Paper ISSN 0189-0514
Online ISSN 1427-4410
J. Anim. Prod. Res. (2022) 34(2):32-41

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EGG LAYING PERFORMANCE, BLOOD PROFILE, EGG EXTERNAL AND INTERNAL QUALITIES OF GUINEA FOWLS RAISED IN THREE DIFFERENT HOUSING SYSTEMS

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ABSTRACT

The study examined the impact of different housing systems on the blood profile, egg production, and egg external and internal characteristics of guinea fowl. Seventy-eight 24-week-old Helmeted Guinea fowl pullets were assigned respectively to different housing systems, namely, battery cage, deep litter, and deep litter with access to run. Data was collected on egg-laying performance and characteristics, and the results showed that the average final weight, weight gain, feed intake, feed per dozen eggs, and total egg were significantly influenced by the housing systems. Egg weight and shell thickness were highest in eggs from birds on deep litter with a run housing system, and the eggs had the deepest yolk color. Hens in deep litter with run had the highest total serum protein, albumin, and glucose values compared to other systems. The study concluded that deep litter housing with run had better growth performance and egg quality traits, suggesting it was more beneficial for guinea fowl production in tropical environments.

Keywords: Albumin, Free run, Glucose, Serum protein, and Quality trait.

INTRODUCTION

An appropriate housing type has been an issue of concern in the domestication and commercial production of guinea fowl eggs and meat in the tropics, of which the most important species is *Numidia meleagris*. Production, management, and housing systems, nutrition, the purpose of egg and meat production, control of mortality of young guinea fowl, and level of breeding activity are the main factors that affect the productive performance of the Guinea fowl (Portillo-Salgado *et al.*, 2022). However, factors such as nutrition, genotype, and pre-incubation and incubation conditions permanently influence the productive performance of guinea fowl (Portillo-Salgado *et al.*, 2022). The evaluation of the effects of housing systems (open air, deep-bed, and battery cage) showed that the body weight of the birds kept in the open air was similar to that of the deep-bed reared hens, but was significantly higher than those of birds reared in battery cages (Oke *et al.*, 2015). The low performance shown by guinea fowl kept in battery cages was linked to cage-induced stress levels, which significantly influenced the rectal temperature, breathing rate, and blood glucose levels of birds (Oke *et al.*, 2015). It was also observed that conventional battery cage systems are not suitable for housing guinea fowl. However, Sánchez-Casanova *et al.* (2020) observed a positive effect of open-air housing and production systems on the well-being of chickens though the mortality rate was compromised to some extent. There is a need to establish further the appropriate housing system fit for the optimal performance of pearl helmet guinea fowl in tropical environments. This study thereby assessed laying production, eggs' external and internal characteristics and the blood profile of guinea fowl reared in varying housing systems.

MATERIALS AND METHODS

Experimental birds, design and management

A total of 234 twenty-four-week-old, Pearl helmeted guinea fowl pullets were used for this research and were randomly assigned to three experimental housing systems namely; cage, deep litter, and deep litter with a free run. Each housing system had 78 pullets arranged in 6 replications of 13 birds each. The cages had 1 m^2 of floor area (1m x 1m) per cell per bird. The deep litter floor also had a stock density of 1 m^2 per bird. The deep litter with run had a 2.5 m^2 per bird outdoor run area (in addition to a deep litter floor of 1 m^2 per bird) covered with grass and small bushes, which enabled pullets to supplement their diets using vegetation and small creatures living outdoors. The deep litter floor was bedded with wood shavings, Housing systems were equipped with wooden nest boxes for egg laying and were naturally ventilated and equipped with feeders and drinkers. The cage housing was a wire net supported by metal bars. Each housing type was equipped with a galvanized feeder and linear drinker. Data collected were arranged in a One-Way Analysis of Variance in a Completely Randomized Experimental Design. Feed and fresh clean water were provided *ad libitum* throughout the experimental period of 16 weeks. The composition of the diet is given in Table 1.

