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ORIGINAL RESEARCH ARTICLE

Effects of breed and rearing systems on the performance and egg quality characteristic of three commercial layers

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ABSTRACT
This study was designed to evaluate the effect of breed and different rearing systems on the performance and some egg quality characteristics of 3 commercial laying chickens in an 18-week trial. A total of three hundred and sixty 12-week-in-lay commercial laying hens of three different breeds; Bovan Nera (BN) Dominant Black (DB) and Harco Black (HB) were used with each of the breed divided into two batches. Each batch of a breed was randomly assigned to either cage or deep litter in a 2 x 3 factorial arrangement in completely randomized design (CRD). Feed intake, weight gain, feed conversion ratio (FCR) and hen day production were determined on weekly basis. Thirty (30), eggs per rearing systems per week were analyzed for determination of internal and external egg parameters using the standard procedure. Out of the three breeds examined, Dominant had the highest yolk weight, shell weight, shell thickness+membrane and HU. No significant ($p > 0.05$) difference was recorded in the systems of rearing except for HU which had the highest mean value (90.58 ± 0.46) observed in the eggs from the cage. Breeds were observed to be different in egg qualities with DB having best quality yolk weight, shell weight shell thickness + membrane, HU, Yolk height and albumin height of egg and FCR among the three, BN produced the heaviest eggs while HB was the highest producer of eggs. Dominant breed reared in the cage had the best result.

Keywords: Breed, deep liter, Egg quality traits, Rearing systems

INTRODUCTION

Poultry production has been identified as a means of ensuring sustainable family income which can be established with minimum capital as a side-project (Sani *et al.*, 2000). Commercial layer strains have been known to produce eggs for human consumption as well as for egg processing industries, especially in this period of high demand for egg products like liquid egg, powdered egg and liquid yolk and yolk oil. The success of commercial egg laying farming enterprises depends on the total number and size of the eggs produced by the flock per day. The performance of chickens is determined in part by genotype and by environmental factors. Genotype is transmissible, while the environmental factors must be controlled in ways that maximize expression of genetic potential and overall performance. Also, external and internal quality traits of the eggs are significant in poultry breeding for their influence on the yield, features of the future generation, breeding performance, quality and growth of the chicks (Altinel *et al.*, 1996). Moreover, in some developed countries where eggs are processed, some of the egg quality traits have direct effects on egg prices.

MATERIALS AND METHODS

The experiment was carried out at the Poultry unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria, while further studies on egg parameters were carried out at the Department of Animal Production and Health Laboratory of the same University. Akure is situated on 350.52m above sea level at latitude 7° 14'N and at longitude 5° 14'E. The vegetation of the area is that of the rainforest characterized by hot and humid climate. The mean annual rainfall is about 1500mm; the rain period is bimodal with short break in August with mean annual relative humidity of 75% and mean temperature of 20°C.

Experimental birds and layout

A total of three hundred and sixty (360) layers of three (3) different breeds; Bovan Nera, Dominant Black and Harco Black that were twelve (12) weeks in lay were used for the experiment. There were 120 layers per breed. Each breed of the laying chickens was divided into two which was later assigned randomly to either cage or floor (deep litter) in a 2 x 3 factorial arrangement in completely randomized design (CRD). Birds were fed commercial feed and

water *ad libitum*. All routine and occasional management practices were observed for the eighteen-week trial. 30 eggs were collected on weekly basis for egg quality determination.

Experimental diets and animal management

A commercial layer feed was used in feeding the laying chickens twice daily and water was supplied *ad libitum*. The layers were randomly divided into two batches with 180 birds per batch. A batch was reared in battery cage system having two tiers and a stocking rate was 2 birds each in a well-ventilated poultry pen and the second batch was kept on deep litter system having a standard dimension, with wooden laying nests, well cemented pen walls and asbestos roof. The litter material used was wood shavings and it was changed on a weekly basis. At the end of each week (precisely on the early morning of its eight day), Birds were fed daily from a predetermined quantity contained in a polythene bag. At the end of the week, the feed intake per housing system was evaluated as the difference between the initial weight in the bag and the sum of leftovers in the bag. Water was given *ad libitum.*

Data collection

At the beginning of the week, a known quantity of feed was measured for the birds, additional feed was added according to the feeding demand of the birds. At the end of each week, feed was withdrawn, and the remnant was weighed using an electronic balance as well as the weight of the birds that week. Weight gain was measured cumulatively by subtracting the initial weight (weight at the 13th week of lay) from the final weight. Feed conversion ratio (FCR) values were obtained as a ratio of feed intake to the weight gained by the birds thirty (30) eggs were collected per housing system from each of the breeds and taken to laboratory for egg quality determination on weekly basis. The length of each egg was determined using Vernier calliper calibrated in centimeters while egg was weighed before being carefully broken out on a table with Formica top and the yolk was separated from the albumen with the aid of a tablespoon. It was then allowed to rest for five minutes before height of albumen and yolk was determined by dipping a calibrated pin. Shells of broken eggs were cleaned of albumen under slowly running water and air-dried for two days before the weights were taken. The egg, yolk and shell weights were determined with sensitive scale calibrated in grammes. The albumen weight was calculated by subtracting the sum of the weights of the shell and the yolk from the total egg weight. Shell thickness was measured with micrometer screw gauge.

