0,042$), number of deformed chicks ($p=0.001$), number of healthy chicks ($p=0.003$), hatchability ($p=0.003$) and hatchability yield ($p=0.002$) were found to be significant. However, the effects of egg weights on % egg weight loss, number of early-period (0 to 6 days) embryo mortality, medium-period (7 to 17 days) embryo mortality, late-period (18 to 21 days) embryo mortality ($p=0.118$), total (0 to 21 days) embryo mortality ($p=0.061$) and fertility rate ($p=0.619$) weren't found to be significant.

While the effects of egg weight on broiler hatching weight ($p<0.001$), 7 day body weight ($p=0.001$), fresh ($p=0.002$), and cooled carcass ($p<0.001$), yields

Table 1 – The effect of egg weight on hatching results

Traits	Hatching egg weight groups			p
	Light (57.74 g)	Medium (62.38 g)	Heavy (67.25 g)	
Egg weight loss				
18. days, g	7.57±0.15[c]	8.35±0.16[b]	8.77±0.14[a]	<0.001
18. days, %	13.03±0.28	13.24±0.25	13.02±0.21	0.768
Shell thickness, mm	0.340±0.00[b]	0.349±0.00[a]	0.348±0.00[ab]	0.042
Embryo mortality, number				
Early period, 0 to 6 day	15	15	16	0.940
Medium period, 7-17 day	1	3	4	0.588
Late period, 18-21 day	11	13	23	0.118
Total, 0-21 day	27	31	43	0.061
Hatching characteristics				
Number of healthy chicks	303[a]	306[a]	281[b]	0.001
Number of deformed chicks	15[ab]	8[b]	23[a]	0.003
Fertility rate, %	95.83±0.48	95.83±0.48	96.66±0.48	0.619
Hatchability, %	87.81±2.23[a]	88.69±1.03[a]	80.76±1.52[b]	0.030
Hatchability yield, %	84.17±2.50[a]	85.00±1.27[a]	78.05±1.21[b]	0.020

[ac]:Different letters in the same line indicate significant differences according to Duncan Multiple Range Test.

were found to be significant, the effects on the 14[th] (p=0.178), 21 (p=0.426), 28 (p=0.097), 35 (p=0.396), 39 (p=0.627) day body weights (g), survival rate (p=0.400), feed conversion ratios (0 to 21 (p=0.916), 21 to 39 (p=0.349) and 0 to 39 (p=0.639) days), relative ratios of carcass parts (breast (p=0.329), drumstick (p=746), wing (p=942), back (p=0.354), neck (p=0.475), breast meat color (p=0.121) and pH (p=0.341) were not found to be significant.

Egg weight had also significant effects on blood triglyceride levels (mg/dL) (p=0.031). However, effects of egg weights on blood glucose level (p=0.314), blood

Table 2 – The effect of egg weight on broiler performance and carcass characteristics.

Traits	Egg weight groups			p
	Light (57.74 g)	Medium (62.38 g)	Heavy (67.25 g)	
Body weight, g				
Hatching weight	38.58±0.10[c]	41.74±0.08[b]	45.50±0.14[a]	<0.001
7. day	170.29±0.95[b]	171.36±1.02[b]	175.49±1.18[a]	<0.001
14. day	481.30±2.57	479.43±2.83	486.75±3.17	0.178
21. day	939.51±5.55	930.10±5.85	939.26±6.06	0.426
28. day	1549.32±10.45	1544.51±11.08	1574.79±10.06	0.097
35. day	2222.68±19.51	2211.42±16.97	2247.09±17.97	0.396
39. day	2512.91±22.53	2494.21±19.89	2524.56±22.18	0.627
Survival rate, %	94.68±1.49	92.00±2.11	92.88±1.86	0.400
Feed conversion ratio, g feed consumption/g body weight increase				
0 to 21 day	1.42±0.02	1.42±0.02	1.42±0.02	0.916
21 to39 day	1.91±0.03	1.98±0.06	1.98±0.04	0.349
0 to 39 day	1.73±0.02	1.77±0.03	1.76±0.02	0.639
Carcass characteristics,%				
Fresh carcass yield	69.67±0.29[b]	71.65±0.59[a]	69.85±0.35[ab]	0.002
Cooled carcass yield	70.96±0.27[b]	73.23±0.59[a]	71.13±0.33[b]	<0.001
Ratio of breast	35.09±0.51	35.81±0.42	35.93±0.26	0.329
Ratio drumstick	28.10±0.41	28.32±0.25	27.98±0.20	0.746
Ratio of wing	10.75±0.16	10.67±0.11	10.71±0.16	0.942
Ratio of back	18.25±0.26	18.26±0.21	18.66±0.18	0.354
Ratio of neck	7.81±1.07	6.93±0.12	6.72±0.13	0.475
Breast meat				
Color (ΔE) value	65.11±3.46	70.40±0.62	71.10±0.59	0.121
pH value	5.92±0.02	6.02±0.04	5.91±0.03	0.341

