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RESEARCH ARTICLE

Effects of Cage and Floor Housing Systems on Fattening Performance, Oxidative Stress and Carcass Defects in Broiler Chicken [1] [2]

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Summary

This study was carried out to compare floor with cage housing systems used for broiler chicken production in terms of performance, some oxidative stress parameters and carcass defects. For this purpose, two cage and two floor housing farms were monitored simultaneously during summer, autumn and winter seasons. Capacities of farms in each housing system were 40.000 and 25.000 chickens. At the end of each summer, autumn and winter season, 15 broilers were selected in both housing systems with capacity of 25.000 chickens for carcass and oxidative stress parameters. Blood samples were taken in slaughtering period from chickens slaughtered with decapitation. Broiler reared in cage housing showed higher live weight at 7 and 14 days (P≤0.05). But this difference disappeared after three weeks, while slaughter weights were found to be similar at both systems. Better feed conversion ratio (FCR) and carcass yield were obtained in floor housing (P≤0.01). Serum malondialdehyde (MDA) level increased in cage housing (P≤0.01). Other carcass traits and antioxidant activity were found to be similar between groups (P>0.05). Cases of wing fractures, wing and breast bruising were found to be higher in cage housing (P≤0.05). Case of shank and drumstick bruising slightly increased in floor housing (P=0.074). The incidence and severity of food pad lesions increased in floor housing (P≤0.01). The results of this study indicated that floor housing had shown better performance and carcass quality at examined production capacities.

Keywords: *Broiler, Floor housing, Cage housing, Performance, Season*

Kafes ve Yer Sistemlerinin Etlik Piliç Üretiminde Besi Performansı, Oksidatif Stres ve Karkas Kusurları Üzerine Etkileri

Özet

Bu araştırma, etlik piliç üretiminde kullanılan yer ve kafes sistemlerini performans, bazı oksidatif stres parametreleri ve karkas kusurları bakımından karşılaştırmak için yürütülmüştür. Bu amaçla, 2 yer ve 2 kafes kümesi yaz, sonbahar ve kış sezonları süresince eş zamanlı olarak takip edilmiştir. Her sistemde kümeslerin kapasitesi 40.000 ve 25.000 piliç şeklindedir. Yaz, sonbahar ve kış sezonları sonunda, 25.000 kapasiteli her iki yetiştirme sisteminden karkas ve oksidatif stres parametreleri için 15 piliç seçilmiştir. Kan numuneleri boyun uçurma yöntemi ile kesimi yapılan piliçlerden kesim esnasında alınmıştır. Kafes sisteminde yetiştirilen piliçler 7 ve 14. günlerde daha fazla canlı ağırlık göstermişlerdir (P≤0.05). Bu farklılık üçüncü haftadan sonra ortadan kaybolmuş ve kesim ağırlıkları her iki sistemde benzer bulunmuştur. Yer sisteminde yemden yararlanma ve karkas randımanı iyileşmiştir (P≤0.01). Serum malondialdehit (MDA) seviyesi kafes sisteminde yükselmiştir (P≤0.01). Diğer karkas özellikleri ve antioksidan aktivite araştırma grupları arasında benzer bulunmuştur (P>0.05). Kanat kırığı, kanat ve göğüs morarması olguları kafes sisteminde yüksek tespit edilmiştir (P≤0.05). İncik ve baget morarması olgusu yer sisteminde önemsiz derecede yükselmiştir (P=0.074). Taban yastığı nekrozlarının görülme oranı ve şiddeti yer sisteminde artmıştır (P≤0.01). Bu araştırma incelenen üretim kapasitelerinde yer sisteminin performans ve karkas kalitesi bakımından daha iyi sonuçlara sahip olduğunu göstermektedir.