Hen-day production (HDP) in percentage was calculated by adding all the eggs per replicate on weekly basis using the formula below:

$$\text{HDP} = \frac{Ne}{Nb\,x\,7} \text{ X } \frac{100}{1}$$

Where Ne = Number of eggs laid per replicate per week

Nb = Number of birds per replicate

7 = Number of days per week

Yolk weight percentage which is the ratio of the yolk weight to the egg weight was calculated as:

$$\%\text{ Yolk weight} = \frac{Yolk\,Weight}{Egg\,Weight} \text{ x } \frac{100}{1}$$

Albumen heights in millimeter were taken with the aid of broom stick and a ruler which was used for the calculation of the Haugh Units. Haugh unit = $100\log\ (AH + 7.57 - 1.7(EW^{0.37}))$

Where AH = Albumen height; EW = Egg weight

Data Analysis

All the data collected were subjected to analysis of variance using Statistical Analysis System (SAS) 2008 version 9.2. Means were separated using Duncan Multiple Range Test (DMRT) of the same package.

RESULTS

Table 1 shows the performance parameters of the 3 breeds of laying hens. The daily feed intake (DFI) of the 3 breeds ranged from

107±0.62 to 111.00 ± 0.97g with Harco Black having significantly highest DFI value. The highest non-significant value of final weight was recorded for Dominant breed (1.63±0.02g) while Harco black had the highest total weight gain (0.10±0.02), although not significantly different from those recorded for Bovan Nera (0.09±0.01) and Dominant (0.09±0.01) respectively. The Hen day production of laying chicken was observed to be significantly (p>0.05) highest in Harco Black breed (83.19±0.90).

Observation showed that rearing systems (cage and floor) has a significant (p>0.05) influence on the total feed intake, daily feed intake and hen day production. The cage rearing system had the significantly higher recorded values for the DFI (112.76±0.42G) and Hen Day production (78.95±0.55%), compared with those values recorded for the floor (106.31±0.19g and 78.95±0.55%) respectively.

The interaction effect between the breed and rearing systems were not significantly influenced across the 3 breeds. For the Bovan Nera, the interaction effect of DFI was observed to be higher in the cage system (113.00±0.01) compared to that of the floor rearing system, while the HDP also had a higher value in the cage system (85.58±0.30). The interaction between the Dominant breed and cage system was higher for the DFI (110.00±0.01) compared with the floor system (105.00±0.01) while for the HDP, the value recorded for the cage system (85.97±0.07) was higher. The cage system of Harco black breed was recorded to have a higher total feed intake (12075.00±0.01) DFI (115.00±0.01) and hen day production (86.04±0.19) compared to values observed for the floor systems 11235.00±0.01, 107.00±0.01 and 79.89±0.7 respectively)

Table 2 reveals the egg quality traits of three breeds of laying chicken at 30 weeks in lay raised on two different rearing systems. The three breeds differed significantly (p < 0.05) for yolk weight, shell weight, shell thickness + membrane, and Haugh unit with Dominant having the highest mean values of 17.65±0.23 g, 5.89±0.07 g, 0.39±0.01 mm, and 91.57±0.53 respectively. For the other traits, Bovan Nera had the highest values of 60.01±0.83g, 54.93±0.36mm and 35.83±0.55 for egg weight, egg length and albumen weight respectively while yolk height and albumen height had their highest values (41.87±0.22 and 7.85±0.08 mm) observed in Dominant. The interaction between the breed and rearing systems was significantly influenced in the egg qualities of the laying birds as observed in the yolk weight, shell weight, shell thickness + membrane and Haugh unit. The highest mean values recorded for the yolk weight (17.65±0.23), shell weight (5.89±0.07), shell thickness +membrane (0.39±0.01) and Haugh unit (91.57±0.53) was observed in the Dominant breed. For the interaction between breed and cage, Dominant had the highest values for the other traits except albumen weight, while the observations in the breed and interaction showed that the highest values varied among the three different breeds for egg qualities. There was no significant (p > 0.05) difference in the two systems of rearing for all the egg qualities except Haugh unit with the highest mean value (90.58±0.46) observed in the eggs from the cage. However, higher values were observed in the other qualities for eggs from the floor.

