Ann. Anim. Sci., Vol. 15, No. 2 (2015) 505–516 *DOI: 10.2478/aoas-2014-0076*

DE GRUYTER
OPEN

EFFECTS OF FLOCK SIZE IN BROILERS REARED IN A FLOOR SYSTEM ON PERFORMANCE, SOME BLOOD PARAMETERS, BONE QUALITY AND *MUSCULUS PECTORALIS* PH LEVEL*

Ulku Gulcihan Simsek♦, Nejla Ozhan

Firat University, Faculty of Veterinary Medicine, Animal Science Department, 23119, Elazig, Turkey
♦Corresponding author: gsimsek@firat.edu.tr

Abstract

This research was conducted to compare performance, some blood parameters, bone quality and *musculus pectoralis* pH level in broiler flocks containing 15,000 (I), 25,000 (II) and 35,000 (III) birds. For this purpose, two different flocks from each capacity were simultaneously observed throughout two growth periods in summer and autumn seasons. A total of 20 broilers (10 males and 10 females) per different flock capacity, having stable live weight were selected on 32nd day of growing period. Broiler chickens were slaughtered by decapitation and their blood samples were drained into special tubes. *Musculus pectoralis* pH measurement was performed ten minutes after slaughter. Bones were extracted from meat and analyzed. Live weights of groups on days 1, 7, 14, 21, 28 and on the day of slaughter were similar to each other (P>0.05). The mortality rate was lower in group I (P≤0.01). Feed efficiency deteriorated negligibly in group III (P=0.078). Serum glucose and uric acid levels were high in group III (P≤0.01). Intergroup differences in serum total cholesterol, very-low-density lipoprotein cholesterol (VLDL), triglycerides, protein levels and enzyme activities of alkaline phosphatase and creatine kinase were statistically insignificant (P>0.05). Dimensions, weights and ash level of tibia and femur, bone mineral density (BMD) and bone mineral content (BMC) of tibia were observed to have similar values among the groups (P>0.05). *Musculus pectoralis* pH level in groups I, II and III was determined as 5.93, 5.94 and 6.13, respectively (P≤0.05).

Key words: broiler, flock size, performance, bone quality, welfare

In broiler farming, as with other branches of farming, economic efficiency comes first as a major factor affecting production. Basically economic efficiency is calculated as a ratio of income obtained from production divided by costs of production. As is the case for all industry areas, also in the poultry industry a superior economic efficiency could only be obtained by means of application of a suitable technology

*Source of research financing: Firat University Scientific Research Projects (FUBAP), Project No: VF.13.04.

comprising latest improvements. Chicken breeding came a long way from early days of primitive farming of low production capacity towards modern technical farming. The companies that can maintain high levels of efficiency by use of suitable controller, feeding system, ventilation and so on can reap a good profit in this sector (Ozdemir, 2010).

To meet growing demand in white meat consumption, broiler production in Turkey has shown a tremendous progress in recent years. Thanks to widespread automation technologies, conception of systems allowing high capacity breeding played an important role in the increased capacities of poultry houses (Ozturk and Durmus, 2001).

For captive animals, group sizes and/or densities are established by humans based on criteria that range from enclosure size to basic needs or economic reasons. By means of overloading poultry houses with animals, efficiency per poultry house increases and production cost diminishes by making better use of fixed expenses like equipment, labour and maintenance (Shaikh and Zala, 2011). On the other hand, increasing number of animals inside of poultry house makes it difficult to manage flock and inner environmental conditions of poultry house (Croney and Newberry, 2007; Estevez et al., 2007). Factors causing the condition of animals to deteriorate make them more sensitive to detrimental effects of environmental factors. Animals under stress easily fall sick and more medications are employed to cure diseased animals (Shini et al., 2010). Originating from this, residuals of medication in animal products increase and this situation endangers public health (Paige et al., 1997). "Flock welfare" is an important issue in animal health and food safety. For this reason, stress factors must be scrupulously analyzed and factors affecting flock health should urgently be revealed.

