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Performance and Correlation of Egg Quality Traits of Dominant Black and Bovan Nera Layers Fed Diets Supplemented with Praseodymium

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ABSTRACT

The effects of supplemental Rare Earth Element (REE), praseodymium and breeds on the egg quality traits of two commercial layer breeds (Dominant Black and Bovan Nera) were investigated in a twelve week experiment. Each of the breeds was placed on four dietary treatments of 40 chickens which were divided equally into 4 replicates, thus resulting to 160 birds per breed. Two diets (growers' and layers') were formulated to meet the nutrient requirements of each phase of production. Each diet was divided into four (4) equal parts. A portion was designated the control diet (no supplemental praseodymium). The 2nd, 3rd, and 4th portions were supplemented with praseodymium at 50, 100 and 150ppm respectively. Each diet was fed to 40 birds and the experiment arranged in a 2 x 4 factorial in a completely randomized design. At 32 week of age, forty (40) eggs collected per treatment from each of the breeds were taken to laboratory for egg quality determination. Results showed that the correlations between the internal and external qualities of the eggs were generally positive and moderately high with some exceptions. Significant ($p \leq 0.05$) relationship existed between egg weight and other qualities. Eggs from Bovan Nera had higher shell thickness (0.37±0.00 mm), shell weight (5.84±0.04 g), albumen height (7.25±0.07 mm), Haugh unit (84.88±0.41), and percentage shell weight (9.80±0.06) compared to those from Dominant Black. The egg qualities were significantly influenced by supplementing the diet with praseodymium at 100ppm. Generally, the two layer breeds performed well under the various treatments but Bovan Nera produced eggs with better quality. Dominant Black had the better feed conversion ratio (2.98±0.00) and hen-day production (85.56±0.37 %) while the 50 ppm inclusion level of praseodymium had the best feed conversion ratio (2.98+0.01).

Keywords: Egg quality traits, Breed, Praseodymium, Dominant Black, Bovan Nera, Rare Earth Elements (REEs).

INTRODUCTION

Feeding the world's population with high-quality food is the core aim of agricultural production. In view of the growing world population, this challenge will continuously become larger, especially in big cities of developing countries (Robert, 2010). The production of eggs in these regions will be of increasing importance as they provide a relatively cheap source of animal protein. The hen's egg has traditionally been considered as an important source of nutrients for humans. Nowadays, it is widely recognized that eggs are more than a source of dietary nutrients; extensive studies identifying and characterizing their biologically active components have been carried out (Mine and Kovacs-Nolan, 2004). Egg production (egg number) is the major index of performance of the commercial layer as it accounts for about 90 per cent of the income from laying hens (Oluyemi and Roberts, 2007). Other economically important traits include egg qualities (particularly egg size), the efficiency of feed utilization and mortality (Oluyemi and Roberts, 2007).

In the world today, there is an increasing demand for food as well as increased meat production. The full ban of antibacterial growth promoters has seriously affected post weaning health and performance (Lynch, 1999). This necessitated the development of new finding and health care strategies. Therefore, there is a strong need for alternative growth promoters such as pro- and prebiotics, enzymes, organic acids as well as herb extracts (Wenk, 2003). These feed additives have to be efficient, safe and should not harm the environment (Khan, 2004). A very new approach in this respect is the supplementation of feed with Rare Earth Elements (REEs) (Rambeck, 2006). According to Rambeck (2006), the REE are not particularly rare in the earth crust, but the term persists.

It has been reported by Rambeck (2006) that REEs increased milk and egg production. This assumption was not verified in Nigeria except for Adu *et al.* (2006, 2009) and Akinmuyisitan *et al.* (2015). In animal production, as with plants, amazing results have been achieved by supplying REEs in animal diets. It was reported by Rambeck (2006) that proper concentrations of REE in diet can improve animal growth performance without affecting quality of products. Feeding experiments performed under western conditions showed that dietary supplementation of REEs had positive effects on both animal growth and feed conversion of pigs and poultry (He and Xia, 1998; Rambeck *et al.*, 1999; He *et al.*, 2001, 2006a,b). Based on results obtained from western feeding experiments, the effects of dietary REEs vary with the animal species. Yet, the concentration and type of REEs as well as the composition of individual REEs have also been shown to be important factors influencing their performance enhancing effects on animals (He *et al.*, 2003, 2006a,b). Therefore, this study was undertaken to evaluate the effects of breed and supplementation of praseodymium on the performance, internal and external egg quality characteristics of two breeds of laying hens at different ages through phenotypic and genetic correlations.

