EFFECTS OF TWO REARING SYSTEMS ON THE DEVELOPMENT OF DIGESTIVE ORGANS AND SLAUGHTER PERFORMANCE OF LUSHI GREEN LAYER BIRDS

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This study evaluated the effects of two management systems (battery cage and semi-intensive) on the digestive organ development and slaughter performance of Lushi green layer birds. Sixty layer chickens, Lushi green, seven weeks old were used. Thirty chickens were placed in each of the two systems. Ten (half male and half female) chickens from each management system were selected randomly for slaughter and relevant indexes were measured. Results showed that the liver, gizzard, pancreas and gizzard organ indexes of the roosters reared under the semi-intensive system were higher than those of the cage reared roosters ($P<0.05$). The digestive organ index of the hens reared under the semi-intensive system was also higher than that of the cage reared hens ($P<0.05$). The lengths of the jejunum, ileum, and ceca and the jejunum relatively small intestine index of the chickens reared under the semi-intensive system were higher than those of the cage reared chickens ($P<0.05$). The thigh muscle and abdominal fat yields of male and female chickens reared under the semi-intensive system were lower compared with those of the cage-reared ones ($P<0.05$). These results indicated that rearing method influences the slaughter performance and digestive organ development of Lushi chickens. The digestion and absorption abilities of chickens reared under the semi-intensive system were generally better than those of cage-reared ones.

Key words: Digestive organ, Lushi green layer birds, Rearing system, Slaughter performance

Lushi green layer birds are excellent indigenous meat and egg-type local chicken breeds that display green-shell eggs and red-

black feather (Xu *et al.*, 2009). The particular birds are rich in nutritive and medicinal values, and formed through long-

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term natural selection in the Lushi mountainous region in Henan Province, China (Zhou *et al.*, 2016). Lushi green layer birds exhibit a slow growth rate, high egg production, delicious meat, and a strong tolerance for and adaptability to coarse feed (Ma *et al.*, 2009). The egg of Lushi green layer birds is rich in selenium, zinc and iodine; it also features low-cholesterol content and serves several healthcare functions, such as prevention of cardiovascular disease (Huang *et al.*, 2017). Such egg is considerably popular among consumers, and its market price is two or three times higher than that of commercial layer birds.

Lack of housing has been a major problem in Lushi green layer bird production in the region. Poor housing of chickens generates heat stress effects, such as low production, suppressed reproduction, reduced feed intake and reduced egg production (Njoya and Picard, 1994). Hameed *et al.* (2012) who found that housing conditions of poultry birds play very important role and poultry parent stock should be provided the conditions that ensure optimum performance of the birds. Therefore, improving the housing system of chickens could help minimize the effects of heat stress and establish breed standards. Poultry stock improvement could also increase the yield of laying hens.

Birds under the semi-intensive rearing system are housed at night but allowed to roam freely during daytime in a restricted area (Barbosafilho *et al.*, 2005). Some

consumers are also interested in birds raised with access to the outdoors. Many consumers buy these products because they believe that outdoor production systems enhance the flavor of chicken compared with conventional confinement systems (Fanatico *et al.*, 2005). Semi-intensive rearing system without any confinement on birds could decrease stress conditions and allow selection of strains that may increase comfort and bird welfare. Chickens under the semi-intensive system are supplemented with either commercially formulated or homemade feed, clean water is provided *ad libitum*, and disease control measures are executed. This system is also an updated alternative system for raising the living standards of rural households by supplying additional income and supplement protein intake in rural and tribe folks (Niranjan *et al.*, 2008). Chickens reared under the semi-intensive system are at high risk of being infected with diseases and ectoparasites due to contamination with soil dust and vegetation when they roam around during daytime (Muchadeyi *et al.*, 2004; Rodenburg *et al.*, 2005). An infestation with red mites can lead to reduce weight gain, anemia and increase mortality (Kilpinen *et al.*, 2005).

The battery cage system allows large capacity, convenient management and high coop utilization rate. This system also favors disease control and prevention, short growth cycle and product security. However, layer chickens in conventional cages are subjected to restricted movement and cannot

fulfill most of their natural behaviors (Vits *et al.*, 2005). Caged hens are prevented from dust bathing and roosting because they are deprived of litter and perches. Movement restriction induces bone disease, particularly in legs and wings (Baxter, 1994). Conventionally confined systems cause animal stress (Jones and Millis, 1999; Marin *et al.*, 2001), which results in poor performance (Mendl, 1999). Dereuk *et al.* (2008) reported that the conventional cage housing system for laying hens has been abolished in the European Union (EU) since 1st January 2012 in accordance with the EU directive (1999/74/EC); the furnished cage and non cage system, which allows bird movement, has been used as an alternative.

