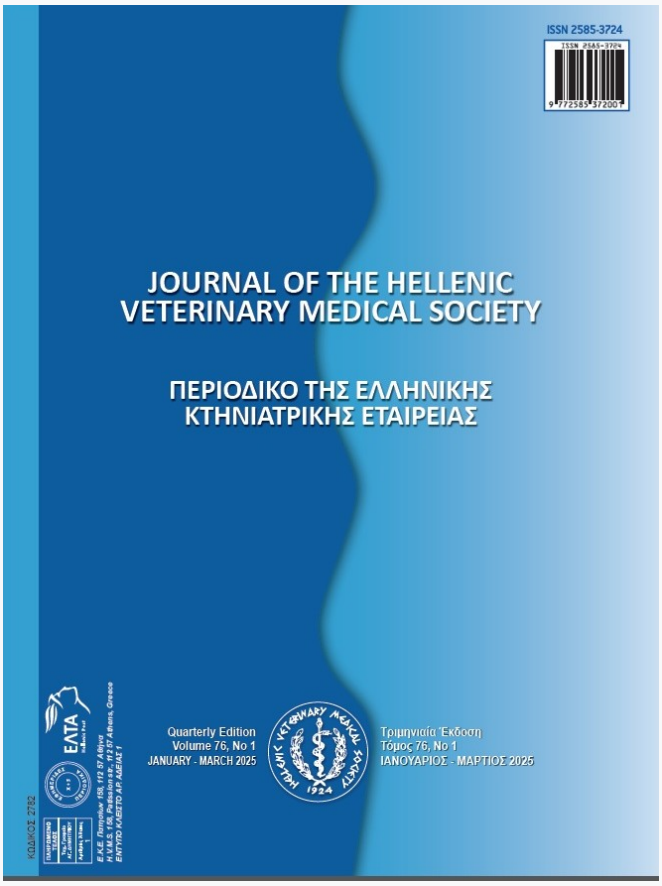
Journal of the Hellenic Veterinary Medical Society

Vol 76, No 1 (2025)



Comparison of cage versus floor rearing systems on broiler performance, welfare and behavioral parameters

B Yilmaz Dikmen, M Gündüz

doi: 10.12681/jhvms.35239

To cite this article:

Yilmaz Dikmen, B., & Gündüz, M. (2025). Comparison of cage versus floor rearing systems on broiler performance, welfare and behavioral parameters. *Journal of the Hellenic Veterinary Medical Society*, *76*(1), 8563–8574. https://doi.org/10.12681/jhvms.35239

J HELLENIC VET MED SOC 2025, 76 (1): 8563-8574
ΠΕΚΕ 2025, 76 (1): 8563-8574

Research article
Ερευνητικό άρθρο

Comparison of cage versus floor rearing systems on broiler performance, welfare and behavioral parameters

B. Yılmaz Dikmen*, M. Gündüz

Department of Animal Science, Faculty of Agriculture, Bursa Uludağ University, 16059, Bursa, Türkiye

ABSTRACT: This study was carried out to determine the effects of the floor type (litter rearing and sledge cage system) on the performance, welfare, and behavior parameters of broilers. A total of 240 one-day-old Ross 308 male broilers were reared in two different rearing systems; sledge cage system (CS) and litter floor system (FS) until 42 days of age. The final body weight and body weight gain between 1-42 days of age tended to be higher in FS than in the CS system (P=0.060). The cumulative feed consumption was similar between the rearing systems at 1-21, 1-28, 1-35, and 1-42 days of age periods (P>0.05). The feed conversion ratio was lower in FS than in the CS system (P<0.01). The productivity index was higher in FS than CS system at 1-42 days of age period (P<0.01). The plumage cleanliness score was higher and foot pad dermatitis was lower in FS than in CS (P<0.05 and P<0.001). The gait score was found similar in both rearing systems but a numerically lower gait problem was found in FS than CS system (P>0.05). The tonic immobility duration and induction number were found similar in both rearing systems (P>0.05). The higher eating, scratching, wing clap-body shaking, spot pecking; and lesser sleeping behavior were observed in FS than in CS (P<0.05, P<0.01, P<0.05, P<0.01 and P<0.01; respectively). The drinking, walking, standing, and sitting behavior of broilers were found similar in both rearing systems (P>0.05). The wing-leg stretching, feather maintenance, and pecking each other behavior of broilers were found similar in both rearing systems (P>0.05). The aggressive pecking behavior tended to be observed more in FS than in the CS system (P=0.062). It has been determined that broilers had better performance, welfare, and behavior parameters in the floor-rearing system when the litter condition is good.

***Keywords*:** Behavior; Broiler; Performance; Rearing systems; Welfare

Corresponding Author:
B. Yılmaz Dikmen, Department of Animal Science, Faculty of Agriculture, Bursa Uludağ University, 16059, Görükle, Bursa, Türkiye
E-mail address: bilgehan@uludag.edu.tr

Date of initial submission: 14-08-2023
Date of acceptance: 23-01-2024

INTRODUCTION

Broiler farming is a widespread poultry production area that is developing rapidly with the adaptation of technological knowledge and selective breeding around the world (Fortomaris et al., 2007; Sogunle et al., 2008; El-Deek and El-Sabrout, 2019). Broiler production is an advantageous and profitable animal production method because of the short production period, and low labor requirements. Broiler meat has both industrial and commercial importance, and also it has an important place in the nutrition of the growing human population (Rudra et al., 2018; Azeez and Akbay, 2021).

In modern animal production systems, increased productivity has a detrimental effect on animal well-being (Clark et al., 2016). Appropriate housing arrangements that prioritize the welfare of the animals lead to improved behavior patterns and increased productivity (El-Deek and El-Sabrout, 2019). Commercial broiler production is mostly carried out in controlled poultry houses on the ground with deep litter (Van Horne and Achterbosch, 2007). The physical activities of birds have changed as a result of genetic selection for rapid growth in broilers, especially in terms of behavior (Schütz and Jensen, 2001) and due to their heavy bodies, six-week-old broilers spend most of their time lying on the ground. Poor litter conditions or unsuitable litter materials result in dermatitis, oedemas on the breast, burns on the knees, and lesions on the foot as a result of bird inactivity in broilers (Haslam et al., 2006; Buijs et al., 2009). In particular, foot lesions are a major concern in broiler production, as animals whose walking activities are affected, have difficulty accessing food and water, ultimately affecting bird welfare and their product quality (Michel et al., 2012; Haslam et al., 2007).