Anahtar sözcükler: *Etlik piliç, Yer sistemi, Kafes sitemi, Performans, Mevsim*

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INTRODUCTION

Two housing systems including floor and cage are used in conventional broiler production. Floor housing is widely used, but implementations of cage rearing in broiler production are not recent. Manufacturing companies began to work in this issue in 1960s. The colony cages were developed with different features in accordance with the needs of the broilers [1-3]. From now on, reduced labor costs per square meter, increased uniformity, improved feed efficiency, more production per unit area, unnecessity of the use of litter, disappearance of dust and wet litter problems which are the major problems in floor system, minimum incidence of diseases such as enteritis and coccidiosis because of decreasing contact with manure, increase at annual production because of convenience of disinfection and cleaning operations, easy and stress-free transport to slaughterhouse have been detected as the advantages of use of cages for broiler breeding [4-6]. However, high initial investment cost, difficulty at poultry management and control of environmental factors at large-scale flocks, deteriorating welfare, increased mortality rates related to leg and wing disorders of chickens, softening of bones, leg and wing fractures, perozis, defects of brisket and decline in quality of meat have been obtained as the disadvantages [3,7-10].

Although cages have been banned in broilers and layers in EU, with more intensive production in a small land, the cage production seems quite attractive and has been quickly growing over the World, especially in Russia, the Middle East, several Asian countries, Africa and Eastern European countries in recent years [10]. However, there is the lack of information in cage reared broilers, especially in commercial flocks. This study aimed to compare simultaneously floor housing with cage housing used in broiler production in terms of performance, some stress parameters and carcass traits during three seasons (summer, autumn and winter).

MATERIAL and METHODS

Experimental Design

The study was conducted at cage and floor farms of an integrated commercial company with the approval of Firat University Animal Researches Ethic Committee (FUHADEK, verdict no: 20.01.2012/07). The study was conducted at 4 farms contracted with the same poultry integration company consisting of cage (2) or floor (2) housing systems. Data were collected from each farm during the two consequent production periods in summer, autumn and winter seasons. Therefore, there were 4 replicate flocks of each cage and floor housing systems with the capacities of 40.000 and 25.000 broilers. Any effort has been made to optimize and to have similar environmental conditions in each flock through the seasons. Ross-308 broiler chicks were randomly placed to the farms.

The cage system had 4 storeys, and each cage unit had 165 cm width x 246 cm length x 75.75 cm in height. All storeys base was made from plastic mesh material. First 28 days, 23 h of light and 1 h of dark schedule was applied to the both housing systems. Thereafter, 20 h of light and 4 h of dark schedule was used. All heating, ventilation, lighting, feeding, watering, capture and delivery systems were controlled digitally. Manure was removed from the coops with digital belt system in cage housing. At the end of production, transportation of chickens to slaughterhouse was performed with same belt system *(http://www.kutlusan.com.tr)*. Stocking density was adjusted at cage and floor flocks to be 17-17.5 chicks/m^2. Wood shaving was used as flooring material at floor coops (5 kg/m^2). Feed and fresh water were automatically distributed and ad libitum. Diets were obtained from commercial feed company and were in accordance with NRC [11]. Compositions of the diets were given at *Table 1*.

Weights of chickens were determined on the days 1st, 7th, 14th, 21st, and 28th. On these days, a balance featuring precision of g scale was used for determination of live weights and each time 10 different broilers (5 males and 5 females) were randomly weighed from 5 different points of poultry house. A total of 50 broilers from each flock were weighed each of on these days. Slaughter weight was collectively determined at special scales of slaughterhouse of the company. 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 it was full and later, while it was empty. Mean live weight were calculated by dividing total live weight to the number of slaughtered birds. Slaughter age was organized according to marketing plan of the company. Digital board was used for feed consumption detection. Food was withdrawn from flocks before 8-10 h of arrival of loading trucks, and within this period 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, mortality rates, by percentage were calculated.