Performance data of broilers, disease and mortality rates are parameters revealing welfare of animals (Lara and Rostagno, 2013). Additionally, it was found that glucose, cholesterol, uric acid and protein levels of blood vary significantly and these parameters may be either high or low depending on source and duration of stress in poultry under stress (Daneshyar et al., 2009; Ciftci et al., 2013). Serum creatine kinase and alkaline phosphatase activity are enzymes associated with muscle and bone tissues so that they may increase significantly under stress (Hocking et al., 2001; Tang et al., 2013). Rapid glucose degradation in muscles observed in poultry exposed to acute stress immediately after slaughter quickly decreases pH level in muscle and causes important changes that will affect meat color and texture. In this case, PSE meats having low pH, faintly-colored, dehydrated during cooking and therefore having poor texture are encountered (Gregory, 2010). As to poultry exposed to chronic stress, since the energy required for maturation of muscle is used in adaptation process to stress condition, DFD meats having high pH, dark color, poor texture, and short shelf-life are observed (Adzitey and Nurul, 2011). For poultry, if pH of meat is $\leq$5.8 then it is classified as PSE, else if it is between 5.9–6.2 as standard meat or if it is $\geq$6.3 as DFD (Ristić and Klaus, 2010).

Bone structure in broilers is of utmost importance for reasons such as mortality, low efficiency and loss of carcass quality. Bone is an active tissue and it is dramatically affected by several environmental factors like age, gender, genetics, breeding,

activity, stress, hormones, infections and toxins (Rath et al., 2000). Bone ash, bone fracture resistance and bone densitometry (mineral content and density of bone) are major parameters for estimating bone quality (Orban et al., 1993). Fast-growing broiler breeds are quite sensitive to bone abnormalities. For these broilers, physical stress may give rise to welfare problems by reducing bone quality (Talaty et al., 2010).

This study, which takes into account the aforementioned factors, is conducted to determine the effects of flock size in broilers bred for commercial purposes on performance, some blood parameters and bone parameters as well as pH of the *pectoralis* muscle.

Material and methods

This research was conducted in poultry houses associated with an integrated facility located in Malatya following approval of Firat University Animal Ethics Committee (FUHADEK decree no: 08.11.2012/103). In the study, six poultry houses consisting of 3 different pairs picked from each capacity within the set of poultry houses with wood shavings flooring material of 15,000, 25,000 and 35,000 capacities were studied during two growth periods in summer and autumn seasons. Dimensions (width × length) of poultry houses are 16×60, 16×100, 16×135 m, respectively. Chicks of Ross-308 strain, obtained from hatchery of the facility which provided the animal material for the study, were placed in poultry houses randomly. Environmental conditions in all capacities were organized according to the needs of broilers. Throughout the study, fresh water and feed produced at the facility's feed factory in accordance with NRC standards were at the disposal of broilers *ad libitum*. Composition of feed is presented in Table 1. During the entire production period, stocking density was arranged in a way to maintain 16 chickens/m^2. Five females and 5 males × 2 production periods, totally 20 broilers per different capacity having a live weight of ~1.8 kg and ~2.0 kg respectively were picked out and transferred for slaughter on 32nd day of study. Whole blood of broiler chickens slaughtered by decapitation were drained into serum gel tubes in the course of slaughter. pH measurements were performed on pectoral muscle of broiler chickens ten minutes after slaughter. After removal of skin and internal organs, bone samples with meat were taken from broiler chickens. Blood and bone samples were delivered to laboratory in cold chain (by means of refrigerated truck).

Weights of chicks were determined on days 1, 7, 14, 21, and 28. On these days, a balance featuring precision of g scale was used for determination of live weights and each time 5 different broilers were randomly weighed from 10 different points of poultry house. A total of 50 broilers from each flock were weighed on each of these days. Slaughter weight was collectively determined on special scales of the company's slaughterhouse. Broilers were taken from flocks at the evening hours, and were sent to slaughterhouse after 12 h total fasting period. Broilers spent their waiting time in special waiting rooms, in trucks and crates. Trucks were weighed before slaughter process, while they were full and later, while they were empty. Mean live

weight was calculated by dividing total live weight by the number of slaughtered birds. Digital board was used for feed consumption detection. Food was withdrawn from flocks within 8-10 hours of arrival of loading trucks, and within this period the remaining food consumption was achieved. Live weight gain and feed consumption per chicken were determined and feed conversion ratio was calculated as feed to gain (kg/kg). Dying chickens during production period were processed to flock board, and at the end of the production period, percentage mortality rates were calculated.