The phenotypic and genetic correlations of the qualities of the eggs of three breeds of laying chickens are shown in Table 3. It can be observed that the phenotypic and genetic correlations for the internal qualities and external qualities of the eggs were similar for majority of the relationships except for the following five relationships: Egg weight (EW) and Albumin weight (AW); Egg weight (EW) and Shell weight (SW); Egg weight (EW) and Shell thickness (ST); Egg length (EL) and shell thickness (ST); and Albumin height (AH) and Haugh Unit (HU). However, the relationship was mainly positive except in some few relationships (AW and YH, AH and YH, HU and YH, and HU and AW) that had no significant relationship (p > 0.05). The highest relationship existed between YH and YW (0.89) for phenotypic and genetic correlations while the poorest relationship, although negative, was found to be between AH and YH (-0.37) for both correlations.

For genetic correlations of the external qualities, the relationship between EL and EW (0.41), SW and EW (0.71) and ST and SW (0.35) were all noticed to be highly significant (p < 0.001). The same was also observed for the phenotypic correlations but with different values: EL and EW (0.41), SW and EW (0.16), ST and EW (0.78) and ST and SW (0.35). For both genetic and phenotypic correlations, the relationship SW and EL (0.26) was noticed to be significant. For the internal qualities, significant relationship ($p < 0.05$) was observed to exist between YH and YW, AH and AW, and HU and AH for both the genetic and phenotypic correlations. The (YH and YW) has a better relationship than the (AH and YH) relationship in the internal qualities as stated above. The correlations among the other inter and external qualities were seen to be insignificant ($P>0.05$).

DISCUSSION

Effect of Breed on Performance Characteristics

In this study, egg production of Harco Black and Dominant was similar to those of Dominant and Bovan Nera. Although the three breeds had very good hen day production, it is noteworthy that Harco Black commercial hens had the highest egg production, though similar to Dominant and Bovan Nera. This is likely to be as a result of the intensive selection of commercial brown egg layers which might have brought their production to similar levels (Scott and Silversides, 2000). Despite being the breed that consumed the lowest quantity of feed, Dominant was found to have the heaviest weight. This might be due to its initial weight. Meanwhile, Harco Black had the highest weight gain with the highest feed consumption and this could be the reason while it produced the highest number of eggs across the breeds.

Effect of Rearing Systems on Performance Characteristics

The amount of feed consumption by floor hens was comparatively lower than that of caged hens. This was evident in the daily feed intake of the hens. This observation was in contrast to the findings of Preisinger (2000), who reported that birds in non-caged system tended to eat more feed compared to conventional cage to provide energy for heat production to compensate for the lower heat. Furthermore, the results from previous study (Emmans and Charles, 1977) have indicated that higher stocking densities in conventional cage hen have been associated with ease of maintaining temperature within the optimal range, resulting in lower feed consumption. It therefore meant that with the stocking density of three birds per cage cell, the hens were likely to consume more feed in order to maintain temperature within the optimal range. However, Tactacan *et al.* (2009) found no variation in feed consumption between conventional cage and non-cages. Birds kept in the cage were only slightly heavier than floor birds probably due to the fact that initial mean weight of the birds in cage was higher than those on the floor. Meanwhile, floor birds gained more weight with lower quantity of feed when compared with the cage birds. It therefore showed that the feed was utilized and converted more by floor hens than the cage hens. This might be due to the high rate of metabolism in the floor hens as they had unrestricted movement which required higher amount of energy. Also, the birds used the increased space more effectively for their physical activities than those in cage. Heavier birds in the floor pens could be attributed to better physical condition.

Egg production of the three breeds of laying hens was lower in floor pens than in cages, possibly because more energy were required for the expression of natural behavioural activities like litter scratching and flight. This was in consonance with Abrahamsson *et al.* (1996) who reported that egg production of laying hens was higher in conventional cage than those housed in alternative systems such as aviaries, floor pens, or free range. Although, it was against the report of Yakubu *et al.* (2007) who found that eggs from conventional cages were larger than those from floor pen, the egg weights in the deep litter hens were higher than that of the cage hens in this experiment. This observation was in line with Vit *et al.* (2005b) and Singh *et al.* (2009) who discovered greater egg weights in floor pens than in conventional cages and this could have correlated with live weight and egg production.

