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Original article

Carcass characteristics of sexed broilers under two rearing systems in three housing zones in environmentally controlled broiler house during winter

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ABSTRACT

The aim of study was to compare carcass characteristics of broiler housed under two different rearing systems (cage and floor) in three housing zones. For this purpose, 240 day old commercial broilers (Hubbard Classic) were purchased and half of them were reared in cages and other half on floor. Under each system, the birds were further divided in three zones of house (near vent, middle and near variable speed fans). There were four replicates containing 10 birds each. The data were analyzed through Analysis of Variance (ANOVA) technique in Completely Randomized Design (CRD) under factorial arrangements. Means were compared using Duncan's Multiple Range Test (DMR) with the help of SAS 9.1. Pre-slaughter and post-slaughter weight of males rear on the floor exhibited significantly ($P<0.05$) higher body weight as compared with those rear in the cages. Similarly female attained significantly ($P<0.05$) higher body weight on floor as compared with those rear in the cages. Dressing percentage, breast weight, leg quarter yield, liver, heart and gizzard weight (filled & empty) in both sexes of broilers reared on floor was significantly ($P<0.05$) higher as compared to those reared in cages. Pre-slaughter body weight, post-slaughter body weight, Dressing percentage, higher breast weight, higher Leg quarter yields, liver, higher heart and gizzard weight (filled & empty) were found to be better near vents. It can be concluded from the

present study that birds reared on floor perform better in area near the vent as compared to the cage.

1. Introduction

Environment control has made the maximum expression of genetic potential possible in broilers (Kao et al., 2011) and harsh environmental conditions have a negative impact on the health and performance of poultry (Dawkins et al., 2004; Estevez, 2007). In winter season minimum ventilation is used to ensure necessary air flow required to provide fresh air containing optimum concentration of oxygen, keeping good air quality and improving animal welfare (Czarick and Fairchild, 2012). Air renewal is necessary to keep the ambient temperature at appropriate level in the house during brooding by removal of excessive humidity from the environment in order to keep the litter dry and reduce the obnoxious gases concentration.

Broiler rearing system is a crucial factor affecting bird's comfort, health and production efficiency (Fouad et al., 2008). In the recent years, lot of research is being conducted on the alternate rearing systems instead of floor (Appleby, 2004; Vits et al., 2005; Guesdon et al., 2006; Nicol et al., 2006; Zimmerman et al., 2006). However, Swain et al. (2002) reported that rearing system (floor v/s cage) had no significant effect on carcass of the broilers but it has also been documented that rearing system significantly affected carcass of the broilers (Sogunle et al., 2008; Santos et al., 2012).

There is the unique relationship between temperature and humidity but these parameters of ventilation vary in the house with some fluctuations (Czarick and Fairchild, 2012) affecting carcass of the broilers in different housing zones. It has been reported that when birds are exposed to low ambient temperature maximum carcass yield (1.5 to 2.2 kg) could be achieved between 28 to 35 day (Simmons et al., 2003; Dozier et al., 2005) however, high temperature may also have adverse effect on broiler growth performance e.g. carcass characteristics.

High humidity exerts damaging effect on performance, wellbeing, growth rate and feed consumption of broiler (Daghir, 2009) causing heavy productive losses (Francesch and Brufau, 2004) adversely affecting the respiratory epithelium of the broilers (Kristensen and Wathes, 2000) resulting into desquamation of respiratory epithelium. It is documented that 70% humidity is a good indicator for minimum ventilation (Czarick and Fairchild, 2012) leading to maximum carcass yield. However, low humidity causes dusty conditions, making the birds susceptible for respiratory diseases (Czarick and Fairchild, 2012).

The preceding discussions, present evidence that temperature and humidity may vary in different areas of the house which may ultimately affect the carcass of broilers. However, the subject has not yet been fully explored under different rearing systems such as cage vs. floor under environmentally controlled housing system. Keeping this in view the present study was undertaken to evaluate the carcass characteristics of broiler maintained under two rearing systems with three housing zones.