Data collection and parameters considered

Data were collected on body weight gain, feed consumption, and survivability. For egg quality analyses, six eggs per replicate pen were sampled weekly. External and internal egg quality assessments were done within 24 hours of egg laying. The eggs were randomly collected weekly from each replicate and weekly data were pooled to obtain mean values for statistical analysis.

Assessment of Egg traits

Egg, albumen, and yolk weights were carefully measured and the dried empty shell was weighed in grams; eggshell thickness was also measured after the egg was broken. The shell thickness (mm) without inner and outer shell membranes was measured. The egg shape index was calculated by dividing the egg width by the egg length and the ratio multiplied by 100. Albumen height was measured with an accuracy of 0.01 mm. Haugh Unit was also calculated as:

$$HU = 100 \log (H+7.5 - 1.7W^{0.37})$$

Where HU = Haugh unit; H =Albumen height in mm; W = egg weight (g)

The number of eggs/weeks was counted as the total number of eggs laid by hens in each group per week.

Blood sample collection for Haematological and Serum parameters

In the 16th week of the feeding trial, four hens were randomly selected from each replicate for blood test. Blood samples were collected via left wings into vials containing Ethylene Diamine Tetra Acetate (EDTA) for hematological parameters according to Van *et al.* (2001). Another 2.5 ml of blood was collected into a sample bottle (without anticoagulant) for serum determination and was centrifuged at 3000U/min for ten minutes to separate the cells from the plasma and fractionated blood separated serum was evaluated using an automated blood chemistry analyzer Hitachi, Japan with DIAS (Diagnostics Systems GmbH, Germany) reagents.

Table 1: Composition (g/kg) of basal experimental diet for guinea hens

Ingredient	Composition (g/kg)
Maize	440.00
Soybean meal	80.00
Fish meal (72% CP)	20.00
Groundnut cake	75.00
Wheat offal	265.50
Bone meal	40.00
Oyster shell	71.00
Lysine	1.50
Methionine	2.00
*Vit. /Mineral Premix	2.50
Salt (NaCl)	2.50
Total	1000.00
Chemical Composition	
Metabolizable Energy (MJ/kg)	10.61
Crude Protein (g/kg)	16.76
Crude Fiber (g/kg)	4.27
Ether Extract (g/kg)	3.85
Calcium (g/kg)	3.77
Available Phosphorus (g/kg)	0.79

**1 Kg contains: Vit A: 10,000,000 IU; Vit D3: 2,500,000 IU; Vit E:20,000mg; Vit K3: 3,000mg; Vit B_3:3,000mg; Vit B_2: 7,000mg; Vit B_6: 5000mg; Vit B_{12}: 25mg; Biotin: 20mg: Niacin: 15,000mg; Pantothenic Acid: 10,000mg; Folic Acid:8500mg; Manganese:80,000mg; Zinc:60,000mg; Iron:40,000mg; Copper:8,000mg; Iodine: 1,000mg; Selenium (1%): 150mg; Cobalt:250mg; Choline:200,000mg and Antioxidant: 100,000mg.*

Statistical model and data analysis

The statistical model adopted was:

$Y_{ij} = \mu + B_i + E_{ij}$

Where Y_{ij} is Individual Observation, µ is the population mean, B_i is the effect of housing systems and E_{ijk} is the residual error.

Data analysis was done using Analysis of Variance in a Completely Randomized

Experimental Design. Significant (P<0.05) differences among means were separated using Duncan's Multiple Range Test as contained in the Statistical Analyst System (SAS, 2003) package.