Today, after the pandemic, the worldwide economic crisis dictates that the energy and production costs must be cheaper in poultry production, as in many other fields. The low energy costs are of great importance for operating profitability and sustainability in many developing countries. The use of cages in broiler breeding started to reduce the cost and economic pressure on producers (Prabakaran, 2003; Shields and Greger, 2013). Cage broiler production is carried out in China, Russia, India, the Middle East, Africa, Eastern Europe, and many Asian countries (Shields and Greger, 2013). Multilayer cage systems have become prevalent in intensive farming, effectively preventing broilers from coming into close touch with their droppings, conserving resources, and allowing automated control (Yan et al., 2021). Thus, some researchers reported that the intestinal bacterial load in cage systems is less than in floor systems (Willis et al., 2002). The injuries such as; dislocations, ruptured liver, trauma, wounds, scratches, and bruises occur on broilers before slaughter in houses during catching, handling, and putting to transport boxes (Cockram and Dulal, 2018). Related that in automatic broiler cage systems, at the end of the production period, the drawers/sledges on the floor of each cage floor are opened and the birds are dropped on the manure belt and sent to the carriers (Shields and Greger, 2013), this reduces the stress of catching and problems caused by catching confusion. While a lot of work has been done on the welfare of cage-raised layers, less emphasis has been placed on the welfare of cage-raised broilers (Zulkifli et al., 2021).

Foot lesions in turkeys are associated with impaired gait as well as discomfort and pain (Weber Wyneken et al., 2015). There is ample evidence from research on the reliability and advantages of behavior as an indicator of welfare (Broom and Johnson, 2000). The rearing systems have a significant impact on avian comfort, welfare, behavior, and productivity (Willis et al., 2002; Sans et al., 2021; Zulkifli et al., 2021). In practice, behavioral measurements are frequently the place to start when evaluating an animal's reaction to its surroundings and, consequently, its welfare. Especially, understanding why birds behave in certain ways in intensive production systems can help with welfare assessments (Dawkins, 2003; Jhetam et al., 2022).

Numerous research assessed the impact of various rearing methods on the productivity of broilers (Thamilvanan et al., 2001; Fouad et al. 2008; Santos et al., 2012; Wang et al., 2015). However, several studies that investigated the welfare and behavior of broilers raised in sledge cage systems are quite limited (Fortomaris et al., 2007; El-Kazaz, 2018; Abdel-Azeem et al., 2020). This study, it was aimed to determine the effects of the floor with litter rearing system and sledge cage system on the performance, welfare, and behavior of broilers.

MATERIALS AND METHODS

This study was carried out in Bursa Uludağ University Faculty of Agriculture Research and Application Unit. In the study, two different rearing systems; sledge cage system (CS) and litter floor system (FS), were used. A total of 240 one-day-old Ross 308 wing

feather sexed male broilers were used in a completely randomized design a 2×4 factorial arrangement of treatments, with 4 replicates in each treatment. In each replicate for CS and FS, there were 30 birds. Practices regarding the care and use of animals for research purposes were in accordance with the laws and regulations of Turkey and approved by the Animal Use and Ethical Committee of Uludağ University (Approval Number 2022-08/01).

Management

All Ross 308 male chicks were weighed with ± 0.01 g a digital scale and randomly placed into cages or pens of rearing systems, with 30 chicks in each group on the initial day of study. During the study, similar standard broiler care management procedures were used in both rearing systems (Aviagen, 2018). A standard broiler starter diet was used for 1 to 10 d (23% CP and 3000 ME kcal/kg), a grower diet was used for 11 to 25 d (21% CP and 3100 ME kcal/kg), then a finisher diet was used for 26 to 42 d (19% CP and 3200 ME kcal/kg). The diets were formulated according to National Research Council specifications (NRC, 1994). Feed and water were offered ad libitum to all birds. The photoperiod was applied for the first four days 24L:0D, then 18L:6D until the end of the study. A standard broiler vaccination program applied Newcastle+Infectious Bronchitis (ND+IB, Intervet International, Holland) at 10 day, Gumboro (Intervet International, Holland) at 15, and Newcastle (ND, Intervet International, Holland) at 21 day of age applied.

The sledge cage system (CS) consisted of two tiers, and each tier consisted of two cage units (4 cages). The cage unit dimensions were 240 × 150 cm and 0.5 m in height. Each cage unit provided a total of 3.6 m^2/ unit/30 bird floor area. A floor area of 1200 cm^2 was provided per bird in each cage unit. A cage unit consisted of 8 nipple drinkers and 2 round feeders. The cage system had a manure belt and plastic mesh floor. A floor-rearing system (FS) dimensions parallel to the CS system. The FS consisted of four same-sized floor units. As a litter 8-10 cm high wood shaving was used in each floor unit. Similar feeding and drinker area provided to birds in both rearing systems.

Performance parameters

All birds were weighed individually with ± 0.01 g, a digital scale on a weekly basis. The mortality was recorded daily. Feed consumption was recorded weekly. According to the data weekly body weight gain, feed consumption, feed conversion ratio (FCR), and cumulative feed consumption were calculated. Productivity index value was calculated by using the followingformula:

*Productivity Index = (Body weight/ (FCR *age, d)) * (100-mortality ratio) *100*

Welfare parameters

A total of 80 broilers were used for welfare traits. Ten broilers from each group were randomly selected at 6 weeks of age for welfare parameters (n=10). Scoring of welfare parameters was performed by the same person. The welfare parameters were based on the externally visible characteristics of the birds. The body feather condition, plumage cleanliness, body wound, hock burn (HB), and footpad dermatitis (FPD) scoring according to Welfare Quality (2009). The body feather condition was scored in 4 categories; 4: represented no feather damage; 1: represented severe feather damage. For the plumage cleanliness score, the dirt condition of the feathers on the breast area was scored in 4 categories; 0: clean; 1: slightly yellowing stained; 2: brownish large dirt; 3: body breast area is completely dirty. The body wound lesions were scored in 3 categories; 0: no lesions on the body and 2: severe body damage. The HB lesions were scored in 5 categories; 0: no inflammation, 1: initial stage, 2: moderate inflammation, 3: crusting, dark-colored inflammation, and 4: advanced and widespread inflammation. The FPD lesions were scored in 5 categories; 0: no lesion; 1: very small superficial lesion; 2: mild lesion, very small superficial lesions; 3: footpad discoloration, superficial lesions, dark papillae; 4: severe lesion; ulcers or crusting, signs of bleeding or swelling.