Various studies have investigated the effect of different feeding methods on the laying performance and economic benefit of layer chickens. However, the effects of different rearing methods on the slaughter performance and digestive organ development of Lushi green layer birds remain unclear to date. Therefore, this study explored the effect of different rearing patterns on the slaughter performance and digestive organ development of Lushi green layer birds.

MATERIALS AND METHODS

Birds and diets: The study was carried out at the Bokang Lushi Chicken Development Co. Ltd. of Lushi County, Henan Province, Henan University of Science and Technology from July 2014 to December 2014. Lushi is situated at latitude of 33°

332 ~ 34° 232 N and longitude of 110° 352 ~ 111° 222 E in the west of Henan Province. The study area is characterized by a temperature range of 12 ~ 13.4°C, a relative humidity of about 71.6% and an annual mean rainfall of about 692.9 mm.

In this study, sixty 7-week-old Lushi green layer birds with medium-heavy egg type were obtained from Bokang Lushi Chicken Development Co. Ltd. of Lushi County. In the experiment, ten 18-week-old Lushi chickens (half male and half female) were randomly selected from the semi-intensive system and the battery cage system for slaughter, and relevant indexes were measured.

The sixty birds were equally divided into the two treatment groups (battery cage and semi-intensive systems). Birds in the two management systems were reared for twelve weeks (7–18 weeks). The experimental design and procedures were approved by the Institutional Animal Care and Use Committee of Henan University of Science and Technology.

Battery cage system: Two layer chickens were reared in a cage with the following dimension: 0.6 m length, 0.4 m width, 0.42 m front height and 0.36 m rear height. The light exposure was 10 h light/day for the whole duration of the study. Feed and water troughs were placed in the cage.

Semi-intensive system: In this system, a fence structure with an area of 121 m² (11m length × 11m width) was constructed in such a way that the birds can roam around during

Table 1. Ingredient and nutrient composition of the experimental diets¹

Diet composition	Amount
Corn (%)	65
Soybean meal (%)	20
Premix ¹ (%)	5
Bran (%)	10
Nutrition level	
Metabolizable energy (MJ/Kg)	11.46
Protein (%)	16.07
Methionine (%)	0.57
Lysine (%)	0.99
Calcium (%)	0.89
Available phosphorus (%)	0.62

¹ Each premix was purchased from the Henan Animal Husbandry Biological Technology Co. Supplied the following per kilogram of total diet: vitamin A (140000 IU), vitamin E (200 IU), vitamin K₃ (25 mg), vitamin B₁ (20 mg), vitamin B₂ (80 mg), vitamin D₃ (30000 IU), Cu (80 mg), Fe (600 mg), Zn (800 mg) and Mn (1000 mg)

daytime to scavenge. The stocking density in the fence was 4 m² per bird (Thiele and Pottguter, 2008). In the house, this density was 10 birds per m² as in the deep litter system.

Chicks were fed the same diet (Table 1). Feed in the morning and evening, clean drinking water was provided *ad libitum* daily, and all diets were formulated to contain adequate nutrient levels as defined by the NRC (1994).

Sample collection and analytical determination: After fasting for 12 h before slaughter, ten 18-week-old Lushi

green layer birds were randomly selected from each treatment group. The birds were weighed individually and killed by manual exsanguinations. The samples, including abdominal fat, breast and thigh muscles, glandular stomach, gizzard, pancreas, liver and intestinal segment (duodenum, jejunum, ileum and ceca), were removed by trained personnel and weighed. The breast muscle, thigh muscle and abdominal fat were calculated as the percentage of eviscerated carcass weight. The relative organ weights (weight of organ/1 Kg live body weights) were calculated. The duodenum, jejunum, ileum and ceca were emptied by gentle

pressure and the length and weight were recorded. The relative index of the small intestine was calculated.