Carcass traits and oxidative stress data have been collected only from the flocks of 25.000. Blood samples of birds from each housing system were collected into tubes at slaughter line during the neck cut and were analyzed by the following procedure. To determine carcass traits, enough chickens were individually weighed on slaughter day. 7 females and 8 males having a live weight of ~2.0 and 2.5 kg respectively were picked out and transferred for

***Table 1.** Ingredients and chemical composition of diets*
***Tablo 1.** Karma yemin bileşimi ve kimyasal kompozisyonu*

Feed ingredients	Days (1-10)	Days (11-27)	Days (28- Slaughter)
Maize	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
Ground 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
Nutritional composition, %			
Dry matter	90.60	90.10	90.89
Crude protein	23.40	22.00	19.70
Crude fibre	3.20	3.50	3.58
Ether extract	5.83	7.75	8.34
Ash	5.50	5.30	3.91
Calcium ***	1.00	0.93	0.85
Available 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 premix supplied per 2.5 kg; (ROVIMIX 123-T+CAR 25/5); 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; Niacine 20.000 mg; Calcium D-pantotenat 10.000 mg; vitamin B_6 5.000 mg; vitamin B_{12} 15 mg; Folik Asit 1.000 mg; D-Biotin 45 mg; vitamin C 50.000 mg; Choline chloride 125.000 mg; Canthaxanthin 2.500 mg; Apo Karotenoik Acid Ester 500 mg; ** Mineral premix supplied per kg; (REMINERAL-S); Mn 80.000 mg; Fe 60.000 mg; Zn 60.000 mg; Cu 5.000 mg; Co 200 mg; I 1.000 mg; Se 150 mg; *** Calculated*

slaughter. Feathers were plucked from selected chickens at slaughter house with wet plucking method, and after feet's cutting, internal organs (except kidneys and lungs) were removed. After removal of internal organs, fat tissue around cloaca, gizzard and duodenum, and covering under surface of peritoneum was removed and determined as abdominal fat weight. Later, carcasses were cut into parts in accordance to TSE [12] shredding technique, and all parts were weighed with skin.

Carcass defects and ammonia burns were performed in company with qualified personnel in slaughterhouse. For this purpose; 300 animals in both flocks were evaluated in each season (150x2). Chicks were selected randomly from cutting lane for each feature. Evaluation of carcasses for lesions was conducted in form of yes/no evaluation, and determination was given as percentage. Evaluation of foot pad ammonia burns was conducted using a 4 scale scoring indicating as 0: No lesion 1: Mild lesion, 2: Moderate lesion, 3: High-intensity lesion, respectively [13].

Chemical Analysis

Chemical composition of food ingredients (dry matter, crude protein, ash and ether extract) were analyzed according to the AOAC [14] procedures and crude fiber was determined by the methods of Crampton and Maynard [15].

Lipid Peroxidation: The levels of malondialdehyde (MDA) were measured in serum with the thiobarbituric acid reaction by the method of Placer et al.[16]. The quantification of thiobarbituric acid reactive substances was determined by comparing the absorption to the standard curve of MDA equivalents generated by acid catalyzed hydrolysis of 1,1,3,3 tetraethoxypropane. Every sample was assayed in duplicate, and the assay coefficients of variation for MDA were less than 3%.

Reduced Glutathione (GSH): The GSH content of the serum was measured at 412 nm using the method of Sedlak and Lindsay [17]. The samples were precipitated with 50% trichloroacetic acid and then centrifuged at 1.000 × g for 5 min. The reaction mixture contained 0.5 ml of supernatant, 2.0 ml of Tris-EDTA buffer (0.2 M; pH 8.9) and 0.1 ml of 0.01 M 5,5′-dithio-bis-2-nitrobenzoic acid. The solution was kept at room temperature for 5 min, and then read at 412 nm on the spectrophotometer.

Catalaz (CAT): The CAT activity of erythrocytes was measured according to the method of Aebi [18]. The degradation rate of H_2O_2 by CAT was spectrophotometrically measured by means of the fact that H_20_2 absorbed light at 240 nm wave length. CAT activity was calculated as k/g Hb.