Table 1. Establishment and composition of diets used in the study (%)

Feedstuffs	0–10th day	11–27th day	28th day – slaughter
Corn	54.10	45.70	54.50
Wheat	-	11.10	6.50
Vegetable oil	1.30	3.50	4.00
Soybean meal (% 48 HP)	30.10	25.10	24.50
Full fat soy	8.00	8.20	6.17
Meat bone meal	3.00	3.27	-
Dicalcium phosphate	1.30	1.20	2.00
Limestone	0.50	0.30	0.70
Sodium bicarbonate	0.50	0.50	0.50
Salt	0.30	0.30	0.30
DL-Methionine	0.40	0.40	0.40
L-Lysine	0.10	0.05	0.05
L-Threonine	0.10	0.08	0.08
Vitamin Mix*	0.20	0.20	0.20
Mineral Mix**	0.10	0.10	0.10
Nutrients			
Dry material	90.60	90.10	90.89
Raw Protein	23.40	22.00	19.70
Raw Cellulose	3.20	3.50	3.58
Raw Oil	5.83	7.75	8.34
Raw Ash	5.50	5.30	3.91
Calcium***	1.00	0.93	0.85
Usable Phosphorus***	0.51	0.51	0.44
Methionine***	0.69	0.66	0.59
Lysine***	1.44	1.27	1.11
Threonine***	0.97	0.88	0.81
ME (Kcal/kg)***	3.011	3.176	3.225

*Vitamin mix: Each 2.5 kg mix includes: Vitamin A 12,000,000 IU; Vitamin D_3 2,000,000 IU; Vitamin E 35,000 mg; Vitamin K_3 4,000 mg; Vitamin B_1 3,000 mg; Vitamin B_2 7,000 mg; Niacin 20,000 mg; Calcium D-pantothenate 10,000 mg; Vitamin B_6 5,000 mg; Vitamin B_{12} 15 mg; Folic Acid 1,000 mg; D-Biotin 45 mg; Vitamin C 50,000 mg; Choline Chloride 125,000 mg; Canthaxanthin 2,500 mg; Apo Carotenoids Acid Esters 500 mg.

**Mineral mix: each 1 kg mix includes: manganese 80,000 mg; iron 60,000 mg; zinc 60,000 mg; copper 5,000 mg; cobalt 200 mg; iodine 1,000 mg; selenium 150 mg.

***Determined by calculation.

Determination of pH in meat is performed on the part of breast muscle (*musculus pectoralis*) by use of meat pH meter manufactured by Hanna (HI 99163, Holland).

Blood samples were centrifuged at 4000 rpm for 4 minutes, and analyses were conducted at Firat University Hospital Central Laboratory. Blood analyzer available in the laboratory (Siemens Advia 2400, Japan) was used to determine the glucose, total cholesterol, very-low-density lipoprotein cholesterol (VLDL), triglycerides, protein, uric acid, alkaline phosphatase and creatine kinase analyses of serums. For physical analysis of bones, right tibio-tarsal bone and femur were used. The bones were initially weighed by precision balance featuring mg precision level, then their sizes were measured by means of digital caliper (Tresna, USA). The bones, chopped into small pieces with the help of a cutting tool for ash determination were evaluated after incineration in a muffle furnace (Protherm, Turkey) at 600ºC for 7–8 hours (Sari and Cerci, 1993). Left tibio-tarsal bones extracted from meats for determination of mineral content were conserved at –20ºC until the day of analysis. Bones removed from –20ºC one day before analysis day were kept at +4ºC for 12 hours and dissolution of their ice was achieved. Twenty pieces (10 females, 10 males) of left tibio-tarsal bones were weighed and 10 pieces (5 females, 5 males) of them were selected according to stable bone weight of ~12 g and ~14 g respectively and analyses of bone mineral content (BMC) and bone mineral density (BMD) were conducted. Analyses were performed at Nuclear Medicine Center of Firat University Research Hospital by making use of *Discovery Wi* (*S/N 84440*) (Figure 1).

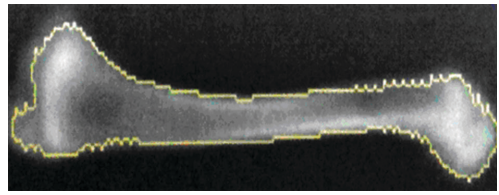

Figure 1. Tibio-tarsal bones scanned at high resolution through *Discovery Wi (S/N 84440)*

After test of normality, to determine the effects of flock size on examined parameters, one-way analysis of variance (ANOVA) was performed in three broiler flocks containing 15,000, 25,000 and 35,000 birds. Because sex was equal among the groups, it was not statistically assessed. Mortality rates were expressed in percentages for each flock and evaluated. To make comparisons among groups, Tukey HSD test was utilized. Statistical analysis was performed with the help of SPSS 21 (2012) software package. When the cases where differences among group averages were $P \leq 0.05$, they were considered statistically significant.