2. Materials and methods

The present study was conducted at Poultry Research and Training Center (PRTC) Department of Poultry Production, University of Veterinary and Animal Sciences, Lahore, Pakistan. The experiment was a 2×3 factorial in completely randomized design (CRD) with each treatment replicated four times. For this study 240 day old commercial broilers were divided in 2 rearing system (120 birds in each) (cage v/s floor). In each rearing system, there were three zones (near vent, middle, near variable speed fans) having 40 birds in each zone consisting of 4 replicates containing 10 birds each. These areas were decided on the basis of difference in temperature and humidity under minimum ventilation conditions during sever winter, replicated 4times containing 10 birds each. Water and commercial feed were offered ad-libitum to the birds throughout the experimental period. Birds were vaccinated (IBH120, ND and IBD) against the prevailing diseases of the area.

2.1. Experimental plan

Rearing systems	Housing zones	Systems = 2
Cage		Zones = 3
Floor	Ventilator (zone-1)	Replicate = 4
Cage		Birds= 2×3×4×10=240
Floor	Middle area (zone-2)	
Cage		
Floor	Variable speed fans (zone-3)	

2.2. Data collection

The data collected for carcass parameters were calculated at the time of slaughtering.

2.3. Statistical analysis

The data thus obtained were analyzed by Analysis of variance (ANOVA) technique in Completely Randomized Design (CRD) with factorial arrangements (Steel et al., 1997). Significant means were compared through Duncan's Multiple Range test (DMR) (Duncan, 1955) using SAS 9.1 software.

2.4. Carcass characteristics

At the 42 days of age two birds from each replicate (one male one female) and a total of 48 birds (24 males & 24 females) were randomly picked and slaughtered by Halal method to get the following parameters.

Pre-slaughtering weight (g)
Post-slaughtering weight (g)
Dressing percentage with giblet (g)
Breast weight (%)
Leg quarter yield (%)
Giblet yield (%)

3. Results and discussion

3.1. Pre-slaughtering weight (g)

Results of present study showed that rearing systems significantly ($P<0.05$) affected the body weight before slaughtering of the sexed broilers. Males reared on the floor exhibited significantly ($P<0.05$) higher body weight (2342.08±61.47 g) as compare with those reared in the cages (2117.50±38.46 g). Similarly female attained significant ($P<0.05$) higher body weight on floor (2028.33±58.46 g) as compare with those reared in the cages (1864.17±22.25 g).

Birds reared in the middle area showed significantly ($P<0.05$) higher body weight (2356.25±73.707g) followed by the ventilator (2194.38±76.709g) and fan areas (2138.75±53.22g) while female attained significantly higher ($P<0.05$) body weight (1978.13±63.18) in the middle area followed by ventilator (1959.38±70.05 g) and fan area (1901.25±52.45) of the house.

3.2. Post-slaughtering weight (g)

Broilers weight after slaughtering was significantly ($P<0.05$) affected by the rearing system. Male reared on the floor exhibited significantly ($P<0.05$) higher post-slaughtering weight (2312.08±60.32g) as compared with those reared in the cages (2044.17±34.06g) and post-slaughtering weight of floor reared female after bled was

significantly (P<0.05) higher (1982.08±54.66g) as compared to the cage (1840.42±21.97g).Housing zones significantly (P<0.05) affected the post-slaughtering weight (g) of male broiler. Birds reared in the middle zone have shown significantly higher post-slaughtering weight (P<0.05) (2278.75±88.72 g) followed by the ventilator (2148.13±78.82 g) and fan area (2107.50±51.27g) of house.