Statistical analysis: All data were analyzed by SPSS 20.0 (SPSS Inc., Chicago, IL, USA) software for independent sample *t*-test and correlation analysis. Results were expressed as means $\pm$ standard deviation (SD). Significant difference was considered at $P < 0.05$.

RESULTS

Digestive organs: The effects of two rearing systems on the length, weight and relative length of the intestinal segments are presented in Table 2. The length and weight of the intestine in the roosters reared under the semi-intensive system were higher than those of the cage reared roosters ($P < 0.05$). The lengths of the jejunum, ileum and ceca in the hens reared under the semi-intensive system were higher than those of the cage reared ones ($P < 0.05$). No significant differences ($P > 0.05$) in intestinal weight values were found between the two systems. The length and relative small intestine length indexes of the jejunum in the roosters reared under the semi-intensive system were higher than those of the cage reared roosters ($P < 0.05$), but their length and relative small intestine length indexes of the ileum were less than those of the cage reared roosters ($P < 0.05$). The total length of the small intestine in the chickens reared under the semi-intensive system was higher than that of the cage reared ones ($P < 0.05$).

Table 3 shows the effects of two rearing systems on the organ index of Lushi green

birds. The liver, gizzard, pancreas, and relative body weight indexes of the gizzard in the roosters reared under the semi-intensive system were higher than those of the cage reared roosters ($P < 0.05$), but no significant difference existed on other indicators ($P > 0.05$). The digestive organ index in the hens reared under the semi-intensive system was higher than that in the cage reared hens ($P < 0.05$), whereas the digestive organ weights of the hens reared under the semi-intensive system indicated a slight increase ($P > 0.05$).

Slaughter performance: The effects of two rearing systems on carcass traits are presented in Table 4. The weights of the gizzard, liver and feet of the roosters reared under the semi-intensive system were higher than those of the cage reared roosters ($P < 0.05$). The abdominal fat weight of the roosters reared under the semi-intensive system was less than that of the cage reared ones ($P < 0.05$). The weights of the carcass, breast muscle, thigh muscle and abdominal fat of the semi-intensive hens were less than those of the cage reared hens ($P < 0.05$). In addition to gizzard and liver, other indicators were less than those of the cage reared hens, but no significant differences were observed ($P > 0.05$).

The thigh muscle and abdominal fat yields of the roosters reared under the semi-intensive system were lower than those of the cage-reared ones ($P < 0.05$). Additionally, the other indexes of the roosters under the two systems increased ($P > 0.05$). The abdominal fat and thigh

Table 2. Effects of two rearing systems on the length, weight and relative length of the intestinal segment of 18-week-old Lushi green birds

Item	Semi-intensive rooster	Semi-intensive hen	Battery cage rooster	Battery cage hen
Length(cm)				
Duodenum	29.72 ^a ±2.16	25.02 ^b ±1.94	22.00 ^c ±3.68	22.16 ^c ±3.22
Jejunum	35.04 ^a ±3.81	32.54 ^a ±4.68	21.88 ^b ±4.63	22.98 ^b ±2.61
Ileum	40.10 ^a ±4.28	36.18 ^a ±2.83	30.62 ^b ±2.53	28.88 ^b ±2.68
Ceca	14.36 ^a ±1.79	13.46 ^a ±2.63	11.48 ^b ±1.26	10.74 ^b ±0.49
Weight(g)				
Duodenum	11.70 ^a ±1.06	7.89 ^b ±0.75	7.43 ^b ±1.43	6.99 ^b ±1.72
Jejunum	14.45 ^a ±1.97	8.30 ^b ±1.71	7.67 ^b ±1.72	6.46 ^b ±0.95
Ileum	13.08 ^a ±1.90	7.93 ^b ±1.25	8.86 ^b ±1.49	7.43 ^b ±1.22
Ceca	6.61±0.61	5.50±1.57	4.58±0.38	4.25±0.68
Intestinal weight	45.84 ^a ±3.89	29.62 ^b ±4.41	28.53 ^c ±4.08	25.13 ^b ±4.06
Relative length¹ (%)				
Duodenum	28.39±0.76	26.81±2.83	29.53±3.10	29.87±2.25
Jejunum	33.39 ^a ±0.85	34.59 ^a ±2.60	29.20 ^b ±3.71	31.07 ^b ±2.63
Ileum	38.22 ^b ±0.94	38.60 ^b ±1.29	41.27 ^a ±1.84	39.06 ^b ±2.05