Glutathione Peroxidase (GSH-PX): The GSH-Px activity was determined according to the method of Lawrence and Burk [19]. The reaction mixture consisted of 50 mM potassium phosphate buffer (pH 7.0), 1 mM ethylene diamine tetra acetic acid (EDTA), 1 mM sodium azide (NaN_3), 0.2 mM reduced nicotinamide adenine dinucleotide phosphate (NADPH), 1 IU/ml oxidized glutathione (GSSG)-reductase, 1 mM GSH, and 0.25 mM hydrogen peroxide (H_2O_2). Enzyme source (0.1 ml) was added to 0.8 ml of the above mixture and incubated at 25°C for 5 min before initiation of the reaction with the addition of 0.1 ml of peroxide solution. The absorbance at 340 nm was recorded for 5 min on a spectrophotometer. The activity was calculated from the slope of the lines as micromoles of NADPH oxidized per minute. The blank value (the enzyme was replaced with distilled water) was subtracted from each value.

Statistical Analysis

Effects of floor and cage housing systems on fattening performance, oxidative stress and carcass defects in broiler chicken were evaluated by independent-samples t test after test of normality. P-values were given in the tables including each season (summer, autumn and winter) and total effect of the housing systems. All analyses were performed by using SPSS for Windows [20]. The results were considered as significant when P values were lower than 0.05.

RESULTS

Mean values and standard errors of examined parameters were given in the tables. Live weights of 7th and 14th days were given in *Table 2* and found to be higher in cage system (P≤0.05). There were no significant difference between groups at later ages and at slaughter weight (P>0.05). Mortality rate and feed intake were found to be similar between groups (P>0.05). Better feed conversion rate (FCR) was obtained in floor system (P≤0.01).

The data presented in *Table 3* indicate that carcass yield was higher in floor housing (P≤0.01), all carcass parts and internal organ weights were similar between groups (P>0.05).

The data including lipid peroxidation presented in *Table 4* show that serum MDA levels of broiler were higher in cage housing system as compared with floor housing (P≤0.01). Serum CAT and GSH-Px activity and serum GSH level took statistically similar values between groups (P>0.05).

When carcass defects were examined *(Table 5)*, ratios of wings bruising (P≤0.001), wing fractures (P≤0.05) and breast bruising (P≤0.001) increased in cage housing. However, ratio of shank and drumstick bruising slightly increased in floor housing (P=0.074). When food pad lesions were examined *(Table 5)*, incidence of lesions decreased in cage housing (P≤0.001). The lesions of level 1 increased in cage housing (P<0.05), while ratios of degree 2 and 3 found to be higher in floor housing (P≤0.01).

DISCUSSION

Significantly higher live weight at 7 and 14 days were found to be in cage housing. Superior early weight gains at cage reared chickens may be an indication of more uniform control of environmental conditions in early stages at cage housing. In later periods, disappearance of difference in body weights was a sign of deterioration in cage conditions. Due to genetic characteristics of broiler chickens, they tend to be less active with increasing age [21]. This tendency may be increased with decreased possibility of moving in cage systems. Although each cage unit was designed to be large, lack of activity was thought to be an important factor affecting the results of the present research. At last stage of growth, lying chicks are the important factor for other chicks because they prevent them to reach water and food [22].

FCR values of reared chickens on the floor were found to be significantly better than reared chickens in the cage. Decreased activity in cage systems was concluded as an effect for the deterioration of FCR value. Skinner et al.[23] were reported drowsiness as a parameter that adversely affected the broiler FCR. It was reported that due to the lack of activity reducing in the bird feed consumption and increasing in mortality rates deteriorate the feed

Table 2. *Performance parameters of broilers reared in cage and floor housing systems*
Tablo 2. *Kafes ve yer sistemlerinde yetiştirilen etlik piliçlerin performans parametreleri*