[ac]: The differences between means of the same line are significant based on Duncan Multiple Range Test.

cholesterol level (p=0.063) and internal organ (liver (p=0.594), hearth (p=0.741) and spleen (p=0.514) weights were not found to be significant. Tonic immobility duration of the hens from heavy eggs were found to be shorter than the durations of hens from light and medium weight eggs, but such differences were not significant (p=0.117).

While the effects of egg weight on back toe length relative and fluctuating asymmetry lengths were found to be significant (p=0.032), effects on other investigated relative (0.064≤p≤0.961) and fluctuating (0.077≤p≤0.850) asymmetry traits were not found to be significant. With regard to general relative asymmetry, statistical differences were not observed in increasing general asymmetry values of hens hatched from light to heavy eggs (p=0.546).

Table 3 – The effect of egg weight on some blood parameters, internal organ weights and tonic immobility duration.

Traits	Egg weight groups			p
	Light (57.74 g)	Medium (62.38 g)	Heavy (67.25 g)	
Blood parameters, mg/dL				
Cholesterol	114.92±3.08	119.85±4.06	126.12±3.54	0.063
Glucose	230.88±3.51	223.92±3.44	229.53±3.44	0.314
Triglyceride	21.23±1.45[a]	17.37±1.03[b]	17.59±0.94[b]	0.031
Internal organ weights,g /100gBW				
Liver	2.15±0.04	2.13±0.05	2.19±0.04	0.594
Heart	0.69±0.02	0.67±0.02	0.67±0.02	0.741
Spleen	0.16±0.01	0.16±0.01	0.16±0.01	0.514
Tonic immobility duration, sec.	186.51±35.49	257.60±36.67	176.57±26.81	0.177

[ac]: The differences between means of the same line are significant based on Duncan Multiple Range Test.

Table 4 – The effect of egg weight on relative asymmetry.

	Egg weight group			p
	Light	Medium	Heavy	
Relative asymmetry				
Face length	1.62±0.26	2.23±0.93	0.95±0.21	0.426
Wattle width	1.73±0.28	2.44±0.60	3.14±0.65	0.623
Mid toe 3rd phalanx length	1.78±0.45	2.88±0.47	3.27±0.50	0.064
Outer toe 4th phalanx length	4.40±0.95	5.96±0.93	6.21±1.60	0.961
Tarsometatarsus length	1.11±0.16	1.27±0.20	1.38±0.27	0.362
Tarsometatarsus width at spur level	3.28±0.64	3.02±0.45	2.67±0.37	0.551
Tarsometatarsus with 1 cm above spur	3.08±0.69	2.71±0.51	2.57±0.46	0.233
Tarsometatarsus width at tibiotarsus joint	2.41±0.22	2.65±0.46	2.23±0.37	0.506
Back toe length	2.82±0.59[b]	4.20±0.63[ab]	5.19±0.77[a]	0.032
General	22.23±2.48	27.35±2.19	27.60±2.53	0.546

[ac]: The differences between means of the same line are significant based on Duncan Multiple Range Test.