Results

Effects of flock size of broilers reared in the floor system on performance properties of broilers are given in Table 2. Mortality rate of broilers sent for slaughter at the age of 37 days to poultry houses of 15,000, 25,000 and 35,000 birds were determined to be 5.94±0.39, 6.99±0.51, 7.05±0.51 respectively, and it was observed that the val-

ue obtained from the group having 15,000 birds was lower compared to the other two groups (P≤0.01). Regarding mortality rates, similar results were obtained in poultry houses of 25,000 and 35,000 birds (P>0.05). In the study, it was found that groups had similar values regarding feed consumption, feed efficiency and live weights of broilers on days 7, 14, 21, 28 of breeding and at the age of slaughter (P>0.05).

Table 2. The effects on some performance parameters related with flock size of broilers reared in the floor system

Traits	15 000	25 000	35 000	P-statistical significance
1st day (g)	40.07±0.62	41.51±0.30	40.18±0.45	NS
7th day (g)	170.73±2.46	173.46±1.42	171.74±3.51	NS
14th day (g)	461.35±6.38	447.02±4.77	453.51±4.53	NS
21st day (g)	943.09±11.49	937.17±9.95	958.29±14.25	NS
28th day (g)	1543.21±22.06	1559.00±17.29	1515.97±16.54	NS
Slaughter age (day)	37	37	37	-
Cumulative feed comsumption (d/chicken)	3496.20±101.98	3544.83±125.03	3563.53±98.52	NS
Live weight during cutting age (d/chicken)	2116.76±57.00	2152.40±67.78	2113.55±65.53	NS
Live weight gain (1st day-slaughtering age), (d/chicken)	2076.69±57.23	2110.89±67.85	2073.37±66.00	NS
Mortality rate (%)	5.94±0.39 b	6.99±0.51 a	7.05±0.51 a	**
Feed efficiency (FCR)	1.68±0.01	1.68±0.00	1.71±0.02	NS

Data are given as mean ± standard error. NS: not statistically significant, **a, b – the difference between rates represented by letters in the same row is significant (P≤0.01).

Effects of flock size of broilers reared in the floor system on some blood parameters are given in Table 3. As shown in the table, serum glucose and uric acid levels in flocks of 35,000 birds were significantly higher (P≤0.01). The lowest serum glucose levels were detected in flocks of 25,000 birds. For flocks of 15,000 birds, serum glucose level was similar in both groups. Uric acid levels were observed to be similar in flocks of 15,000 and 25,000 birds (P>0.05). Differences among groups in terms of serum total cholesterol, VLDL cholesterol, triglyceride, protein, alkaline phosphatase and creatine kinase values were insignificant (P>0.05).

Upon examination of the effects of flock size on some bone values for flocks of 15,000, 25,000 and 35,000 birds (Table 4), it was observed that the broilers having equalized mean live weights were similar to each other in terms of tibia and femur weights, tibia length and width, femur length and width, tibia and femur ash ratios (P>0.05). In groups with stable tibia weights, no statistical difference among groups in BMC and BMD values was observed (P>0.05). According to the table, pH values in *musculus pectoralis* for the flocks of 15,000, 25,000 and 35,000 birds were measured as 5.93±0.02, 5.94±0.04 and 6.13±0.04 respectively and pH value in flock of

35,000 birds was higher than other groups (P≤0.05). Flocks of 15,000 and 25,000 birds showed similarities in terms of pH value in meat (P>0.05).

Table 3. The effects on some blood parameters related with flock size of broilers reared in the floor system

Traits	15 000	25 000	35 000	P-statistical significance
Glucose (mg/dL)	258.20±4.50 ab	238.42±4.70 b	270.77±7.32 a	**
Cholesterol (mg/dL)	119.90±6.33	129.55±4.12	129.72±4.06	NS
VLDL cholesterol (mg/dL)	20.00±2.67	14.85±1.44	18.72±1.44	NS
Triglycerides (mg/dL)	99.70±13.76	74.85±7.19	93.66±6.99	NS
Protein (g/dL)	3.46±0.06	3.50±0.13	3.63±0.10	NS
Uric acid (mg/dL)	4.91±0.21 b	4.07±0.44 b	6.06±0.28 a	**
Alkaline phosphatase (U/L)	8342.45±871.08	7324.45±1021.89	7147.72±886.08	NS
Creatine kinase (U/L)	16083.11±2219.82	12256.48±2058.41	10838.17±1558.44	NS

Data are given as mean ± standard error. NS: not statistically significant, **a, b – the difference between rates represented by letters in the same row is significant (P≤0.01).