RESULTS

The results of the laying performance of guinea fowl reared in the three housing systems as presented in Table 2 show a significant (p<0.05) effect of the housing system on weight gain, feed intake, feed per kg egg, body weight at 1st egg lay and hen day egg production. Birds in deep litter with run had the highest total egg produced (209.00±6.03) and hen-day egg production of 15.58±0.05 compared to cage (81.67±3.17 and 6.64±0.10, respectively) and those of deep litter, (197.00±4.51 and 14.67±0.78 respectively). However, the values were statistically similar for guinea fowls raised in deep litter and deep litter with a run. Table 3 shows a significant effect of housing systems on egg weight, shell thickness, and egg shape index. Guinea fowl reared in the cage had a significantly higher shell thickness. Yolk color was mostly intense in eggs from guinea fowl kept in the deep litter with run housing.

Table 2: Effect of housing system on laying performance of guinea fowl hens (24 to 40 weeks of age)

Parameters	Housing systems		
	Deep litter	**Battery cage**	**Deep litter with run**
Weight gain(g/bird)	395.33±33.75^{ab}	415.33±14.01^{a}	375.00±2.33^{b}
Feed intake (g/bird/day)	75.59±0.24^{a}	75.09±0.12^{b}	75.32±0.13^{ab}
Feed/kg egg laid	6.71±0.14^{a}	6.12±0.62^{b}	6.31±0.17^{a}
Hen-housed per replicate (no)	13.00	13.00	13.00
Age at 1st lay (wk)	27.67±0.33	25.33±1.67	27.33±0.33
Body wt. at 1st egg lay(g)	1387.08±0.07^{b}	1423.04±0.15^{a}	1413.20±0.07^{ab}
Hen-day egg production (%)	14.67±0.78^{a}	6.64±0.10^{b}	15.58±0.50^{a}
Total egg production per week (no)	197.00±4.51^{a}	81.67±3.17^{b}	209.00±6.03^{a}
Survivability (%)	92.31±10.33	84.62±10.58	92.31±10.33

^{a,b} Means on the same row with different superscripts are significantly different (p<0.05).

Table 3: Egg quality traits of guinea fowl hens raised in different housing systems

Parameters	Housing systems		
	Deep litters	**Cage**	**Deep litters with run**
External egg quality			
Egg weight (g)	35.66±0.13[ab]	35.11±0.82[b]	37.02±0.17[a]
Egg length (mm)	42.69±0.22[a]	37.23±2.89[b]	41.94±0.17[ab]
Egg breadth (mm)	33.95±0.23	28.53±3.04	34.11±0.30
Egg shape index (%)	78.63±0.27[ab]	73.91±2.89[b]	80.24±0.56[a]
Shell weight (g)	5.66±0.23	5.51±0.04	5.58±0.08
Shell thickness (mm)	0.58±0.01[b]	0.64±0.03[a]	0.53±0.01[b]
Shell weight (%)	15.87±0.24	15.69±0.44	15.07±0.12
Internal egg quality			
Albumen height (mm)	6.15±0.06	6.48±0.29	6.59±0.11
Albumen weight (g)	18.63±0.35	18.20±0.25	18.24±0.08
Albumen index %	50.33±0.87	50.99±0.49	51.13±0.13
Albumen pH	8.76±0.03	8.49±0.13	8.50±0.01
Yolk weight (g)	10.60±0.12	10.43±0.17	10.41±0.09
Yolk weight (%)	28.68±0.18	29.33±0.35	29.24±0.24
Yolk height (mm)	13.17±0.11	13.78±0.37	13.25±0.15
Yolk color	1.54±0.07[b]	1.74±0.13[b]	5.51±0.07[a]
Haugh unit	87.93±0.64	87.55±1.40	87.98±0.37

[a,b] = Means on the same row with different superscripts are significantly different (p<0.05)

There was a significant (p<0.05) difference in white blood cells and lymphocytes (Table 4). The white blood cell counts were significantly (p<0.05) highest in birds on deep litter but similar to the values obtained in birds on deep litter with run and lowest in birds in the cage housing system. However, lymphocyte values were statistically similar in deep litter and deep litter with run but lower than that of the cage. In Table 5, the albumin showed that guinea fowl on deep litter (2.50 g/dl) and deep litter with run (2.57 g/dl) was significantly higher than caged fowls (1.67 g/dl), the same trend was observed in glucose values, with deep litter (205.00 mg/dl) and deep litter with run (208.33 mg/dl) having higher values, while cage has a lower (182.33 mg/dl), on the contrary for globulin, the cage had the highest (1.93 g/dl) followed by deep litter with run (1.70 g/dl), and then deep litter (1.43 g/dl). No significant differences were noticed in uric acid which demonstrated similar levels among the housing systems, meanwhile, comparable cholesterol levels were observed in all housing with no significant differences.