With regard to general fluctuation asymmetry index, although the hens from light eggs had lower fluctuating asymmetry values, such differences were not found to be significant (p=0.683).

Table 5 – The effect of egg weight on fluctuating asymmetry.

	Egg weight groups			p
	Light	Medium	Heavy	
Fluctuating asymmetry, mm				
Face length	0.57±0.09	0.78±0.32	0.33±0.07	0.212
Wattle width	0.43±0.07	0.60±0.16	0.69±0.13	0.303
Mid toe 3rd phalanx length	0.35±0.09	0.56±0.09	0.63±0.09	0.077
Outer toe 4th phalanx length	0.06±0.05	0.06±0.06	0.06±0.08	0.456
Tarsometatarsus length	0.80±0.11	0.93±0.14	0.99±0.19	0.309
Tarsometatarsus width at spur level	0.40±0.08	0.38±0.06	0.33±0.05	0.699
Tarsometatarsus with 1 cm above spur	0.41±0.10	0.37±0.07	0.37±0.06	0.850
Tarsometatarsus width at tibiotarsus joint	0.58±0.05	0.63±0.11	0.54±0.09	0.718
Back toe length	0.46±0.09[b]	0.71±0.11[ab]	0.85±0.13[a]	0.038
General	4.22±0.41	5.30±0.55	5.03±0.49	0.683

[ac]: the differences between means of the same line are significant based on Duncan multiple range test.

DISCUSSION

Egg weight loss in grams increased significantly from the light egg group to the heavy egg group however, differences in % egg weigh losses of weight groups were not significant. Findings of the present study were similar with findings of Abiola *et al*., (2008) as weight losses (%) were found to be higher in medium-weight group. The similarity in the results obtained on egg weight loss may suggest that the 3 egg size categories used for the study probably had equal proportion of pore areas and pore diameter regardless of the size of the egg (Abiola *et al*., 2008).

With regard to embryo mortality during incubation, except for the highest early-period (0 to 6 days), medium-period (7 to 17 days) and late-period (18 to 21 days) embryo mortality rates of the heavy weight group, insignificant differences in mortality rates of weight groups totally comply with the results of earlier studies (Toplu *et al*., 2007; Çağlayan *et al*., 2009). Egg weight has no significant effect on embryo mortality rates but total (0-21 days) embryo mortality rates was increased with increasing egg weight. Also, embryo mortality rates depend more on storage and incubation conditions (Nakage *et al.,* 2003; Bergoug *et al.,* 2013).

Toplu *et al*. (2007) reported increasing fertility rates with decreasing egg weight and indicated that such differences were not significant. Contrariwise, Çağlayan *et al.* (2009) and Dere *et al*. (2009) reported increasing fertility rates with increasing egg weight and indicated such differences as significant. Therefore, present study complies with the findings of Çağlayan *et al*. (2009) and Dere *et al*. (2009) with regard to increasing fertility rates with increasing egg weight and complies with the findings of Toplu *et al*. (2007) with regard to insignificance of differences. These discrepancies in the literature depends on the use of animals from different breeds and ages in different studies because fertility is a hereditary trait and also depends on environmental factor (Wolc *et al.,* 2009) but it is mostly related with breeder flock ages and breed of chicks (Ulmer-Franco *et al.,* 2010). Also fertility can highly vary even within the same breed mainly due to poor management and improper proportion of males or poor ability of males in the flock to produce viable sperms (Malago & Baitilwake, 2009)

Çağlayan *et al*. (2009) reported significantly low hatchability for light eggs but indicated insignificant differences between weight groups. Results obtained on hatchability in the present study conform to earlier findings (Elibol & Brake, 2008; Hesna Sahin *et al.*, 2009; Ulmer-Franco *et al.,* 2010; Alabi *et al.,* 2012) which recommended the setting of average sized eggs for the purpose of incubation. As many researcher suggested that eggs should be in average weight in order to achieve good hatchability (Elibol & Brake, 2008; Hesna Sahin *et al.*, 2009; Ulmer-Franco *et al.,* 2010; Alabi *et al.,* 2012).