Table 4. The effects on some bone parameters related with flock size of broilers reared in the floor system

Traits	15 000	25 000	35 000	P-statistical significanc
Live weight (g)	1911.00±46.05	1903.33±22.96	1914.16±28.08	NS
Tibia weight (g)	14.31±0.57	13.25±0.35	13.49±0.50	NS
Femur weight (g)	10.05±0.40	9.85±0.26	9.82±0.27	NS
Tibia length (mm)	95.91±0.62	94.94±0.41	95.65±0.58	NS
Femur length (mm)	70.12±1.33	71.97±0.42	71.33±0.36	NS
Tibia width (mm)	7.50±0.20	7.50±0.17	7.58±0.18	NS
Femur width (mm)	8.12±0.21	8.13±0.13	8.28±0.15	NS
Tibia ash (%)	15.65±0.41	15.44±0.39	16.31±0.22	NS
Femur ash (%)	15.48±0.24	16.17±0.24	16.30±0.16	NS
Discovery Wi (S/N 84440)				
Researched tibia weight (g)	13.00±0.57	13.10±0.34	12.99±0.24	NS
Tibia BMC (g)	2.52±0.05	2.68±0.06	2.68±0.06	NS
Tibia BMD (g/cm^2)	0.26±0.00	0.27±0.00	0.27±0.00	NS
Hanna (HI 99163)				
pH in pectoral muscle	5.93±0.02 b	5.94±0.04 b	6.13±0.04 a	*

Data are given as mean ± standard error. NS: not statistically significant, *a, b – the difference between rates represented by letters in the same row is significant. (P≤0.05).

BMC: bone mineral content, BMD: bone mineral density.

Discussion

Upon examination of performance data shown in Table 2 derived from the study, no statistical difference was observed for groups of 15,000, 25,000, 35,000 birds other than the mortality rates of broilers sent for slaughter at the age of 37 days.

Differences in feed efficiency among treatment groups were considered to be insignificant (P=0.078). For floor poultry houses with a small capacity of 15,000 birds, mortality rate was observed to be significantly lower compared to the two other groups. Increase in mortality rate depending on poultry house capacity can be associated with physical and social environment within poultry house. Increase in capacity of poultry house may change climatic factors within poultry house and could particularly cause problems related to ventilation (Heier et al., 2002; Vale et al., 2010). Fast growing broiler breeds are significantly affected by air temperature, ammonia level and density of dust particles due to their genetic capacities (Wideman et al., 2013). Especially towards the end of the growing period, the level of heat released from the body increases dramatically. High ambient temperature increases thermal burden on broilers and the resultant thermal stress may cause deaths in broilers (Vieira et al., 2011). Whilst high ratio of dust hung in the air causes upper respiratory tract infections, microorganisms such as viruses, bacteria and fungi clinging to dust particles could give rise to deaths due to inhalation (Arné et al., 2011). During the breeding period, ammonia level in poultry house should be <25 ppm. In a similar vein, high ammonia level affects broilers and causes economic losses (Wang et al., 2010). Most particularly, air and litter management in high capacity poultry houses of which length is excessive might be important factors affecting mortality rate. Moreover, Estevez et al. (2007) stated that in groups of large capacity, individuals of flock did not know each other and therefore hierarchical order was not fully formed. This situation increases aggressive behaviors of broilers in the course of getting feed and water, and it could lead to stress. Keeling et al. (2003) found that hierarchical order was established in flocks of small capacity more quickly and properly, and this situation significantly improved performance of poultry.