Table 4: Effect of housing system on haematological indices of guinea fowl hens

Parameters	Housing Systems		
	Deep litter	**Cage**	**Deep litter with run**
Packed cell volume (%)	37.00±4.73	40.67±5.78	37.00±1.53
Hemoglobin (g/dl)	12.30±1.27	13.10±2.06	12.28±0.66
Red blood cells ($x10^{12}$/L)	2.73±0.35	3.0±0.40	2.73±0.12
White blood cells ($x10^{9}$/L)	21.20±1.73^{a}	13.70±1.01^{b}	20.20±1.10^{a}
Lymphocytes (%)	67.00±1.53^{b}	74.00±1.15^{a}	66.00±2.08^{b}
Eosinophils (%)	0.67±0.67	0.33±0.33	0.33±0.33
Basophils (%)	0.00±0.00	0.33±0.33	0.00±0.00
Monocytes (%)	0.33±0.33	0.67±0.33	0.00±0.00
Mean cell volume (fl)	135.33±0.33	135.33±1.45	135.67±0.33
Mean cell hemoglobin (p_g)	47.67±2.91	43.67±1.20	44.67±1.20
MCHC (g/d)	33.47±0.79	32.07±0.52	33.13±0.78

$^{a, b}$ Means on the same row with different superscripts are significantly different ($p<0.05$).

Table 5: Effect of housing system on serum chemistry of guinea fowl hens

Parameters	**Housing Systems**		
	Deep litter	**Cage**	**Deep litter with run**
Total protein (g/dl)	3.93±0.30	3.60±0.12	4.27±0.18
Albumin (g/dl)	2.50±0.06[a]	1.67±0.09[b]	2.57±0.12[a]
Globulin (g/dl)	1.43±0.28	1.93±0.09	1.70±0.06
Uric acid (mg/dl)	4.23±0.45	4.57±0.32	4.23±0.56
Glucose (mg/dl)	205.00±6.81[a]	182.33±5.55[b]	208.33±4.41[a]
Cholesterol (mg/dl)	102.67±2.91	104.33±6.69	99.67±3.18

[a, b] Means on the same row with different superscripts are significantly different ($p<0.05$)

DISCUSSION

The highest weight gain obtained in guinea fowl in the cage was a spectacle that cannot be explained however the value is not statistically different from the value obtained in birds on deep litter with run. The deep litter housing may provide the birds with non-digestible particles that, upon ingestion, have remarkable effects on digestibility, feed efficiency, growth, and meat yield (Santos *et al.*,2012). Traditionally, dietary fibre has been considered an anti-nutritional factor and a diluent in poultry diets. Several reports show a strong negative correlation between the fiber content of the diet and the digestibility of protein and fats. Those reports also indicate that increased fibrous components of the diet reduce growth performance and impair nutrient retention in turkeys and broiler chickens. This dietary fibre cannot be hydrolyzed by the digestive enzymes in the small intestine but can be fermented to a certain degree by the microflora in the GIT. It was reported by Santos *et al.* (2012) that broilers reared in a conventional litter-based house had superior growth performance results when compared to those raised in a non-litter cage-based housing system. Birds in the three housing systems investigated were fed the same commercial diet and the fowls reared in cages consumed less feed and gained more body weight with less kilogram egg laid compared to fowls reared in deep litter and deep litter with the free run house. This affirms the fact that the housing system is an external factor that influences growth and production. Sekeroglu *et al.* (2009) concluded that the free-range housing system significantly decreased the total feed intake and body weight of broilers. Current feed intake findings comply with the results of previous studies indicating higher feed consumption for the deep litter or floor system than for the cage system. Layers kept in the litter system consumed more feed than the layers housed in cage systems. Feed consumption here was higher for the floor system (deep litter and deep litter with free run) than for the cage system. This was in line with the findings of Preisinger (2000) who reported that birds in floor systems ate more feed than those in cage systems.