A total of 80 broilers were used for lameness (gait score; GS). Ten birds from each group that were not used in the measurement of FPD and HB were randomly selected and observed for gait scoring. The GS of the broilers was evaluated individually according to (Welfare Quality, 2009; Costa et al., 2014) by creating a walking corridor with a portable wire fence in the poultry house. The GS was scored in 6 categories; 0: Normal walk; 1: Slightly irregular gait but no abnormality; 2: Irregular gait; slightly unsteady movement of the body; 3: Significant walking problem and limping; 4: Gait is severely affected; moves slowly and has obvious difficulty walking, limping, can take few steps; 5: Severe difficulties in walking and standing and inability to walk.

A total of 40 broilers (5 broilers per group) were

tested individually for tonic immobility (TI) reaction at 6 wk of age. To measure the duration of TI, broilers were caught randomly and carried into a separate place. A few seconds after the broilers were caught, a TI test was induced according to Ghareeb et al. (2014). For the TI test, birds were placed on their back on a cloth-covered table, and their head and abdomen were pressed for 15 seconds. It was thought that TI was achieved in birds that did not turn to their right side within 10 seconds after being released, and the TI time was recorded by the observer standing approximately 1 m away from the bird. If the TI could not be induced after 5 repeated interventions, the bird was considered susceptible and scored 0. The test period was limited to a maximum of 10 minutes, and the TI time was evaluated as 600 seconds in birds that could not turn to their right side at the end of this period. In addition, the induction number was determined for each individual.

Behavioral Parameters

Behavioral parameters of the broilers at the 4^{th} and 6^{th} weeks of age were observed by scan sampling method in 3 periods (9:00-10:00 in the morning, 13:00-14:00 in the afternoon and 17:00-18:00 in the evening) (Lehner, 1992). The same cage and floor system groups were observed for 3 consecutive days at each age period. Before starting the measurements, the observer dressed in a white dress sat in front of the unit for 10 minutes and the chickens were adapted to the human presence. Each observation was made for 1 minute every 10 minutes. (n=6/hour). During the observation, the number of birds showed eating, drinking, sitting, walking, standing, sleeping, scratching, leg-wing stretching, feather maintenance, wing flap-body shake, spot pecking (ground and objects), pecking (each other), and aggressive pecking were recorded as behavioral parameters (Fortomaris et al., 2007).

Statistical Analyses

The study was conducted on a completely randomized design and performance data was analyzed by analysis of variance using General Linear Models (Minitab, 2013). Differences in performance and welfare parameters according to the type of rearing systems were analyzed by two sample T-test.

The behavioral data was analyzed with using PROC GLIMMIX procedure of SAS Statistical analysis program (SAS, 2020; Gebhardt-Henrich et al., 2021). The model included the fixed effects of the system (cage and floor), age (4^{th} and 6^{th} week), and replicate (1-4) (May et al., 2022).

The mortality ratio was analyzed using chi-square tests (Minitab, 2013). Data were presented as mean ± standard error (SE) in all the tables. Differences were considered significant at $P \leq 0.05$ and the statistical difference at $P < 0.10$ was described as a tendency.

RESULTS

Performance parameters

The effect of the rearing system on broiler performance parameters are presented in Table 1. The body weight was found similar between the rearing systems at the initial day, 14, 28, and 35 days of age ($P>0.05$). The effect of the rearing system on body weight was found significant at 7 and 21 days of age ($P<0.05$), and it tended to be significant at 42 days of age ($P=0.060$). A higher body weight was found in FS than CS system at 7 and 21 days of age, and final body weight tended to be higher in FS than CS system. The effect of the rearing system on body weight gain was found significant between 1-7, 14-21, and 35-42 days of age ($P<0.05$, $P<0.05$, and $P<0.01$; respectively). The higher body weight gain was found in FS than CS system between 1-7, 14-21, and 35-42 days of age. The effect of the rearing system on body weight gain between 1-42 days of age tended to be higher in FS than CS system ($P=0.060$).

The feed consumption in the FS rearing group tended to be higher than in the CS group at 1-7 and 7-14 days of age period ($P=0.062$ and $P=0.087$, respectively). However, feed consumption was similar between the rearing systems at 14-21, 21-28, 28-35, and 35-42 days of age periods ($P>0.05$). The cumulative feed consumption in the FS group tended to be higher than in the CS group at 1-7 and 1-14 days of age period ($P=0.062$ and $P<0.05$, respectively). However, cumulative feed consumption was similar between the rearing systems at 1-21, 1-28, 1-35, and 1-42 days of age periods ($P>0.05$). The effect of the rearing system on FCR was not significant between the 1-7, 1-14, 1-21, 1-28, and 1-35 days of age period ($P>0.05$). However, the effect of the rearing system on FCR was found significant at 1- 42 days of age period, and FCR which was lower in FS compared to the CS system ($P<0.01$). The effect of the rearing system on the productivity index was found significant and the productivity index was higher in FS than in CS ($P<0.01$). The mortality ratio was found similar between the rearing systems during to study ($P>0.05$) (Table 1).

Table 1. Effects of rearing system on broilers performance

Variables	Rearing Systems	Age (day)						
		1	**7**	**14**	**21**	**28**	**35**	**42**
Body weight, (g/bird)	CS	44.07 ± 0.70	158.5 ± 5.10^{b}	459.8 ± 6.17	870.2 ± 25.7^{b}	1549.8 ± 65.9	2238 ± 148	2755 ± 189
	FS	44.38 ± 0.55	168.6 ± 7.34^{a}	468.8 ± 18.70	931.9 ± 59.9^{a}	1561.4 ± 89.8	2360 ± 131	3037 ± 149
P Value		NS	0.024	NS	0.034	NS	NS	0.060
		1 - 7	**7 - 14**	**14 - 21**	**21 - 28**	**28 -35**	**35 - 42**	**1-42**
Body weight gain, (g/bird)	CS	114.43 ± 5.30^{b}	301.3 ± 1.70	410.4 ± 23.7^{b}	679.5 ± 40.3	688.0 ± 103	517.0 ± 47.6^{b}	2711 ± 190
	FS	124.25 ± 7.36^{a}	300.1 ± 12.1	463.1 ± 46.2^{a}	629.5 ± 33.0	798.4 ± 44.4	676.7 ± 47.2^{a}	2992 ± 148
P Value		0.030	NS	0.028	0.085	NS	0.002	0.060
		1 - 7	**7 - 14**	**14 - 21**	**21 - 28**	**28 -35**	**35 - 42**	
Feed consumption, (g/bird)	CS	116.02 ± 1.31	409.95 ± 9.40	590.9 ± 16.9	939.1 ± 49.6	1116.0 ± 83.2	1272 ± 107	
	FS	121.12 ± 6.39	425.0 ± 17.70	608.7 ± 48.1	912.2 ± 54.7	1189.8 ± 66.1	1328 ± 86.4	
P Value		0.062	0.087	NS	NS	NS	NS	
		1 - 7	**1 - 14**	**1 - 21**	**1 - 28**	**1-35**	**1 - 42**	
Cum Feed consumption, (g/bird)	CS	116.02 ± 1.31	525.97 ± 9.87^{b}	1116.87 ± 7.88	2055.9 ± 57.0	3172 ± 110	4444 ± 204	
	FS	121.12 ± 6.39	546.10 ± 18.6^{a}	1154.8 ± 59.8	2067.0 ± 87.2	3257 ± 130	4585 ± 186	
P Value		0.062	0.037	NS	NS	NS	NS	
		1 - 7	**1 - 14**	**1 - 21**	**1 - 28**	**1-35**	**1 - 42**	
Feed conversion ratio	CS	0.73 ± 0.03	1.14 ± 0.04	1.28 ± 0.03	1.33 ± 0.03	1.42 ± 0.05	1.62 ± 0.04^{a}	
	FS	0.72 ± 0.03	1.17 ± 0.06	1.24 ± 0.06	1.32 ± 0.05	1.38 ± 0.04	1.51 ± 0.04^{b}	
P Value		NS	NS	NS	NS	NS	0.004	