Performance parameters	Summer			Autumn			Winter			Total Effect of Housing Systems (P_t)
	CH	FH	P	CH	FH	P	CH	FH	P	
Initial weight of the study, g	42.0±0.29	41.4±0.52	NS	41.2±0.23	42.0±0.29	NS	40.1±0.31	41.4±0.35	NS	NS
Day 7th, g	180±2.96	175±1.56	NS	178±2.18	176±1.54	NS	194±2.86	166±1.60	***	***
Day 14th, g	473±13.39	447±5.34	NS	438±6.34	465±3.33	**	520±7.92	466±6.14	**	*
Day 21st, g	956±6.25	920±6.35	**	969 ±9.40	996±11.14	NS	948±11.58	921±10.90	NS	NS
Day 28th, g	1583±10.93	1499±16.09	NS	1552±12.05	1642±16.23	**	1566±21.09	1561±8.12	NS	NS
Mean of slaughter ages of four production periods, day	36			35			33			-
Mortality rate, %	6.24±1.12	8.98±0.52	NS	9.64±1.01	7.80±1.34	*	5.70±1.39	6.82±1.35	NS	NS
Slaughter weight, kg	2.02±0.06	1.99±0.03	NS	1.93±0.03	2.04±0.05	NS	1.81±0.07	1.77±0.02	NS	NS
Weight gain, kg (1st- slaughter age)	1.97±0.08	1.94±0.05	NS	1.88±0.02	1.99±0.04	NS	1.77±0.09	1.72±0.02	NS	NS
Cumulative feed intake per broiler, kg	3.47±0.13	3.34±0.07	NS	3.27±0.09	3.27±0.09	NS	2.96±0.15	2.82±0.06	NS	NS
Feed conversion, FCR	1.76±0.02	1.72±0.02	NS	1.73±0.02	1.64±0.02	**	1.67±0.03	1.63±0.02	NS	**

***CH:** Cage housing; **FH:** Floor housing; **P:** Statistical significance; Mean ± SEM.; **NS:** Not statistically significant; * P≤0.05; ** P≤.0.01; *** P≤0.001*

Table 3. *Carcass traits of broilers reared in cage and floor housing systems*
Tablo 3. *Kafes ve yer sistemlerinde yetiştirilen etlik piliçlerin karkas özellikleri*

Carcass traits	Summer			Autumn			Winter			Total Effect of Housing Systems (P_t)
	CH	FH	P	CH	FH	P	CH	FH	P	
Adjusted slaughter weight, kg	2.30±0.02	2.29±0.03	NS	2.29±0.03	2.29±0.02	NS	2.27±0.02	2.27±0.02	NS	NS
Carcass weight, kg	1.52±0.02	1.49±0.02	NS	1.52±0.02	1.55±0.01	NS	1.47±0.01	1.63±0.01	***	*
Carcass yield, %	66.1±0.68	65.2±0.64	NS	66.3±0.54	67.6±0.43	*	64.8±1.03	71.8±0.68	***	**
Thigh ratio, %	40.0±0.33	40.1±0.33	NS	39.4±0.30	39.9±0.34	NS	41.4±0.41	39.9±0.27	*	NS
Breast ratio, %	37.0±0.37	35.6±0.53	*	37.3±0.50	36.4±0.37	NS	35.7±0.55	37.3±0.56	NS	NS
Wings ratio, %	9.80±0.19	10.2±0.24	NS	9.67±0.15	9.85±0.11	NS	10.1±0.10	9.98±0.21	NS	NS
Back and neck ratio, %	13.2±0.22	13.1±0.34	NS	13.5±0.20	13.8±0.25	NS	12.8±0.25	13.8±0.26	NS	NS
Abdominal fat ratio, %	1.52±0.09	1.62±0.10	NS	1.67±0.08	1.48±0.09	NS	1.57±0.06	1.57±0.09	NS	NS
Liver ratio, %	1.77±0.03	1.84±0.07	NS	1.89±0.02	1.79±0.02	*	1.82±0.06	1.97±0.04	NS	NS
Heart ratio, %	0.433±0.01	0.418±0.01	NS	0.411±0.00	0.460±0.01	*	0.490±0.01	0.492±0.01	NS	NS
Spleen ratio, %	0.092±0.00	0.113±0.00	NS	0.095±0.00	0.098±0.00	NS	0.120±0.01	0.100±0.00	NS	NS

CH: *Cage housing;* ***FH:*** *Floor housing;* ***P:*** *Statistical significance; Mean ± SEM.;* ***NS:*** *Not statistically significant; * P≤0.05; ** P≤.0.01; *** P≤0.001; Weights of hot carcass, liver, heart, spleen and abdominal fat were proportioned to slaughter weight; Weights of thigh, breast, wings, back and neck were proportioned to carcass weight*