Upon examination of data in Table 3, serum glucose and uric acid level were observed to be considerably high especially regarding the flocks with a capacity of 35,000 birds. Rise in glucose level may increase depending on the environmental factors. The increase of serum glucose level is a sign exposing various acute and chronic stress factors. Ciftci et al. (2013) found as a result of their study that serum glucose level in quail bred under chronic heat stress was significantly high whereas stress factors had no effect on blood lipids. Zhang et al. (2009) ascertained that glucose level in broiler chicks subjected to transportation stress from 45 minutes to 3 hours initially rises dramatically in the first 45 minutes and then drops. Puvadolpirod and Thaxton (2000) reported that injection of adrenocorticotropic hormone into 5-week-old broilers for 7 days raised dramatically the concentrations of glucose and cholesterol in blood. On the other hand, they also reported that the rises observed in triglyceride levels were of no significance. Daneshyar et al. (2009) discovered that glucose level in blood was noticeably high, protein level in blood was low and triglyceride and cholesterol levels in blood did not change under cold stress condition in broilers. Similarly, significant differences between treatment groups in this study were not observed in terms of serum cholesterol, triglyceride and protein levels. Lin et al. (2004 a) stressed that short-term corticosterone administration (injection of 4 mg/kg live weight) in broilers raised plasma uric acid level and total antioxidant capacity by activating antioxidant level in broilers. In another study, Lin et

al. (2004 b) discovered that regarding broilers daily bred by feed supplemented with 30 mg/kg corticosterone for 2 weeks (long-term treatment, chronic stress) caused the rise of plasma uric acid and ceruloplasmin level rose dramatically starting from the third day of treatment and broilers tried to defend themselves against severe damage of oxidative stress in this manner. The fact that uric acid level was quite high for experimental group of 35,000 birds in this study might be a result of the fact that broilers show resistance to stress using a similar mechanism. No statistical difference was encountered among experimental groups with respect to values of alkaline phosphatase and creatine kinase enzyme activities. Unlike these findings, Tang et al. (2013) reported that serum creatine kinase (CK) activity rose dramatically in broilers exposed to acute heat stress at the time of slaughter and this parameter could be considered as an indicator of stress. Rajman et al. (2006) observed that for controlled and feed restricted groups in broilers under restriction of feed during growing period plasma glucose level was similar, alkaline phosphatase level was low for feed restricted group whilst creatine kinase level was high for the group fed *ad libitum*. The researchers related these findings to a negative impact of fastgrowing on health and welfare of broilers.

Upon close examination of data in Table 4, intergroup differences were not considered as statistically significant in terms of tibia and femur ash rate in live weight equalized broilers sent for slaughter, tibia BMC and BMD levels in tibia weight equalized groups. In the period of growth, movement space increases in high capacity flock. It was anticipated that increased movement space would encourage broilers to do some activities. In the same way, Newberry and Hall (1990) discovered that total usage of surface area for the broilers bred in a large poultry house (large settlement space) between 4 and 9 weeks was dramatically higher than for the broilers bred in a smaller poultry house (smaller settlement space). Physical activity is an important parameter improving mineral content and strength of bone (Almeida Paz and Bruno, 2006). However, findings of this research indicated that broiler activities in high capacity poultry house did not improve bone quality considerably. Similarly, Sherlock et al. (2010) ascertained in their study in which they examined relationship between physical activity and leg health in broilers that due to their genetic structures, broilers do not move around so as to affect their bone quality and cortical density during breeding period. Simsek et al. (2009) reported that increased physical activity had no effect on mineral content and density of bone in tibio-tarsal bone for broilers whose living space was enriched with sand pad and perch. Bizeray et al. (2002) established that increased activity thanks to environmental enrichment had no influence on tibia ash level and fracture resistance but increased tibial diaphyseal diameter substantially. Škrbić et al. (2011) found that tibia quality improved for broilers having low stocking density.

Analysing pH values in *musculus pectoralis* in Table 4, it can be seen that pH value rises correlated with the increase in flock size. Even though high pH was observed in the flock of 35,000 birds, pH for those three groups were within the range of standard meat values (pH: 5.9–6.2) defined by Ristić and Klaus (2010). Dadgar et al. (2011) found that pH value in *musculus pectoralis* of broilers exposed to cold stress at the age of slaughter, depending on degree of cold level, rose significantly

compared to the control group. Tang et al. (2013) stated that pH value in *musculus pectoralis* of broilers exposed to heat stress for a short period of time at the age of slaughter dropped substantially compared to the control group and cooking loss rose.