Productivity Index		42 day	Mortality, %	1-42 day
	CS	402.8 ± 30.0^{b}	Cage	0.83
	FS	477.1 ± 32.8^{a}	Floor	0.83
P Value		0.008	*P* Value	NS
			Chi-square	0.000

a,b: Values with different superscripts in the same column differ statistically ($P < 0.05$). NS: Not significant
CS: Cage rearing system, FS: Floor rearing system

Welfare parameters

The effects of the rearing system on the welfare parameters of broilers are presented in Table 2. The effect of the rearing system on body feather score was found not significant, and body feather score was found similar in both rearing systems (P>0.05). The effect of the rearing system on plumage cleanliness score was found significant, and it was higher in FS than in CS (P<0.01). The plumage was dirtier in FS than CS group. The effect of the rearing system on body wound, HB, and GS was found not significant, and body wound, HB, and GS were found similar in both rearing systems (P>0.05). The effect of the rearing system on FPD score was found significant, and there was less FPD in FS than in CS (P<0.001). The effect of the rearing system on TI duration and induction number were found not significant, they were found similar in both rearing systems. But numerically lower TI duration and induction number were found in FS than CS group (P>0.05).

Behavioral Parameters

The effects of the rearing system on the general behaviors of broilers are presented in Table 3. The effect of the rearing system on the eating and sleeping behavior of broilers was found significant, and higher eating and lesser sleeping behavior were observed in FS than in the CS system (P<0.05 and P<0.01; respectively). The effect of the rearing system on the drinking, walking, standing, and sitting behavior of broilers was found not significant, these behaviors of broilers were found similar in both rearing systems (P>0.05).

Also in the study, the effect of daytime on the general behaviors of broilers was found not significant (P>0.05); except for the eating and sleeping behaviors of broilers (P<0.001 and P=0.058; respectively). The higher eating behavior was observed in the morning and higher sleeping behavior was observed at noon and in the afternoon. In the study the effect of age on the general behaviors of broilers was found not signif-

icant (P>0.05); except for walking behavior (P<0.01), higher walking behavior was observed at 4th weeks of age (P<0.01) (Table 3).

The effect of the rearing system on the comfort behaviors of broilers is presented in Table 4. The scratching and wing clap-body shake behaviors of broilers were significantly different among rearing systems, and higher scratching and wing clap-body shake behavior were observed in FS than in the CS system (P<0.01 and P<0.05; respectively). The wing-leg stretching and feather maintenance behaviors of broilers were found similar in both rearing systems (P>0.05).

Table 2. Effects of rearing system on broilers welfare parameters

Feather score[1]	**CS**	**FS**	***P - Value***
Neck	4.00 ±0.00	4.00 ±0.00	*NS*
Breast	2.53 ± 0.55	2.33 ± 0.53	*NS*
Vent	2.98 ± 0.66	3.13 ± 0.76	*NS*
Back	4.00 ±0.00	4.00 ±0.00	*NS*
Wings	4.00 ±0.00	4.00 ±0.00	*NS*
Tail	4.00 ±0.00	4.00 ±0.00	*NS*
Total	21.50 ± 0.99	21.25 ± 1.41	*NS*
Mean	3.58 ± 0.17	3.54 ± 0.24	*NS*
Plumage Cleanliness[2]	1.38 ± 0.81[b]	1.88 ± 0.88[a]	*0.010*
Body wound[3]	0.58 ± 0.55	0.60 ± 0.50	*NS*
Hock burn[4]	1.30 ± 0.61	1.20 ± 0.52	*NS*
Footpad dermatitis[4]	2.60 ± 0.87[a]	0.95 ± 1.32[b]	*0.0001*
Gait score[5]	2.08 ± 1.47	1.70 ± 1.04	*NS*
Induction number	1.55 ± 0.76	1.35 ± 0.59	*NS*
Tonic immobility	205 ± 157	170 ± 126	*NS*

a,b: Values with different superscripts in the same column differ statistically ($P < 0.05$). NS: Not significant
CS: Cage rearing system, FS: Floor rearing system
[1]score for feather condition ranged from 1 to 4, with 4 signifying no damage and 1 signifying severe damage.
[2]score for plumage cleanliness ranged from 0 to 3, with 0 signifying clean and 3 signifying very dirty.
[3]score for body wounds ranged from 0 to 2, with 0 signifying no lesions on the body and 2 signifying severe damage.
[4]score for hock burn and footpad dermatitis ranged from 0 to 4, with 0 signifying no lesions and 4 representing severe lesions.
[5]score for gait ranged from 0 to 5, with 0 signifying normal walking and 5 representing incapable walking.