3.3. Dressing % with giblets

Results of the present study showed that rearing system significantly (P<0.05) affected the birds dressing percentage. Dressing percentage in both sexes of broiler reared on floor was significantly (P<0.05) higher as compared to those reared in the cages. Dressing percentage (66.63±0.47%) in both sexes of broilers reared on floor was significantly (P<0.05) higher as compared to those reared in cages (64.71±0.74%) as compared to cage. These findings are in line with Ratsaka et al. (2012) who reported that dressing percentage of broilers was significantly (P<0.05) affected by the rearing systems and floor exhibited more dressing weight as compared to the cages. Sogunle et al. (2008) also proved that floor reared birds exhibited significantly (P<0.05) higher dressing percentage as compared to floor. Iogjus and Stele (1969) also observed similar findings about dressing % of broilers which was high in broilers reared on deep litter system.

Housing zones significantly (P<0.05) affected the dressing percentage in both sexes of broilers. Broilers (male and female) reared in the fan area have shown significantly (P<0.05) higher dressing percentage (67.51±0.56%) followed by the middle (65.65±0.63%) and ventilator area (63.86±0.73%) of house because dressing percentage is positively influenced by high temperature. These findings are in-line with (Filho et al., 2005) who reported that birds reared high-temperature, showed better dressing percentage.

3.4. Breast weight (%)

Results of the present study indicated that rearing system significantly (P<0.05) affected birds breast weight. Broilers reared on floor showed significantly (P<0.05) higher breast weight (31.40±0.71 %) as compared to cage (30.04±0.48%) and significantly (P<0.05) higher breast weight were also observed in case of female reared on the floor (28.32±0.25 %) and cage (27.82±0.20 %). Similar findings were observed by Santos et al. (2012) who reported that birds reared on floor showed significantly (P<0.05) higher breast meat yields as compare to the cage reared birds. Sogunle et al. (2008) also reported that breast meat yield showed significant variation among the different rearing systems. Zhao et al. (2012) also observed that the birds reared in the pen showed significantly higher breast weight as compared to the cage reared birds.

Male reared in ventilator area showed significantly (P<0.05) higher breast weight (33.01±0.46 %) followed by middle (30.22±0.52 %) and fan (28.59±0.43%) area of house. Similarly breast weight of the females reared in ventilator was (28.70±0.25 %) significantly (P<0.05) to middle (28.07±0.26 %) and fan (27.43±0.15 %) area of house. Decrease in the breast weight of the broilers reared in the fan area might be due to the high temperature. These findings concise with those recorded by Filho et al. (2005) who reported decrease in the breast weight when the temperature increases towards the critical limit. Ain-Baziz et al. (1996) also observed that breast meat yields of the broilers decreases as temperature increases. Howlider and Rose (1989) also reported that breast muscle yield decreases with increase in temperature. Leenstra and Cahaner (1992) reported negative correlation between temperature and breast yield.

3.5. Leg quarter yield (%)

Results of present study showed that rearing systems significantly (P<0.05) affected the leg quarter yields of broilers. Male reared on floor achieved significantly (P<0.05) higher Leg quarter yields (27.37±0.14 %) as compared to the cage (25.41±0.58 %). Female reared on floor showed significantly higher (P<0.05) Leg quarter yields (27.07±0.64 %) as compared to the than cage (24.88±0.50 %).The results of the present study are in line with Weitzenbuger et al. (2005) who also reported that leg quarter weight of birds is significantly (P<0.05) higher in the birds reared on the floor.

The results of present study showed non-significant (P>0.05) difference for leg quarter yield in both sexes broilers reared in different housing zones. These findings are in accordance with Howlider and Rose (1989) who also reported that leg quarter yield was not influenced by the temperature.

Table 1

Pre-slaughter Body weight in sexed broilers reared on cage v/s floor within 3 house zones.

Systems	Floor	Cage	Mean	Floor	Cage	Means
Zones						
	Male			**Female**		
Ventilator	2278.75±130.04b	2110.00±76.19b	2194.38±76.709ab	2066.25±117.67	1852.50±37.94	1959.38±70.05
Middle	2526.25±56.62a	2186.25±53.67b	2356.25±73.707a	117.67±83.29	1866.25±57.86	1978.13±63.18
Fan	2221.25±62.795b	2056.25±68.84b	2138.75±53.22b	1928.75±108.40	1873.75±24.098	1901.25±52.45
Means	2342.08±61.47a	2117.50±38.46b		2028.33±58.46a	1864.17±22.25b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 2

Post-slaughter weight (g) of the sexed broilers reared in cage v/s floor within three housing zones.