Effect of Breed on Egg Qualities

The study revealed that the three breeds showed differences in the qualities of the eggs especially in yolk weight, shell weight, shell thickness with membrane and the Haugh unit. Dominant produced eggs with the best qualities and the heaviest eggs were laid by Bovan Nera. This showed that egg shell quality traits were more affected by the breed than the rearing system. The least egg weight (57.74±0.79g) was observed in Harco Black hens in comparison with Bovan Nera (60.01±0.83g) or Dominant (59.69±0.76g). The highest recorded yolk weight was observed in the Dominant breed (17.65±0.23g) as compared with the Bovan Nera (17.22±0.21g) and Harco Black (16.79±0.22g). The effect of breed on yolk weight was described by Leyendecker *et al.* (2001), Singh *et al.* (2009) and Tumova *et al.* (2009b). The effect of breed was also important for albumen quality which was confirmed by significant differences within three breeds and was in accordance to Tumova *et al.* (2011). The highest Haugh units were detected in eggs from Dominant hens (91.57±0.53) while the lowest ones in eggs from Bovan Nera hens (88.16±0.53).

Effect of Rearing Systems on Egg Qualities

Growing consumer demand has led to cage-free methods of poultry production, including free-run systems (Savory, 2004), which allow expression of a greater behavioural repertoire compared with conventional cages (McLean *et al.*, 1986). However, the effect of changing from conventional cages to other systems on production traits requires investigation, especially in relation to the ability of different strains of chickens to adapt to these alternate systems. It is reported that egg quality traits including albumen height, Haugh units, egg shell thickness are superior in birds housed in cages than in birds kept on litter (Lichovnikova and Zeman, 2008; Tumova *et al.*, 2009b; Singh *et al.*, 2009).

This study showed that the rearing system did not affect the egg weight although value was higher in the deep litter system. Egg weight is one of the most important economic parameters of egg production and the effect of different factors on egg weight would therefore influence the economics of egg production on a farm. Egg weight increased with advancing hen age in deep litter system which was in support of Tumova *et al.* (2009a), although it was not affected by the system of rearing.

Heavier yolk, higher yolk height and heavier albumen were found in deep litter eggs, this was in agreement with Singh *et al.* (2009) who reported the same observation. Internal egg quality can be expressed through Haugh units which are more accurate indicators of egg quality in comparison with albumen height. The albumen height of the eggs studied was observed to be higher in those laid by cage hens. However, the effect of rearing system was only significant for Haugh unit with lower values observed majorly in the deep litter system throughout the experiment. Inferior quality of albumen in deep litter systems was described by van den Brand *et al.* (2004), Hidalgo *et al.* (2008), Singh *et al.* (2009) and Tumova *et al.* (2009b). The results of this study for albumen quality were also in agreement with the finding of Benton and Brake (2000) who reported that lower albumen quality in eggs collected from the deep litter system and observed that this may be due to the fact that eggs from a litter system are more exposed to ammonia from litter, which according to Robert (2004) would reduce the albumen quality. Besides, Leyendecker *et al.* (2001) stated that the effect of rearing system on Haugh units depended on strain because Haugh units of eggs from hens kept in free range did not differ significantly from cage eggs.

The present results for eggshell weight agreed with the finding reported by van den Brand *et al.* (2004) who observed greater eggshell weight in eggs from deep litter layers.

Effects of Interaction of Breed and Rearing System on Egg Qualities

The interaction of rearing systems with breed did not produce a significant variation in all the egg quality traits bar Haugh unit. Generally, Haugh units were dependent on breed in all rearing systems (Tumova *et al.*, 2011) which corresponded with the results of Leyendecker *et al.* (2001) and Singh *et al.* (2009). The interaction of the Dominant breed with cage had the best Haugh unit.

Genetic and Phenotypic Correlation of the Qualities of Egg

Genetic and phenotypic correlations of the qualities traits of eggs in this study were generally high and positive except in some few negative correlations. The positive relationships indicated unidirectional movement among the parameters, that is, they were moving towards the same improvement direction. The genetic correlations among the parameters followed the same trend as that of the phenotypic correlations between the parameters. Egg weight (EW) had the best relationship with most of the parameters especially, with the positive correlations with other qualities examined.

Yolk height (YH) had the strongest relationship with the yolk weight (YW) but was not in accordance with Kul and Seker (2004) that found the strongest relationship to be between AW and EW in their study. Moreover, Stadelman (1986) stated that 0.26 was the positive correlation value between the egg weight and the shell thickness (ST). Using this value (0.26) as standard, positive correlation was noticed in this study where the phenotypic correlation between EW and ST was low, and the genetic correlation was high which was in accordance with Silversides and Scott (2001) findings that stated that heavier eggs tended to have thicker shells.

CONCLUSION

The results obtained in this study showed that there is a distinction between the breed and type of rearing systems. Although the three breeds evaluated had good quality eggs, Dominant breed was observed to have the best egg quality traits. Good shell thickness which was exhibited by the 3 breeds revealed that rearing of Dominant breed especially in the cage will give the best result.

CONFLICT OF INTEREST

Authors have declared no conflict of interest concerning submission of this manuscript for publication.

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