Table 3. Effects of rearing system on general behaviors of broilers (%) (mean ± SEM)

		General Behaviors					
		Eating	**Drinking**	**Walking**	**Standing**	**Sitting**	**Sleeping**
System	CS	26.28 ± 1.67[b]	11.25 ± 0.80	5.33 ± 0.81	0.33 ± 0.16	32.71 ± 2.65	27.94 ± 1.75[a]
	FS	33.99 ± 1.67[a]	11.32 ± 0.80	6.77 ± 0.81	0.56 ± 0.16	33.64 ± 2.65	18.27 ± 1.75[b]
P		0.011	NS	NS	NS	NS	0.003
Time	M	38.59 ± 2.14[a]	12.51 ± 1.08	6.62 ± 0.92	0.67 ± 0.20	32.49 ± 2.57	19.31 ± 2.13[b]
	N	26.00 ± 2.13[b]	10.42 ± 1.08	5.67 ± 0.92	0.25 ± 0.20	31.72 ± 2.58	23.00 ± 2.12[ab]
	A	28.83 ± 2.14[b]	10.93 ± 1.08	5.86 ± 0.92	0.42 ± 0.20	35.31 ± 2.57	27.01 ± 2.13[a]
		0.0001	NS	NS	NS	NS	0.058
Week	4th	31.16 ± 1.70	10.73 ± 0.81	7.94 ± 0.82[a]	0.50 ± 0.16	33.12 ± 2.70	20.83 ± 1.76
	6th	29.11 ± 1.70	11.84 ± 0.81	4.16 ± 0.82[b]	0.39 ± 0.16	33.24 ± 2.70	25.38 ± 1.76
P		*NS*	*NS*	0.009	*NS*	*NS*	*0.097*

a,b: Values with different superscripts in the same column differ statistically ($P < 0.05$). NS: Not significant
CS: Cage rearing system, FS: Floor rearing system
M: Morning, N: Noon, A: Afternoon

Also in the study, the effect of daytime on the comfort behaviors of broilers was found not significant (P>0.05); except for scratching and wing-leg stretching behaviors of broilers (P<0.05 and P<0.001; respectively). The higher scratching and wing-leg stretching behaviors were observed at noon and in the afternoon. The effect of age on the comfort behaviors of broilers was found not significant, the comfort behavior of broilers was found similar in both age periods (P>0.05) (Table 4).

The effect of the rearing system on the pecking behavior of broilers is presented in Table 5. The effect of the rearing system on spot-pecking behavior was found significant, and higher spot-pecking behavior was observed in the FS system (P<0.001). The effect of the rearing system on pecking each other behavior was found not significant, pecking each other behavior was found similar in both rearing systems (P>0.05). The effect of the rearing system on the aggressive pecking behavior of broilers tended to be significant, and numerically higher aggressive pecking behavior was observed in FS compared to the CS system (P=0.062).

Also in the study, the effect of daytime on the pecking behaviors of broilers was found not to be significant (P>0.05); except for aggressive pecking behaviors of broilers (P<0.05). The higher aggressive pecking behavior was observed in the morning. The pecking each other, and aggressive pecking behavior of broilers were found similar in both age periods (4^{th} vs 6^{th} week; P>0.05). However, the effect of age on the spot-pecking behavior of broilers tended to be significant, and numerically higher spot-pecking behavior was observed at 6^{th} week of age (P=0.061) (Table 5).

Table 4. Effects of rearing system on comfort behaviors of broilers (%) (mean ± SEM)

		Comfort Behaviors			
		Scratching	**Wing-leg Stretching**	**Feather maintenance**	**Wing clap body shake**
System	CS	0.34 ± 0.91^{b}	12.44 ± 0.88	16.56 ± 0.92	2.35 ± 0.33^{b}
	FS	4.54 ± 0.91^{a}	11.49 ± 0.88	18.22 ± 0.92	3.38 ± 0.33^{a}
P		0.009	NS	NS	0.047
Time	M	0.07 ± 1.12^{b}	6.83 ± 1.15^{b}	18.59 ± 1.36	2.83 ± 0.56
	N	4.33 ± 1.11^{a}	16.00 ± 1.15^{a}	18.67 ± 1.36	3.13 ± 0.55
	A	2.92 ± 1.12^{ab}	13.07 ± 1.15^{a}	14.91 ± 1.36	2.64 ± 0.55
		0.037	0.0001	NS	NS
Week	4^{th}	3.00 ± 0.92	11.83 ± 0.89	18.15 ± 0.93	2.93 ± 0.34
	6^{th}	1.88 ± 0.92	12.11 ± 0.89	16.63 ± 0.93	2.80 ± 0.34
P		NS	NS	NS	NS

a,b: Values with different superscripts in the same column differ statistically ($P < 0.05$). NS: Not significant
CS: Cage rearing system, FS: Floor rearing system
M: Morning, N: Noon, A: Afternoon

Table 5. Effects of rearing system on pecking behaviors of broilers (%) (mean ± SEM)

		Pecking Behaviors		
		Spot Pecking	**Pecking each other**	**Aggressive pecking**
System	CS	3.48 ± 0.86^{b}	0.70 ± 0.31	0.23 ± 0.28
	FS	10.85 ± 0.86^{a}	0.35 ± 0.31	1.09 ± 0.28
P		0.001	NS	0.062
Time	M	6.42 ± 0.85	0.74 ± 0.29	1.42 ± 0.33^{a}
	N	7.18 ± 0.86	0.18 ± 0.29	0.41 ± 0.33^{b}
	A	7.90 ± 0.85	0.64 ± 0.29	0.14 ± 0.33^{b}
		NS	NS	0.024
Week	4^{th}	5.83 ± 0.87	0.92 ± 0.32	0.80 ± 0.29
	6^{th}	8.50 ± 0.87	0.13 ± 0.32	0.52 ± 0.29
P		0.061	NS	NS

a,b: Values with different superscripts in the same column differ statistically ($P < 0.05$). NS: Not significant
CS: Cage rearing system, FS: Floor rearing system
M: Morning, N: Noon, A: Afternoon

DISCUSSION

Performance parameters

There were no differences in the body weight of FS-reared broilers to CS-reared ones in middle and late age periods but, the final body weight of broilers' tended to be higher in FS compared to CS system. Thus, some authors reported that broilers reared on a floor system had higher body weight than those reared in a cage system (Tolon and Yalçın, 1997; Fouad et al., 2008; Yan et al., 2021; Zulkifli et al., 2021), with this, Fortomaris et al. (2007) reported that there were no differences for cobb 500 strain broilers' body weight at 28 and 35 days of age on different housing system (deep litter versus cage system). In general, body weight gain was found higher in the FS system than CS system also, body weight gain tended to be higher in the FS system between 1-42 days of age. In accordance with our results, some authors reported that broilers reared on a floor system had better weight gain than those reared in a cage system (Santos et al., 2012; Yan et al., 2021). However, some studies reported that there were no differences in body weight gain between broilers reared in floor systems and cage systems (Swain et al., 2002; Sogunle et al., 2008; Wang et al., 2015). Also, Abdel-Azeem et al. (2020) reported a higher body weight and body weight gain in the cage system than floor system at 35 days of age. The inconsistency of most of the findings in these studies with each other may be caused by many factors such as; genotype, slaughter age, cage system type, housing type, litter materials, density, and climatic environment in the housing.