Systems	Floor	Cage	Mean	Floor	Cage	Mean
Zones						
	Male			**Female**		
Ventilator	2255.00±131.26b	2041.25±64.43b	2148.13±78.82ab	2028.75±117.50ba	1822.50±35.74b	1925.63±68.93
Middle	2492.50±49.69a	2065.00±61.68b	2278.75±88.72a	2061.25±78.86a	1846.25±57.86ba	1953.75±60.83
Fan	2188.75±57.60b	2026.25±67.47b	2107.50±51.27b	1856.25±68.90ba	1852.50±22.78ba	1854.38±33.60
Mean	2312.08±60.32a	2044.17±34.06b		1982.08±54.66a	1840.42±21.97b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 3
Dressing % with giblets of sexed broilers reared in floor v/s cage within three house zones.

Systems	**Floor**	**Cage**	**Mean**	**Floor**	**Cage**	**Mean**
Zones						
	Male			**Female**		
Ventilator	67.93±0.40a	67.09±1.09ba	67.51±0.56a	67.93±0.40a	67.09±1.09ba	67.51±0.56a
Middle	66.75±0.48bac	64.55±0.91dc	65.65±0.63b	66.75±0.48ac	64.55±0.91dc	65.65±0.63b
Fan	65.23±0.91bc	62.50±0.65d	63.86±0.73c	65.23±0.91bc	62.50±0.65d	63.86±0.73c
Mean	66.63±0.47a	64.71±0.74b		66.64±0.47a	64.71±0.74b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 4
Breast yield % of broilers reared in cage v/s floor within three house zones.

Systems	**Floor**	**Cage**	**Mean**	**Floor**	**Cage**	**Mean**
Zones						
	Male			**Female**		
Ventilator	34.07±0.16a	31.74±0.24b	33.01±0.46a	29.05±0.20a	28.35±0.41ba	28.70±0.25a
Middle	31.53±0.30b	28.92±0.18c	30.22±0.52b	28.65±0.23a	27.50±0.23c	28.07±0.26b
Fan	28.59±0.67c	28.58±0.65c	28.59±0.43c	27.26±0.14c	27.60±0.26bc	27.43±0.15c
MEAN	31.40±0.71a	30.04±0.48b		28.32±0.25a	27.82±0.20b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 5
Leg quarter yield % of sexed broilers reared in cage v/s floor within three housing zones.

Systems	**Floor**	**Cage**	**Mean**	**Floor**	**Cage**	**Mean**
Zones						
	Male			**Female**		
Ventilator	27.52±0.39a	26.70±1.47ba	27.11±0.72	27.28±1.12	24.90±0.94	26.09±0.81
Middle	27.28±0.08a	24.95±0.63b	26.12±0.53	26.50±1.05	25.43±1.23	25.97±0.78
Fan	27.30±0.24a	24.57±0.53b	25.94±0.58	27.43±1.42	24.31±0.40	25.87±0.90
Mean	27.37±0.14a	25.41±0.58b		27.07±0.64a	24.88±0.50b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 6
Liver weight % of sexed broilers reared in cage v/s floor within three house zones.

Systems	Floor	Cage	Mean	Floor	Cage	Mean
Zones						
	Male			**Female**		
Ventilator	1.91±0.02ba	1.83±0.06b	1.87±0.03b	1.90±0.04b	1.83±0.00b	1.86±0.02b
Middle	2.02±0.05a	1.92±0.08ba	1.97±0.05ba	1.89±0.04b	1.90±0.02b	1.90±0.02ba
Fan	2.05±0.03a	1.95±0.05ba	2.00±0.03a	2.13±0.11a	1.88±0.03b	2.01±0.07a
Mean	2.00±0.03a	1.90±0.04b		1.97±0.05a	1.87±0.01b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 7
Heart weight % of sexed broilers reared in cage v/s floor with in three house zones.