Values within a row followed by different upper case letters are significantly different (P<0.05), ¹Calculated as a percentage of intestine length

Table 3. Effects of two rearing systems on the organ index of 18-week-old Lushi green birds

Item	Semi-intensive rooster	Semi-intensive hen	Battery cage rooster	Battery cage hen
Organ weight(g)				
Liver	27.45 ^a ± 1.55	18.59 ^b ±4.95	20.79 ^b ±1.80	17.58 ^b ±2.27
Glandular stomach	4.99 ^a ± 0.84	3.61 ^b ±0.56	4.27 ^a ± 0.63	3.14 ^b ± 0.35
Gizzard	35.36 ^a ± 2.85	25.17 ^b ±3.07	22.80 ^b ± 2.97	21.66 ^b ±2.63
Pancreas	2.91 ^a ± 0.44	2.17 ^b ±0.30	2.11 ^b ±0.44	2.03 ^b ± 0.24
Organ index¹(g/Kg)				
Liver	20.12 ^{ab} ± 0.75	22.61 ^a ±3.63	17.05 ^b ±2.70	16.42 ^b ±1.91
Glandular stomach	3.64 ^b ± 0.40	4.44 ^a ± 0.49	3.48 ^b ± 0.54	2.94 ^b ± 0.40
Gizzard	25.91 ^b ± 1.54	30.94 ^a ±0.44	18.61 ^c ±2.90	20.31 ^c ±2.86
Pancreas	2.12 ^b ± 0.22	2.68 ^a ± 0.39	1.73 ^b ± 0.45	1.90 ^b ± 0.19

Values within a row followed by different upper case letters are significantly different (P<0.05), ¹Calculated as a percentage of live BW

Table 4. Effects of two rearing systems on the carcass characteristics of 18-week-old Lushi green birds

Item	Semi-intensive rooster	Semi-intensive hen	Battery cage rooster	Battery cage hen
Dressed weight (g)	1189.80 ^a ± 89.49	720.80 ^c ± 94.64	1060.00 ^a ± 128.93	944.00 ^b ± 125.42
Eviscerated weight (g)	847.60 ^a ± 43.80	484.00 ^c ± 50.55	755.00 ^a ± 91.72	668.00 ^b ± 82.36
Breast muscle weight (g)	190.08 ^a ± 14.84	116.25 ^c ± 14.55	164.80 ^a ± 20.62	170.55 ^b ± 30.18
Thigh muscle weight (g)	242.86 ^a ± 24.97	144.53 ^b ± 14.91	260.36 ^a ± 49.00	223.99 ^b ± 31.29
Abdominal fat weight (g)	1.12 ^c ± 0.19	1.28 ^c ± 0.38	17.98 ^b ± 8.88	24.56 ^a ± 20.94
Heavy feet (g)	56.25 ^a ± 5.45	27.73 ^c ± 3.28	47.48 ^b ± 5.80	34.39 ^c ± 5.42
Heart weight (g)	5.70 ^a ± 0.81	3.38 ^b ± 0.51	5.23 ^a ± 0.86	3.74 ^b ± 0.52
Gizzard weight (g)	35.36 ^a ± 2.85	25.17 ^b ± 3.07	22.80 ^c ± 2.97	21.66 ^b ± 2.63
Liver weight (g)	27.45 ^a ± 1.55	18.59 ^c ± 4.95	20.79 ^b ± 1.80	17.58 ^c ± 2.27
Slaughter yield ¹ (%)	87.09 ± 1.25	88.55 ± 2.95	85.87 ± 3.46	87.74 ± 3.74
Eviscerated yield ¹ (%)	62.12 ± 1.48	59.61 ± 1.31	61.15 ± 1.84	62.14 ± 2.23
Breast yield ² (%)	22.41 ^b ± 0.79	23.99 ^{ab} ± 1.19	21.83 ^b ± 0.51	25.42 ^a ± 1.86
Thigh muscle yield ² (%)	28.61 ^b ± 1.94	29.88 ^b ± 1.09	34.36 ^a ± 3.43	33.51 ^a ± 1.59
Abdominal fat yield ² (%)	0.13 ^b ± 0.02	0.27 ^b ± 0.09	2.32 ^a ± 1.15	3.30 ^a ± 2.62

Values within a row followed by different upper case letters are significantly different (P<0.05)

¹Calculated as a percentage of live BW

²Calculated as a percentage of eviscerated carcass weight

muscle yields of the hens reared under the semi-intensive system were lower than those of the cage-reared hens (P<0.05); the other indexes of the hens under the two systems increased (P>0.05).