Table 4. *Lipid peroxidation and antioxidant activity of broilers reared in cage and floor housing systems*
Tablo 4. *Kafes ve yer sistemlerinde yetiştirilen etlik piliçlerin lipit peroksidasyonu ve antioksidan aktivitesi*

Oxidative stress parameters	Summer			Autumn			Winter			Total Effect of Housing Systems (P_t)
	CH	FH	P	CH	FH	P	CH	FH	P	
Malondialdehyde (MDA), nmol/ml	1.60±0.12	1.32±0.08	*	1.99±0.06	1.74±0.04	NS	2.33±0.16	1.92±0.09	***	**
Glutathione (GSH), mmol/g Hb	2.64±0.19	3.51±0.24	*	4.34±0.16	3.06±0.13	*	3.61±0.23	3.16±0.16	NS	NS
Catalaz (CAT), k/g Hb	5.90±0.66	2.34±0.33	**	7.10±1.38	7.42±1.52	NS	6.57±0.91	5.13±1.28	NS	NS
Glutathione peroxidase (GSH-Px), U/g Hb	26.7±0.69	21.6±0.78	*	43.8±2.98	52.4±3.11	NS	42.0±2.45	41.9±4.61	NS	NS

CH: *Cage housing;* ***FH:*** *Floor housing;* ***P:*** *Statistical significance Mean ± SEM.;* ***NS:*** *Not statistically significant; * P≤0.05; ** P≤.0.01; *** P≤0.001*

Table 5. *Carcass defects and food pad burns of broilers reared in cage and floor housing systems*
Tablo 5. *Kafes ve yer sistemlerinde yetiştirilen etlik piliçlerde karkas kusurları ve taban lezyonları*

Carcass defects	Summer			Autumn			Winter			Total Effect of Housing Systems (P_t)
	CH	FH	P	CH	FH	P	CH	FH	P	
Wings bruising	16.2±1.12	11.0±1.04	*	16.9±1.64	13.2±0.92	NS	15.6±1.08	8.63±0.85	***	***
Wing fractures	10.5±2.06	8.50±1.82	NS	8.68±0.49	4.80±0.69	**	16.4±1.41	10.5±1.13	**	*
Shank and drumstick bruising	3.83±0.75	3.60±0.64	NS	4.20±0.69	5.30±0.84	**	2.33±0.20	4.18±0.52	NS	NS
Breast bruising	2.83±0.52	1.10±0.10	*	4.12±0.35	2.32±0.91	NS	1.20±0.00	1.18±0.14	NS	***
Food pad burns										
No lesion	42.6±6.33	27.3±8.38	NS	41.3±3.00	30.3±3.75	**	46.1±3.64	23.1±3.27	*	***
Level 1	30.2±3.64	22.8±9.07	NS	37.5±2.95	24.9±6.04	NS	38.6±3.19	35.3±3.73	NS	*
Level 2	20.7±1.42	33.9±3.25	NS	19.5±1.36	29.5±4.09	*	13.9±1.29	32.7±10.12	*	**
Level 3	6.56±1.66	16.5±6.05	NS	1.72±0.57	15.3±2.83	*	1.37±0.43	8.83±2.27	*	**