Systems	Floor	Cage	Mean	Floor	Cage	Mean
Zones						
	Male			**Female**		
Ventilator	0.57±0.08b	0.71±0.03a	0.64±0.05	0.59±0.05b	0.69±0.06ba	0.64±0.04
Middle	0.52±0.04b	0.71±0.03a	0.61±0.04	0.57±0.01b	0.69±0.03a	0.63±0.03
Fan	0.63±0.03ba	0.72±0.02a	0.68±0.02	0.58±0.05b	0.81±0.08ba	0.70±0.06
Mean	0.57±0.03b	0.71±0.01a		0.58±0.02b	0.73±0.04a	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 8

Gizzard weight % (filled) in cage v/s floor within three house zones.

System	Floor	Cage	Mean	Floor	Cage	Mean
Zones						
	Male			**Female**		
Ventilator	2.04±0.07	1.83±0.04	1.93±0.05	1.96±0.12ba	1.77±0.07ba	1.86±0.07
Middle	1.98±0.07	1.81±0.05	1.90±0.05	1.95±0.18ba	1.61±0.07b	1.78±0.11
Fan	1.87±0.11	1.84±0.06	1.86±0.06	2.10±0.10a	1.64±0.05b	1.86±0.10
Mean	1.97±0.05a	1.83±0.03b		2.01±0.07a	1.67±0.04b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

Table 9

Gizzard weight % (empty) of sexed boilers reared in cage v/s floor within three house zones.

Systems	Floor	Cage	Mean	Floor	Cage	Mean
Zones						
	Male			**Female**		
Ventilator	1.43±0.05a	1.38±00.02ba	1.40±0.03	1.40±0.01a	1.32±0.02b	1.36±0.02
Middle	1.38±0.05ba	1.26±0.03a	1.32±0.03	1.39±0.00a	1.35±0.02b	1.37±0.01
Fan	1.44±0.06a	1.34±0.04ba	1.39±0.04	1.38±0.00a	1.31±0.01b	1.35±0.01
Mean	1.42±0.03a	1.32±0.02b		1.39±0.00a	1.33±0.01b	

*Different alphabets in rows and column on means show significant difference at P<0.05.

3.6. Giblets yield (%)

3.6.1. Liver weight (%)

Results of the present study showed that rearing system significantly (P<0.05) affected the liver weight. Male reared on floor achieved significantly higher (P<0.05) liver weight (2.00±0.03 %) as compared to the cage (1.90±0.04%) while female reared on the floor showed significantly higher (P<0.05) liver weight (1.97±0.05 %) as compare to the cage (1.87±0.01%). These findings were also in line with Santos et al. (2012) who also reported that liver weight of the birds reared on floor was significantly (P<0.05) higher as compared to cage reared birds.

Liver weight of broilers (male and female) reared in different housing zones was significantly (P<0.05) affected. Male reared in the fan showed significantly (P<0.05) higher liver weight (2.00±0.03 %) followed by middle (1.97±0.05 %) and ventilator (1.87±0.03 %) area of house. Similarly female reared in the fan area achieved significantly (P<0.05) higher liver weight (2.00±0.03 %) followed by middle (1.97±0.05 %) and ventilator (1.87±0.03%) area of the house. Increase in liver weight might be due to high temperature in fans area of the house. These findings are in-line with Schmalhusen (1926); (Dumm and Levy, 1949) they reported the increase in liver weight with the increase in temperature and significantly (P<0.05) higher liver weight was also observed by (Leksrisompong et al., 2007) who also reported increased heart weight with increasing temperature.