In conclusion, in flocks of 35,000 birds mortality rates, glucose and uric acid levels in blood rose, no significant changes occurred in bone parameters, and pH level in pectoral muscle (breast muscle) rose albeit at an acceptable level. In accordance with the findings of this study, it can be said that flock size is a source of stress for broilers. The broiler sector in Turkey grows day by day due to the reasons such as exportation potential, no market problems, lower prices compared to red meat, being consumed willingly and contributions of several support units to stockbreeding. In this context, several poultry houses of high capacities are constructed. Effects of poultry house capacities employed in broiler breeding on performance and welfare of broilers should be revealed, and future production strategies should be planned in this direction.

Acknowledgement

I would like to thank FUBAP (VF.13.04) for financially supporting this study, owner of commercial company, and all flock owners and flock employees.

References

Adzitey F., Nurul H. (2011). Pale soft exudative (PSE) and dark firm dry (DFD) meats: causes and measures to reduce these incidences – a mini review. Int. Food Res. J., 18: 11–20.

Almeida-Paz I.C.L., Bruno L.D.G. (2006). Bone mineral density: review. Braz. J. Poult. Sci., 8: 69–73.

Arné P., Thierry S., Wang D., Deville M., Le Loc'h G., Desoutter A., Féménia F., Nieguitsila A., Huang W., Chermette R., Guillot J. (2011). *Aspergillus fumigatus* in poultry. Int. J. Microbiol., Article ID 746356: 1–14.

Bizeray D., Estevez I., Leterrier C., Faure J.M. (2002). Influence of increased environmental complexity on leg condition, performance, and level of fearfulness in broilers. Poultry Sci., 81: 767–773.

Ciftci M., Simsek U.G., Azman M.A., Çerçi I.H., Tonbak F. (2013). The effects of dietary rosemary (*Rosmarinus officinalis* L.) oil supplementation on performance, carcass traits and some blood parameters of Japanese quail under heat stressed condition. Kafkas Univ. Vet. Fak. Derg., 19: 595–599.

Croney C.C., Newberry R.C. (2007). Group size and cognitive processes. Appl. Anim. Behav. Sci., 103: 215–228.

Dadgar S., Lee E.S., Leer T.L.V., Crowe T.G., Classen H.L., Shand P.J. (2011). Effect of acute cold exposure, age, sex, and lairage on broiler breast meat quality. Poultry Sci., 90: 444–457.

Daneshyar M., Kermanshahi H., Golian A. (2009). Changes of biochemical parameters and enzyme activities in broiler chickens with cold-induced ascites. Poultry Sci., 88: 106–110.

Estevez I., Andersen I.L., Naevdal E. (2007). Group size, density and social dynamics in farm animals. Appl. Anim. Behav. Sci., 103: 185–204.

Gregory N.G. (2010). How climatic changes could affect meat quality. Food Res. Int., 43: 1866–1873.

Heier B.T., Høgåsen H.R., Jarp J. (2002). Factors associated with mortality in Norwegian broiler flocks. Prev. Vet. Med., 53: 147–158.

Hocking P.M., Maxwell M.H., Robertson G.W., Mitchell M.A. (2001). Welfare assessment of modified rearing programmes for broiler breeders. Br. Poultry Sci., 42: 424–432.

Keeling L.J., Estevez I., Newberry R.C., Correia M.G. (2003). Production-related traits of layers reared in different sized flocks: the concept of problematic intermediate group sizes. Poultry Sci., 82: 1393–1396.

Lara L.J., Rostagno M.H. (2013). Impact of heat stress on poultry production. Animals, 3: 356–369.

Lin H., Decuypere E., Buyse J. (2004 a). Oxidative stress induced by corticosterone administration in broiler chickens (*Gallus gallus domesticus*): 2. Short-term effect. Comp. Biochem. Physiol. B-Biochem. Mol. Biol., 139: 745–751.

Lin H., Decuypere E., Buyse J. (2004 b). Oxidative stress induced by corticosterone administration in broiler chickens (*Gallus gallus domesticus*) 1. Chronic exposure. Biochem. Physiol. B-Biochem. Mol. Biol., 139: 737–744.

Newberry R.C., Hall J.W. (1990). Use of pen space by broiler chickens: effects of age and pen size. Appl. Anim. Behav. Sci., 25: 125–136.

Orban J.I., Roland D.A., Bryant M.M., Williams J.C. (1993). Factors influencing bone mineral content, density, breaking strength, and ash as response criteria for assessing bone quality in chickens. Poultry Sci., 72: 437–446.