There were no differences in feed consumption and cumulative feed consumption of FS-reared broilers to CS-reared ones in middle and late age periods. Similar to our results there was no difference in feed intake of broilers reared in cage or floor systems reported by several others (Swain et al., 2002; Fortomaris et al., 2007; Ebrahim et al., 2013; Wang et al., 2015; Abdel-Azeem et al., 2020). However, a higher feed intake in broilers reared on the floor system than in the cage system was also reported by (Fouad et al., 2008; Yan et al., 2021; Zulkifli et al., 2021). Sogunle et al. (2008) reported that higher feed intake for Anak titan strains of broilers reared in the cage than in the floor system. FCR was found better in FS-reared broilers than in CS-reared ones at 1- 42 days of age period. Similar to our results Sogunle et al. (2008) for Anak titan strains of broilers, and Santos et al. (2012) reported that broilers reared in floor system had better feed conversion ratio than those reared in cage system. However, caged broilers had a better feed conversion ratio than floor-reared ones reported by several authors (Abdel-Azeem et al., 2020; Zulkifli et al., 2021). And, there were no differences for cage and floor rearing systems on FCR in broilers reported by (Ebrahim et al., 2013; Wang et al., 2015; Yan et al., 2021).

There were no differences in the mortality ratio of FS-reared broilers to CS-reared ones. Similar to our results some researchers reported that there was no difference in the mortality ratio of broilers reared between floor systems and cage systems (Fouad et al., 2008; Sogunle et al., 2008; Wang et al., 2015; Yan et al., 2021; Zulkifli et al., 2021). In contrast to our findings, Thamilvanan et al. (2001) and Abdel-Azeem et al. (2020) reported that a higher survival rate was found in cage reared system when compared floor reared system.

Performance index is a metric parameter that indicates the rate of success rate of maintaining broiler chicken production output over time. This parameter is one of the criteria taken as a standard in broiler production (Farida et al., 2022). A higher productivity index was found in the FS system than CS system. Similar to our findings Santos et al. (2012) reported that floor reared system had better production efficiency than cage reared system. However, Abdel-Azeem et al. (2020) reported a higher European performance efficiency index in cage-reared systems than in floor-reared systems. As a matter of fact, in the current study, the slaughter age was determined as 42 days, but it is observed that there is a decrease in the movements due to the increased body weight and limited space in the cage system group as the age progresses, and accordingly, there is a decrease in the performance parameters. For this reason, it may be recommended to prioritize the early slaughter age for in cage production systems.

Welfare parameters

Caged broilers were frequently linked to welfare issues such as feather loss, low bone strength, and restrictions on normal behavior (Shields and Greger, 2013). In the study, there were no differences in body feather score and body wound score in both rearing systems. However, according to Edens et al. (1999), floor raised broilers had superior feather conditions than those raised in cages. And also Wang et al. (2021) reported that the feather quality of yellow

feather broilers was better in the floor system than in the cage system. The plumage cleanliness score was higher in the FS system and it was dirtier in the FS than CS group. This is due to the fact that the birds are in constant contact with manure and litter in the ground-rearing system.

Poor litter quality in floor pens may increase the incidence of pododermatitis and hock burn in broilers (Berg, 2004). In the production of broilers, hock burns and footpad dermatitis (FPD) are both significant welfare factors that cause pain (Shepherd and Fairchild, 2010; Bassler et al., 2013). There were no differences in HB scores in both rearing systems. However, the FPD score was lower in the FS than in the CS group. The FPD lesions were in the initial stages, thus, the score values were quite low (2.60 ± 0.87 in CS and 0.95 ± 1.32 in FS). As a matter of fact, footpad dermatitis manifests itself as small erosions and skin discoloration in the early stages, while in the advanced stages, it is seen as areas of inflammation and necrosis on the epidermis and dermis of the toes and foot (Micheal et al., 2012). Gait and skeletal abnormalities have been linked to inactivity (Thorp and Duff, 1988). Thus, according to Fouad et al. (2008), cage-raised broilers were more prone to gait issues, leg deformities, and reduced walking ability than floor-raised ones. The lameness - GS was found similar in both rearing systems, but a numerically lower gait problem was found in FS than in CS. Thus, these findings were also associated with good litter quality throughout the study. However, Wang et al. (2021) reported that rearing systems (floor versus cage) not affected gait scores of yellow feather broilers. The wire floors might be stressed or bother the caged broilers, which might lead to weaker legs (Fouad et al. 2008). However, according to Zulkifli et al. (2021) incidence of foot pad dermatitis on broilers was negatively impacted by the floor system.

According to Jones (1997), fear is a potent and harmful stressor as well as an unwelcome condition of suffering. The environment in which birds live can alter tonic immobility length as a measure of fear (Bilcik et al., 1998). Thus, Fouad et al. (2008) reported that broilers reared in cages were more afraid than those reared on floors. In the study, TI duration and induction number were found similar in both rearing systems; but numerically higher TI duration and induction number were found in CS than in FS. Similar to our findings Zulkifli et al. (2021) reported that there was no difference in TI duration of the broiler in both rearing systems but, the number of inductions was higher in the cage system than in the floor system. A higher tonic immobility duration is reasonable to assume that there is a higher level of stress in caged birds and thus lower welfare in poultry in caged systems. Thus, El-Kazaz (2018) reported that broilers showed a higher tonic immobility duration in the cage system than the floor system.

Behavioral parameters

The higher eating and aggressive pecking behaviors were observed in the morning. The higher sleeping, scratching, and wing-leg stretching behaviors were observed at noon and in the afternoon. In general, the birds show feeding activity and related locomotor activity behaviors in the cool hours of the morning, and in the hot hours of noon, and later they are busy with maintenance, resting, and comfort behaviors.

The higher walking behavior was observed at 4th week of age. Similar to our results Fortomaris et al. (2007) reported that walking decreased with age in broilers. The eating, drinking, standing, sitting, sleeping, comfort behaviors, and pecking behaviors of broilers were found similar in both age periods. In broilers, increasing body weight with age resulted in a decrease in locomotor activity.