3.6.2. Heart weight (%)

Results of the present study showed that rearing system significantly (P<0.05) affected the heart weight. Male birds reared in cage exhibited significantly (P<0.05) higher heart weight (0.71±0.01 %) as compared to the floor (0.57±0.03 %) and female reared in the cages achieved significantly (P<0.05) higher heart weight (0.58±0.02%) as compared to the floor (0.73±0.04%).The results of the present study are in accordance with (Ratsaka et al., 2012) who also reported that birds reared in cages showed significantly (P<0.05) higher heart weight as compared to cage because caging added stress to the chickens. Broilers (male & female) reared in different housing zones showed non-significant effect for heart weight.

3.6.3. Weight of gizzard filled & empty (%)

Results of the present study showed that rearing system significantly (P<0.05) affected gizzard (filled and empty) weight. Male reared on floor achieved significantly (P<0.05) higher gizzard weight (1.97±0.05%) as compared to cage (1.83±0.03%) and female reared on floor showed significantly (P<0.05) higher gizzard weight (2.01±0.07 %) as compared to cage (1.67±0.04 %). The results of the present study are in accordance with Hetland et al. (2003)who also reported that gizzard weight is significantly (P<0.05) influenced by the rearing system. Santos et al. (2012) also reported that floor reared birds showed significantly (P<0.05) higher gizzard weight as compared to cage. Deaton et al. (1985) also noted that rearing system put influence on the gizzard weight of broilers. Different housing zones showed non-significant (P>0.05) effect for Gizzard weight of both sexes in broilers.

4. Conclusion

Based on the findings of this study, it may be stated that maintenance of broilers on floor near vent area exhibited better carcass quality as compared to those reared in cages.

References

Ain-Baziz, H., Geraert, P., Padilha, J., Guillaumin, S., 1996. Chronic heat exposure enhances fat deposition and modifies muscle and fat partition in broiler carcasses. Poult. Sci., 75, 505-513.

Appleby, M., 2004. What causes crowding? Effects of space, facilities and group size on behavior with particular reference to furnished cages for hens. Ani. Wel., 13, 313-320.

Czarick, M., Fairchild, B., 2012. Relative humidity, the best measure of overall poultry house air quality (poultry housing tips). extension article and cooperative extension service University of Georgia, (USA) 24, 2.

Daghir, N., 2009. Nutritional strategies to reduce heat stress in broilers and broiler breeders. Lohman Inform., 44, 6-15.

Dawkins, M., Donnelly, C., Jones, T., 2004. Chicken welfare is influenced more by housing conditions than by stocking density. Nat., 427, 342-344.

Deaton, J., Bransto, S., Lott, B., Brake, J., 1985. Noted differences in the digestive system in caged and floor-reared commercial egg type pullets. Poult. Sci., 64, 1034-1035.

Dozier, W., Lott, B., Branton, S., 2005. Live performance of male broilers subjected to constant or increasing air velocities at moderate temperatures with a high dew point. Poult. Sci., 84, 1328-1331.

Dumm, M., Levy, M., 1949. Chemistry of the chick embryo. VII. The accumulation of solids in nitrogen, lipids, and peptidase by the gizzard and liver of the chick embryo. J. Cell. Comp. Phys., 33, 373-382.

Duncan, D., 1955. Multiple Range and Multiple F tests. Biometrics., 11, 1-42.

Estevez, I., 2007. Density allowances for broilers: Where to set the limits? . Poult. Sci., 86, 1265-1272.

Filho, D., Rosa, P., Vieira, B., Macari, M., Furlan, R., 2005. Protein levels and environmental temperature effects on carcass characteristics, performance, and nitrogen excretion of broiler chickens from 7 to 21 days of age. Rev. Bras. Cienc. Avic., 7.

Fouad, M., Abeer, H., Razek, A., Badawy, M., 2008. Broilers welfare and economics under two management alternatives on commercial scale. Int. J. Poult. Sci., 7, 1167-1173.

Francesch, M., Brufau, J., 2004. Nutritional factors affecting excreta/litter moisture and quality. W. Poult. Sci., 60, 64-75.

Guesdon, V., Ahmed, A., Mallet, S., Faure, J., Nys, Y., 2006. Effects of beak trimming and cage design on laying hen performance and egg quality. Briti. Poult. Sci., 47, 1-12.