With regard to hatching weights of chicks, present findings comply with the researches reporting significant impacts of egg weights on hatching weights and lighter chicks from light eggs and heavier chicks from heavy eggs (Yıldırım &Yetişir, 1998; Witt de& Schwalbach, 2004; Nazlıgül *et al*., 2005; Çağlayan *et al*., 2009). Significant effects of egg weight on body weight were lost after the second week as Yıldırım & Yetişir (1998) reported. But some researchers report that hatching egg weights affect the growth performance until the slaughter of hens (Petek *et al*., 2003; Nazlıgül *et al*., 2005). This situation could be explained by compensative growth as Nazlıgül *et al*., (2005) reported that chicks could be reached to the normal levels from smaller and bigger eggs with intensive care.

In terms of survival rate, the present study complies with most studies (Witt de & Schwalbach, 2004; Nazlıgül *et al*., 2005; Egbeyale *et al.,* 2011; Alabi *et al.,* 2012) which report that there is an insignificant effect of egg weights on survival rate. Also, Singh *et al.* (2003) who noticed that the egg weight has no effect on the survival rate as the age of parent affected.

Feed conversion ratios was not affected by egg weights because FCR is related mostly with environmental factor such as age, sex, air temperature, stress, form of diet and diet ingredients like amount of fiber (Amad *et al.,* 2011; Mateos *et al.,* 2012). Current findings were similar to findings of previous researchers (Petek *et al*., 2003; Witt de & Schwalbach, 2004; Ulmer-Franco *et al.,* 2010; Egbeyale *et al.,* 2011).

In the current study, the effects of egg weights on fresh and cooled carcass yields of broilers were found to be significant. Carcass yields of pullets from medium weight eggs were better than the others. The proportion of dressed weight to live weight determines the carcass quality (Egbeyale *et al.,* 2011). It can be concluded from the result of this study that setting of medium egg sizes could be advantageous for producers if the target was to get better carcass yield as mostly aimed. However, the effects of egg weights on breast, drumstick, wing, back and neck weights were not significant in this study and previous ones (Egbeyale *et al.,* 2011).

The effects of egg weights on broiler meat color and pH were found to be insignificant. Lighter breast meat colors are preferred in broilers (McCurdy *et al*., 1996; Owens *et al*., 2000). Meat color and pH are closely related in broilers and lower pH levels indicate better animal welfares before the slaughter (Castellini *et al*., 2002). Similarly, internal organ weights may also indicate animal welfare levels (Puvadolpirod & Thaxton, 2000; Ravindran *et al*., 2006). Egg weights of the current study did not have any significant effects on internal organ (liver, heart and spleen) weights of broilers. In the present study, while the egg weights did not have any effect on glucose and total cholesterol levels, blood triglyceride levels differed by egg weights. Blood parameters of broilers are mostly specified by genotype, feed, climate, growing and housing systems, age and physical state of hens (Meluzzi *et al*., 1992). Blood constituents may also be used as an indicator for animal welfare level (Mitchell & Kettlewell, 1998). Most of the traits are symmetric in broilers. Such traits are expected to grow symmetrically under optimum conditions but minor random deviations may sometimes be observed in bilateral characteristics. Fluctuating asymmetry level is a good indicator for compatibility of a hen against environmental stress factors (Møller & Swaddle, 1997). Egg weights in the present study had significant effects on back-toe length in terms of relative and fluctuating asymmetry levels of broilers. Increased relative and fluctuating asymmetry values were observed with increasing egg weights. However, such differences with other weight groups were not found to be significant. Although tonic immobility durations of hens as a welfare indicator (Gallup, 1979) from medium weight eggs were relatively higher than the others, differences again were not found to be significant. In the light of these results of stress parameters, it can be concluded that egg size has no adverse effect on broiler welfare levels.

CONCLUSIONS

It was concluded in the present study that medium-weight eggs had better hatching results and the chicks of medium-weight eggs also yielded better outcomes with regards to other investigated parameters. Therefore, it was recommended that medium-weight eggs should be preferred for hatching implementations.

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