CH: *Cage housing;* ***FH:*** *Floor housing;* ***P:*** *Statistical significance Mean ± SEM.;* ***NS:*** *Not statistically significant; * P≤0.05; ** P≤.0.01; *** P≤0.001;* ***Level 1:*** *Mild lesion;* ***2:*** *Moderate lesion;* ***3:*** *High-intensity lesion* efficiency [24,25]. Feed consumption and mortality rates were found to be similar between the groups and this finding suggested another factor for affecting feed efficiency; feed waste. Perforated structure of cage ground leads to spillage of food to manure belt and spilled food cannot be reached by chickens. However, at floor system, spilled food can be consumed again and utilized by chickens. At the same time, rush to food after dark schedule increased the food wastage at cage housing and mortality due to sudden death syndrome. In addition, Santos et al.[26] revealed that broilers reared on litter had a better FCR than those raised in cages (1.71 vs. 1.81 g/g) due to larger the jejunum villus area, mucosal depth and heavier relative gizzard weights, whereas the small intestine was lighter and shorter. In another research, Santos et al.[27] reported that although broiler reared on litter floors showed greater 14 day *Salmonella* colonization than cage reared broiler, their digestion capacity appeared superior than cage reared broiler, and they had fewer undigested feed particles in their distal small intestine which correlates with enhanced growth performance and breast meat yield. Fouad et al.[28] mentioned that floor reared broilers had significantly heavier final body weight, body weight gain, better FCR and lower mortalities throughout the whole rearing period (0-6 weeks). Lacin et al.[9] found higher body weight in floor group than cage without any effect on FCR and carcass traits. Aslam Athar et al.[5] emphasized significant increase in performance of broiler at cage housing systems. However, Bahreiny et al.[29] found no significant difference between cage and floor systems in terms of live weight, feed intake and FCR.

Broiler weights in each system and each season were equalized before slaughter in order to compare results between the groups. Groups were found to be similar in terms of proportional values of parts of carcasses and proportional values of lymphoid organs. The superiority of carcass yield might be associated with better welfare status of broilers reared at floor. Significantly lower serum MDA levels in broiler reared at floor as compared with the caged ones supported this idea. Higher serum MDA levels in caged birds would account for higher stress in these birds as compared with the floor housing. Reactive oxygen species (free radicals) are natural products of cell oxygen metabolism. However, depending on environmental stress, these metabolites increase rapidly in cell. Increased metabolites damage cell structure. This condition is defined as oxidative stress [30,31]. MDA is end product of lipid peroxidation in cell and an important indicator of stress [32]. Due to the increase in the level of MDA values in cage housing, it can be said that chickens were stressed. This parameter can also be associated with worsening feed efficiency and carcass yield in cage reared broiler chickens in the present study. In another study [33], performance and carcass quality of broiler chickens grown under chronic stress were found to be significantly impaired since the increase in synthesis of corticosterone impairing protein synthesis. Sogunle et al.[7] referred that dressing percentage and breast weight were higher in the floor housing than cage housing while Bahreiny et al.[29] and Lacin et al.[9] did not find any difference between groups in carcass yield and parts. Antioxidant metabolism was found to be similar in terms of both groups.

High carcass defects in cage reared broilers could be associated with fall of broiler chickens onto conveyor belts during transport to slaughter and wing flapping on this line during progress. Weak bone structure might be another affecting factor in cases of wing fractures in cage reared broiler [8,34]. Numerical superiority of shank and drumstick bruising in floor housing were associated with capturing of chickens from feet during transport to slaughter (P=0.07). Formation of ammonia burns on foot pad at cage housing was observed to be intensive at level 1. However, deeper and wider lesions were detected at foot pad of chickens in floor housing. Higher level lesions such as level 2 and level 3 in floor housing were related with litter management. The other studies showed that poor litter management caused the higher incidence of foot pad lesions at broiler chickens [35,36]. Incidence and severity of these lesions dropped at cage housing, because litter was not used in this system. However, lack of activity and structural feature of ground and manure that not filtered along cage ground especially in later ages were found to be related with etiology of foot lesions in broiler chickens reared in cage housing.

In conclusion, in spite of increasing automation with subsequently developing technology in cage housing, broiler chickens reared in floor housing showed better performance. Although it is possible to grow more chickens with multi-storey cage housing, cost of cages in this housing system and mending costs are very high. Placing of the chicks from hatcheries to the system and collecting of the dead during production increase the labor cost. Higher mortality rate towards the end of production period leads to early delivery of chicks to slaughter. It might be possible that activity in caged birds was limited by cage conditions and birds were not able to express their natural behavior resulting in increased stress and reduced welfare in birds. However, dust problem in poultry house and litter problems are dissolved in this system. These important considerations should be carefully taken into account in future decisions regarding the expansion of cage system for broiler production.

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