Hetland, H., Svihus, B., Krogdahl, 2003. Effect of oat hulls and wood shavings on digestion in broilers and layers feed diets based on whole or ground wheat. Brit. Poult. Sci., 44, 275-282.

Howlider, M., Rose, S., 1989. Rearing temperature and the meat yield of broilers. Brit. Poult. Sci., 30, 61-67.

Iogjus, G., Stele, A., 1969. The meat production of broilers reared in batteries and deep litter. Anim. breed Abst., 37, 956.

Kao, L., Moura, D., Carvalho, T., Bueno, L., Vercellino, R., 2011. Ammonia emissions in tunnel-ventilated broiler houses. Rev. Bras. Cienc. Avic., 13, 4.

Kristensen, H., Wathes, C., 2000. Ammonia and poultry welfare: A review. W. Poult. Sci. J., 56, 235-245.

Leenstra, F., Cahaner, A., 1992. Lines selected for high weight gain, favorable feed conversion, and high or low fat content. Poult. Sci., Vol. 71.

Leksrisompong, N., Sanchez, R., Plumstead, P., Branan, K., Brake, J., 2007. Broiler incubation effect of elevated temperature during late incubation on body weight and organs of chicks. Poult. Sci., 86, 2685-2691.

Nicol, C., Brown, S., Glen, E., Pope, S., Short, F., Warriss, P., Zimmerman, P., Wilkins, L., 2006. Effects of stocking density flock size and management on the welfare of laying hens in single-tier aviaries. Brit. Poult. Sci., 47, 135-146.

Ratsaka, M., Ngambi, J., Ndlovu, L., 2012. Effect of potable cage rearing system and stocking density on growth, feed intake and carcass characteristics of Ross 308 broiler chickens. J. An. Sci. Adv., 2, 312-320.

Santos, F., Santos, A., Oviedo-Rondon, E., Ferket, F., 2012. Influence of housing system on growth performance and intestinal health of Salmonella challenged broiler chickens. Curr. Rese. Poult. Sci., 2, 1-10.

Schmalhusen, I., 1926. Mem. Acad. Sci. Ukraine. Class Sci. Phys., Math 2, 302-360.

Simmons, J., Lott, B., Miles, D., 2003. The effects of high air velocity on broiler performance. Poult. Sci. 82, 232-234.

Sogunle, O., Egbevale, L., Bamigboie, O., Fanimo, A., 2008. Comparison of the performance, arcasscharactrtics and hamatological parameters of broiler chicks reared in cage and floor. Pak. J. Biol. Sci., 11, 480-483.

Steel, R., Torrie, J., Dickey, D., 1997. Principles and Procedures of Statistics, McGraw-Hill; New York, USA.

Swain, B., Sundaram, R., Barbuddhe, S., Nirmale, A., 2002. Influence of cage and deep litter rearing systems on the performance of broilers. In. J. An. Sci., 79, 467-469.

Vits, A., Weitzenburger, D., Hamann, H., Distl, O., 2005. Production, egg quality, bone strength, claw length and keel bone deformities of laying hens housed in furnished cages with different group sizes. Poult. Sci., 84, 1511-1519.

Weitzenbuger, D., Vit, A., Hamann, H., Distl, O., 2005. Effect of furnished small group housing systems and furnished cages on mortality and causes of death in two layer strains. Brit. Poult. Sci., 46, 553-562.

Zhao, X., Siegel, P., Liu, Y., Wang, Y., Gilbert, E., Zhu, Q., Zhang, L., 2012. Housing system affects broiler characteristics of local Chinese breed reciprocal crosses. Poult. Sci., 9, 2405-2410.

Zimmerman, P., Lindberg, A., Pope, S., Glen, E., Bolhuis, J., Nicol, C., 2006. The effect of stocking density, flock size and modified management on laying hen behavior and welfare in a non-cage system. Apl. Ani. Beh. Sci., 101, 111-124.