Heavier eggs obtained in the deep litter with a free-run housing system can be associated with access to an open-free run, where fowls could supplement their diet from vegetation and invertebrates. According to Sokołowicz *et al.* (2018) free runs inhabited by soil invertebrates, including earthworms are rich in nutrients which can be an additional source of protein for fowls. Also, green forage consumed in the run can supply additional nutrients to fowl rear in the deep litter with a free-run housing system (Sokołowicz *et al.,* 2018). There are diverse reports on the effects of housing on egg weight and egg production. The values of egg weight (37.02±0.17, 35.11±0.82, 35.66±0.13 g) reported for guinea fowls in this study were lower than the egg weight of the indigenous pearl and black guinea fowls reported by Obike *et al.* (2011). The reason for this disparity in reports could be due to environmental and genetic variations that affect egg weight. (Goto *et al*., 2021). Egg weight values of the three-housing system were in the range reported by Kyere *et al*. (2017) in their study who obtained a mean egg weight of 23-39 g for the small egg size group of guinea fowl.

The cage housing system physically shortened age at 1st lay but with a concomitant increase in body weight at 1st egg lay relative to other housing treatments used in this study. Also, guinea fowl raised in deep litter with free run housing system had better egg-laying performance in terms of the total number of eggs laid and hen day egg production when compared with battery cage and deep litter housing systems. Hen day egg production was 120% better in both deep litter and deep litter with run housing compared to cage-reared fowls. The hen day egg production of guinea fowl in deep litter with free run was 6% better than those reared in deep litter house.

In this study, eggs from deep litter with or without free run were characterized by a higher shape index than eggs from the cage system. Dalle Zotte *et al*. (2013) observed no significant effect of the rearing system on the egg shape index compared to what was obtained in this study. The typical elliptic egg shape has been considered a beneficial trait because it reduces breaking losses during transport, As suggested by Nedomová *et al.* (2009) the egg shape index influences eggshell strength. The higher mean shell thickness values obtained in this study may be due to fatigue or stress associated with cage housing wherein birds are unable to exercise or exhibit their natural behavior. The shell formation is by activities of cells of the oviduct and uterus and under stress conditions, the secretions of these cells may become acidic which may damage or destroy these cells and can induce the formation of eggshells that have high or excess deposits of calcium. The observation of more golden yolk in eggs from the guinea fowls reared in the deep litter with free run compared to the eggs from other housing systems corroborated the claims of Sokołowicz *et al.* (2018). This was so because the fowls on the free run had access to green plants which are abundant in the pigment xanthophyll. The Haugh unit value obtained in this study is higher than the 70% benchmark noted for quality eggs.

A significant difference was noticed in the white blood cell count and lymphocytes. The white blood cell count was significantly higher in the deep litter with a run and deep litter than those in the cage. These values are signals that the birds were in a perpetual state of well-being for the research interval. The WBCs are responsible for defending the body against infections, while high lymphocytes indicate that the body of the bird is dealing with an infection or inflammatory condition, A spike in lymphocytes means that white blood cells are springing into action to read the body of causes of ill-health. (Adedibu *et al*., 2014). The insignificant difference noted in blood serum biochemistry indices across housing systems seems to suggest that birds are healthy and underwent varying housing systems without any stress. Based on the results of this study, laying guinea fowl hens showed a better egg production potential when raised in the deep litter with free run housing system, and raising them in either deep litter or deep litter with free-run housing systems will give them optimum health compared to rearing them in cage housing.

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