Environmental and husbandry circumstances have been discovered to be extremely crucial aspects of chicken production since they directly affect chicken behavior (El-Deek and El-Sabrout, 2019). The higher eating behavior was observed in FS than in CS. Similar to our findings Fouad et al. (2008) and El-Kazaz (2018) reported that higher feeding behavior was observed in the floor system than cage system in broilers. There were no differences in the drinking, walking, standing, and sitting behavior of broilers in rearing systems. Similar to our results Fortomaris et al. (2007) reported that there were no differences in walking and immobility (sitting, lying, or sleeping) behaviors of broilers reared in deep litter and cage housing systems. However, El-Kazaz (2018) reported that higher drinking, walking, and crouching behaviors were observed in the floor system than cage system. Also; contrary to our findings, Sosnowka-Czajka and Muchacka (2005) reported that cage-reared broilers were less lying than floor-reared broilers, and Fouad et al. (2008) reported that standing and drinking behaviors more often in cage-reared broilers than floor reared ones. Birds housed in cages generally ex-

hibit inferior behavioral patterns since they are unable to move around due to the tiny surface area available and the low height of the cages (Hansen, 1994). Thus, compared to floor-reared broilers, caged broilers showed more sleeping behavior. We hypothesized that caged broilers did not have a chance to walk or stand on the wide-area due to limited cage space and they spent most of their time lying and sleeping. In fact, this behavioral situation of caged birds may also indicate that they were in a stressful environment.

Tolon and Yalçın (1997) reported that the differences in the wing bones of broilers to the inability of birds to perform normal wing-related behaviors such as flapping their wings in the cage environment. Thus, higher wing clap-body shake behavior was observed in FS than in CS. The higher scratching behavior was observed in FS than in CS. Raising the birds in cages may prevent them from showing their natural behaviors such as scratching and dust bathing (Shields and Greger, 2013). However, during to study another comfort behavior of dust bathing behavior was not observed in both rearing systems.

There were no differences in wing-leg stretching and feather maintenance behavior of broilers in rearing systems. Contrary to our findings, El-Kazaz (2018) reported that higher wing stretch, leg stretch, and wing & leg stretch behavior were observed in the cage system than floor system. Fortomaris et al. (2007) reported that a higher preening behavior was observed in the deep litter system than cage system.

Fouad et al. (2008) reported that higher pecking behavior was seen in floor-reared broilers than cage cage-reared ones. Compared to caged broilers, floor-reared broilers exhibited more spot-pecking behavior. There were no differences in pecking each other and aggressive pecking behavior of broilers in rearing systems. But, numerically higher aggressive pecking behavior was observed in FS than in CS. Fortomaris et al. (2007) reported that there were no differences in the pecking behaviors of broilers in different housing systems (deep litter versus cage system), but they also reported that aggressive behavior was higher in broilers reared in deep litter than cage-reared ones.

CONCLUSIONS

Companies that produce cage systems for broilers claim to have generally overcome problems with leg and carcass defects. However, our study has demonstrated that the floor-rearing system appeared to be more beneficial for body weight gain, feed conversion ratio, incidence of foot lesions, and locomotor activity in broilers. Raising broilers on floor systems improves broilers' performance and welfare compared to caged broilers.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abdel-Azeem F, Al-Gamal MA, Abd El-Halim HAH, El-Deen AS (2020) Effect of two housing systems on productive performance and some physiological traits of broiler chickens reared in enclosed houses. Egypt J of Appl Sci 35(1):1-12.

Aviagen (2018) Ross broiler management hand book. https://aviagen.com/assets/Tech_Center/Ross_Broiler/Ross-BroilerHandbook2018-EN.pdf [accessed 14 July 2023].

Azeez JA, Akbay C (2021) An economic analysis of broiler chicken production for different production rotations in the northern region of Iraq. TEAD 7(2): 76-89.

Bassler AW, Arnould C, Butterworth A, Colin L, De Jong IC, Ferrante V (2013) Potential risk factors associated with contact dermatitis, lameness, negative emotional state, and fear of humans in broiler chicken flocks. Poult Sci 92:2811-2826.

Berg CC (2004) Pododermatitis and hock burn in broiler chickens. In: Measuring and auditing broiler welfare. Weeks CA, Butterworth A(eds.), CABI Publishing CAB International, Wallingford, UK: pp 37-49.

Bilcik B, Keeling LJ, Newberry RC (1998) Effect of group size on tonic immobility in laying hens. Behav Proc 43: 53-59.

Buijs S, Van Poucke E, Tuyttens FAM, Keeling L, Rettenbacher S (2009) Stocking density effects on broiler welfare: Identifying sensitive ranges for different indicators. Poult Sci 88:1536-1543.

Broom DM, Johnson KG (2000) Stress and animal welfare. Springer/Kluwer Scientific & Business Media, Dordrecht, Netherlands, pp.211.

Clark B, Stewart GB, Panzone LA, Kyriazakis I, Frewer LJ (2016) A systematic review of public attitudes, perceptions and behaviours towards production diseases associated with farm animal welfare. J Agric Environ Ethics 29: 455-478.

Cockram MS, Dulal KJ (2018) Injury and mortality in broilers during handling and transport to slaughter. Can J Anim Sci 98(3):416-432.

Costa MJ Da, Grimes JL, Oviedo-Rondón JO, Barasch I, Evans C, Dalmagro M, Nixon J (2014) Footpad dermatitis severity on turkey flocks and correlations with locomotion, litter conditions, and body weight at market age. J Appl Poult Res 23:268-279.

Dawkins MS (2003) Behaviour as a tool in the assessment of animal welfare. Zool 106: 383-387.

Ebrahim B, Poorya D, Malihe M, Mohamad B (2013) Effect of different level of energy to protein ratio and breeding system on performance and carcass characteristics of male and female broilers. Int J Agric Res Rev 3:597-607.

Edens FW, Parkhurst CR, Havenstein GB (1999) The effects of conventional versus cage housing and inorganic versus organic selenium on feathering in broilers. In: Proceedings of Alltechs 15th annual symposium, Biotechnology in the Feed Industry, Under the Microscope-Focal Points for the New Millennium); Nottingham University Press, Nottingham, UK: 567-577.

El-Deek A, El-Sabrout K (2019) Behaviour and meat quality of chicken under different housing systems. World's Poult Sci J 75(1):105-114.

El-Kazaz SE (2018) Evaluation of behavior and welfare in broilers reared in two different housing systems. Assiut Vet Med J 64(157):94-98.

Farida TE, Hanafi ND, Tafsin M (2022) Comparative study of broiler chicken performance in closed house and conventional system in North Sumatera. In: Proocedings of the 5th international conference on agriculture, environment, and food security, IOP Conf. Series: Earth and Environmental Sci 977: 012138.

Fouad MA, Abdel Razek AH, Badawy EM (2008) Broilers welfare and economics under two management alternatives on commercial scale. Int J Poult Sci 7(12):1167-1173.

Fortomaris P, Arsenos G, Tserveni- Gousi A, Yannakopoulos A (2007) Performance and behaviour of broiler chickens as affected by the housing system. Arch Geflügelk 71(3):97-104.