DISCUSSION

Effect on the development of digestive organs: The weights of the liver, glandular stomach, gizzard, pancreas and the relative weight index of the semi-intensive chickens were higher than those of the cage-reared chickens. The results indicated that the digestion and absorption functions of the chickens reared under the semi-intensive

system were generally better than those of the caged chickens. This result agreed with those of Santos *et al.* (2008), who reported that the relative gizzard weights of broiler chickens raised on litter (soft pine shavings) are heavier than those of caged broiler chickens. Similar results were reported by Hetland and Svihus (2001) who fed broiler chickens with diets containing oat hulls. Gonzálezalvarado *et al.* (2008) found that a minimal amount of fiber in broiler chicken diet is required to stimulate the development of the gastrointestinal tract. In the present experiment, the birds raised in the semi-intensive system gained access

to pasture and various forages, insects and worms; consequently, their crude fiber content was higher than that of the caged chickens. In the low digestion and absorption of physiological conditions, the body can show compensatory physiological reaction, which increases creep dynamic strength and digestive organ weight, promotes the proliferation of digestive organs, and increases the secretion of digestive enzymes. This result can be attributed to the high-quality food utilized. In addition, the digestive organs of the roosters were heavier than those of the hens, which caused the slightly lower organ index of the roosters compared with the hens.

Animal internal organs adapt to the external environment; the internal organ weight and relative weight index can be used as approximate indicators to measure function (Ciftci *et al.*, 2003; Lalpanmawia *et al.*, 2014). The results of the present study indicated that the length and weight of the intestinal segments of the semi-intensive chickens were higher than those of the cage-reared chickens. Contrarily, Santos *et al.* (2008) reported that the relative total intestine weight and length of broiler chickens reared on litter are lighter and shorter than those of chickens reared in cages. Such contrasting results on intestine weight might be due to the different environmental conditions, physiologies or breeds.

Effect on the slaughter performance: The breast muscle, thigh muscle and carcass yields are indicators reflecting the carcass quality of poultry (Dransfield and Sosnicki, 1999; Castellini *et al.*, 2002). Lushi green layer birds showed a high slaughter rate

(Table 4) under different raising methods. The abdominal fat yield of the semi-intensive in Lushi green layer birds was less than that of the cage-reared chickens. The reduced abdominal fat may have resulted from the considerable motion and muscle mass development, which is in accordance with the result of Ricard (1977); Lewis *et al.* (1997) and Castellini *et al.* (2002).

In the present study, no significant differences existed in carcass yields. However, the thigh muscle yield of the semi-intensive chickens was less than that of the caged ones. On the contrary, Ricard (1977) and Castellini *et al.* (2002) found that the percentages of breast and thigh meat increase when birds gain an outdoor access; furthermore, the stocking density in an organic production system is low because of forced motor activity. Such contrasting results on thigh muscle yield might be due to the different rearing patterns. Jiang *et al.* (2008) found that the half eviscerated and eviscerated yields of semi-intensive chickens are higher than those of all caged chickens. Moreover, the slaughter, leg muscle and gizzard yields of the caged chickens are better than those of semi-intensive ones. Comparison of the free and caged chickens shows that the abdominal fat yield is reduced by 12.2%. The present results are not completely consistent with this observation, which is probably due to the different chicken breeds used.

Semi-intensive system had a limited effect on slaughter performance and digestive organ development of Lushi green layer birds. The digestion and absorption abilities

of the chickens reared under the semi-intensive system were better than those of the caged ones. The results of this study imply that semi-intensive system, in which birds can roam around during daytime to scavenge, might be a feasible and effective system for Lushi green layer birds.

Conflict of interest: Authors declare that there is no conflict of interest regarding the present research work.

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ACKNOWLEDGEMENTS

This study was supported by the Key Science and Technology Project of Henan (Research and application of molecular breeding techniques of Lushi chicken, 82102130001) and the Key Science and Technology Project of Luoyang (Research and demonstration of ecological farming model of Lushi chicken, 0701040A).

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