Ozdemir S. (2010). The broiler industry yesterday, today and tomorrow. National Poultry Congress, 07–09.10.2010, Kayseri-Turkey.

Ozturk F., Durmus I. (2001). An investigation on poultry sub-sectors of Turkey within the framework of relations with the European Union. Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Research. Evaluation and Planning Meeting of Poultry Program. 25–27.09.2001, Ankara, pp. 15–92.

Paige J.C., Tollefson L., Miller M. (1997). Public health impact on drug residues in animal tissues. Vet. Hum. Toxicol, 39: 162–169.

Puvadolpirod S., Thaxton J.P. (2000). Model of physiological stress in chickens 1. Response parameters. Poultry Sci., 79: 363–369.

Rajman M., Juráni M., Lamošová D., Máčajová M., Sedlačková M., Košťál Ľ., Ježová D., Výboh P. (2006). The effects of feed restriction on plasma biochemistry in growing meat type chickens (*Gallus gallus*). Comp. Biochem. Physiol. A: Physiol., 145: 363–371.

Rath N.C., Huff G.R., Huff W.E., Balog J.M. (2000). Factors regulating bone maturity and strength in poultry. Poultry Sci., 79: 1024–1032.

Ristić M., Klaus D. (2010). The meaning of pH-value for the meat quality of broilers – Influence of breed lines. Tehnol. Mesa, 51: 120–123.

Sari M., Cerci I.H. (1993). Animal feeds and nutritional diseases. Chemical analysis of feeds. Elazığ-Tolga-Ofset, pp. 266–279.

Shaikh A.S., Zala Y.C. (2011). Production performance and economic appraisal of broiler farms in Anand district of Gujarat. Agr. Econ. Res., 24: 317–323.

Sherlock L., Demmers T.G., Goodship A.E., McCarthy I.D., Wathes C.M. (2010). The relationship between physical activity and leg health in the broiler chicken. Br. Poultry Sci., 51: 22–30.

Shini S., Huff G.R., Shini A., Kaiser P. (2010). Understanding stress-induced immunosuppression: Exploration of cytokine and chemokine gene profiles in chicken peripheral leukocytes. Poultry Sci., 89: 841–851.

Simsek U.G., Dalkilic B., Ciftci M., Cerci I.H., Bahsi M. (2009). Effects of enriched housing design on broiler performance, welfare, chicken meat composition and serum cholesterol. Acta Vet. Brno, 78: 67–74.

Škrbić Z., Pavlovski Z., Lukić M., Milić D. (2011). The effect of rearing conditions on carcass slaughter quality of broilers from intensive production. Afr. J. Biotechnol., 10: 1945–1952.

Talaty P.N., Katanbaf M.N., Hester P.Y. (2010). Bone mineralization in male commercial broilers and its relationship to gait score. Poultry Sci., 89: 342–348.

Tang S., Yu J., Zhang M., Bao E. (2013). Effects of different heat stress periods on various blood and meat quality parameters in young Arbor Acer broiler chickens. Can. J. Anim. Sci., 93: 453–460.

Vale M.M., Moura D.J., Nääs I.A., Pereira D.F. (2010). Characterization of heat waves affecting mortality rates of broilers between 29 days and market age. Braz. J. Poultry Sci., 12: 279–285.
Vieira F.M.C., Silva I.J.O., Barbosa Filho J.A.D., Vieira A.M.C., Broom D.M. (2011). Preslaughter mortality of broilers in relation to lairage and season in a subtropical climate. Poultry Sci., 2011, 90: 2127-2133.
Wang Y.M., Meng Q.P., Guo Y.M., Wang Y.Z., Wang Z., Yao Z.L., Shan T.Z. (2010). Effect of atmospheric ammonia on growth performance and immunological response of broiler chickens. J. Anim. Vet. Adv., 9: 2802–2806.
Wideman R.F., Rhoads D.D., Erf G.F., Anthony N.B. (2013). Pulmonary arterial hypertension (ascites syndrome) in broilers: A review. Poultry Sci., 92: 64–83.
Zhang L., Yue H.Y., Zhang H.J., Xu L., Wu S.G., Yan H.J., Gong Y.S., Qi G.H. (2009). Transport stress in broilers: I. Blood metabolism, glycolytic potential, and meat quality. Poultry Sci., 88: 2033–2041.

Received: 9 VI 2014
Accepted: 12 IX 2014