Gebhardt-Henrich SG, Stratmann A, Dawkins MS (2021) Groups and individuals: optical flow patterns of broiler chicken flocks are correlated with the behavior of individual birds. Animals 11: 568.

Ghareeb K, Awad WA, Sid-Ahmed OE, Bohm J (2014) Insights on the host stress fear and growth responses to the deoxynivalenol feed contaminant in broiler chickens. Plos One 9(1):E87727.

Hansen I (1994) Behavioral expression of laying hen in aviaries and cages: Frequencies, time budgets and facility utilization. Br Poult Sci 19:549-557.

Haslam SM, Brown SN, Wilkins L, Kestin SC, Warriss PD, Nicol CJ (2006) Preliminary study to examine the utility of using foot burn or hock burn to assess aspects of housing conditions for broiler chicken. Br Poult Sci 47:13-18.

Haslam SM, Knowles TG, Brown SN, Wilkins LJ, Kestin SC, Warriss PD, Nicol CJ (2007) Factors affecting the prevalence of foot pad dermatitis, hock burn and breast burn in broiler chicken. Brit Poult Sci 48(3):264-275.

Jhetam S, Buchynski K, Shynkaruk T, Schwean-Lardner K (2022) Evaluating the effects of stocking density on the behavior, health, and welfare of turkey hens to 11 weeks of age. Poult Sci 101:101956.

Jones RB (1997) Animal welfare: fear and distress. Wallingford (UK): CAB International.

Lehner PN (1992) Sampling methods in behaviours research. Poult Sci 71:643-649.

May F, Stracke J, Heitmann S, Adler C, Krasny, A, Kemper N, Spindler B (2022) Structuring broiler barns: how a perforated flooring system affects animal behavior. Animals; 12, 735.

Michel V, Prampart E, Mirabito L, Allain V, Arnould C, Huonnic D, Bouquin SL, Albaric O (2012) Histologically validated footpad dermatitis scoring system for use in chicken processing plants. Brit Poult Sci 53(3):275-81.

Minitab (2013) MINITAB release 17.1.0, Minitab Inc, USA.

Prabakaran R (2003) Good practices in planning and management of integrated commercial poultry production in South Asia. FAO Animal Production and Health Paper 159: 106.

Rudra PG, Hasan T, Rony AH, Adrian G, Debnath A, Islam F, Paul P (2018) Economic Profitability of Broiler Farm Comparing the Two Commercial Broiler Strain. Austin J Vet Sci & Anim Husb 5(2):1045.

Sans ECO, Tuyttens FAM, Taconeli CA, Rueda PM, Ciocca JR, Molento CFM (2021) Welfare of broiler chickens reared under two different types of housing. Anim Welf 30:341-353.

Santos FBO, Santos AA, Oviedo-Rondon EO, Ferket PR (2012) Influence of housing system on growth performance and intestinal health of salmonella-challenged broiler chickens. Curr Res Poult Sci 2:1-10.

SAS (2020) A user's guide to SAS software V9.4.M7. SAS Institute, Inc., Cary, NC.

Schütz KE, Jensen P (2001) Effects of resource allocation on behavioral strategies: a comparison of red junglefowl (*Gallus gallus*) and two domesticated breeds of poultry. Ethol 107:753-765.

Shepherd EM, Fairchild BD (2010) Footpad dermatitis in poultry. Poult Sci 89:2043-2051.

Shields S, Greger M (2013) Animal welfare and food safety aspects of confining broiler chickens to cages. Animals 3(2):386-400.

Sogunle OM, Egbeyale LT, Bajomo TT, Bamigboje OV, Fanimo AO (2008) Comparison of the performance, carcass characteristics and haematological parameters of broiler chicks reared in cage and floor. Pak J Biol Sci 11(3):480-483.

Sosnowka-Czajka E, Muchacka R (2005) Effect of management system on behaviour and productivity of broiler chickens. In: Proceedings of the 12th ISAH congress on Animal Hygiene, Warsaw, Animals and environment 2:106-110.

Swain BK, Sundaram RNS, Barbuddhe SB, Nirmale AV (2002) Influence of cage and deep litter rearing systems on the performance of broilers. Indian Vet J 79:467-469.

Thamilvanan T, Thiagarajan M, Ramesh V, Gnanaraj PT, Sivakumar T (2001) Performance of broiler chicken under cage and floor systems of management fed differently processed feeds. Indian J Anim Sci 71:985-988.

Thorp BH, Duff SRI (1988) Effect of exercise on the vascular pattern in the bone extremities of broiler fowl. Res Vet Sci 45:72-77.

Tolon B, Yalcin S (1997) Bone characteristics and body weight of broilers in different husbandry systems. Br Poult Sci 38:132-135.

Van Horne PLM, Achterbosch TJ (2007) Animal welfare in poultry production systems: Impact of European Union standards on world trade. World's Poult Sci J 64(1):40-52.

Wang Y, Ru YJ, Liu GH, Chang WH, Zhang S, Yan HJ, Zheng AJ, Lou RY, Liu ZY, Cai HY (2015) Effects of different rearing systems on growth performance, nutrients digestibility, digestive organ weight, carcass traits, and energy utilization in male broiler chickens. Livest Sci 176:135-140.

Wang L, Zhang Y, Kong L, Wang Z, Bai H, Jiang Y, Bi Y, Chang G, Chen G (2021) Effects of rearing system (floor vs. cage) and sex on performance, meat quality and enteric microorganism of yellow feather broilers. J Integr Agric 20(7):1907-1920.

Weber Wyneken C, Sinclair A, Veldkamp T, Vinco LJ, Hocking PM (2015) Footpad dermatitis and pain assessment in turkey poults using analgesia and objective gait analysis. Br Poult Sci 56:522-530.

Welfare Quality (2009) Welfare Quality assesment protocol for poultry (broiler, laying hens). Welfare Quality Consortium, Lelystad, Netherlands. ISBN: 9789078240068.

Willis WL, Murray C, Talbott C (2002) Campylobacter isolation trends of cage versus floor broiler chickens: a one-year study. Poult Sci 81(5):629-631.

Yan L, ZZ, LV, An S, Xing K, Wang ZG, MB, LV, Choct M, Guo M, Zhou GL (2021) Effects of rearing system and narasin on growth performance, gastrointestinal development, and gut microbiota of broilers. Poult Sci 100(3): 100840.

Zulkifli I, Norsam NS, Silahuddin MF, Awad EA (2021) Growth performance, well-being, and gut microbial population of broilers raised in cages and floor pens under the hot and humid tropical climate. Ital J Anim Sci 20(1): 383-394.