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. Further studies on egg parameters were carried out at the Laboratory of the Department of Animal Production and Health, Federal University of Technology Akure, Ondo State, Nigeria. Akure lies 350.52 m above sea level on the geographical coordinate of 7° 58' 0" N, 8° 46' 0"E. The vegetation of the town is that of the rainforest while the climate is humid tropical characterized by wet and dry season transitions. The mean annual rainfall is between 1700 and 2200 mm. The rainy season is bimodal with short break in August. The mean annual relative humidity of the town is about 75% while mean temperature is about 25°C.

Experimental birds and layout

Three hundred and twenty (320) pullets of two (2) breeds (Dominant Black D 109 and Bovan Nera) of fifteen (15) weeks old were obtained from a reputable farm and 40 birds assigned to 4 diets and replicated 10 times. The experiment was arranged in a 2 x 4 factorial arrangement in completely randomized design (CRD). All routine and occasional management practices were observed for the eighteen-week feeding trial as outlined by the Teaching and Research farm of Federal University of Technology, Akure. Each breed has a total number of 160 birds and eggs were collected at the last week of the experiment for examination.

Experimental diets and animal management

Experimental (growers' and layers') diets, which met the nutrient requirements of growing and laying chickens, were formulated to meet the National Research Council (1994) standard. The growers' diet (15 – 19 weeks) was mixed in one batch and divided into four equal portions. Praseodymium, a rare earth element, was added at 0, 50, 100 and 150 ppm respectively to each portion of the diet. Each diet was, thereafter, mixed thoroughly. Similar procedure was undertaken for the layers' diet (20 – 32 weeks). The praseodymium was obtained from BDH Chemical Ltd, Poole, England. The gross and analyzed compositions of the experimental diets are presented in Table 1. The layers were reared in battery cage system with well ventilated poultry pen. Daily feed consumptions were measured while the trial lasted.

Table 1: Gross composition (g/100gDM) of the experimental diets

Ingredients	Growers %	Layers %
Maize	51.80	53.50
Brewers' dry grain	16.00	12.00
Groundnut cake	2.00	10.00
Maize offal	2.00	4.00
Wheat offal	20.00	11.50
Palm kernel cake	2.00	-
Fish meal	4.50	3.00
Bone meal	1.00	3.00
Oyster shell	-	2.00
Lysine	-	0.10
Methionine	0.20	0.40
Salt	0.25	0.25
Grower premix	0.25	-
Layer premix	-	0.25
Total	100	100
Calculated Analysis		
Metabolisable Energy (Kcal/kg)	2748.58	2748.57
Crude Protein (%)	15.87	16.54
Crude Fibre (%)	6.65	5.55
Ether extract	4.65	4.48
Ca	0.72	2.06
Phosphorus	0.43	0.67
Lysine	0.75	0.75
Methionine	0.51	0.68

Composition: Vitamin/Mineral Mix 1 kg (layers):Vitamin A 1000000 IU, Biotin 40 g, Vitamin B12 10 mg. Folic acid 500 mg, Manganese 4800 mg, Zinc 58 mg, Iron 5800 mg, Selenium 120 mg, Iodine 60 mg, Cobalt 300 mg. Composition of methionine 20,000 mg, Butylatedhydroxytolerance BHT 50,000 mg.

Experimental procedure

Feed was supplied from a pre-determined quantity contained in a polythene bag. At the end of each week (precisely on the early morning of its eight day), the intake per replicate was evaluated as the difference between the initial weight in the bag and the sum of the leftovers in both the bag and the feeding trough. Weight gain was measured cumulatively by subtracting the initial weight, taken at 20th week, from the final weight. Feed conversion ratio (FCR) values were obtained as a ratio of feed intake to the weight gained by the birds. At 32 week of age, forty (40) eggs collected per treatment from each of the breeds were taken to laboratory for egg quality determination. Each whole egg was weighed before being carefully broken out 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 was measured with an optical pin placed on top of the albumen against an adjacent wooden surface to the table-top. The albumen height was subsequently determined using mathematical dividers to measure the distance from the table-top to the optical pin. The distance between the dividers (that is, albumen height) was determined with the use of a ruler. Shells of broken eggs were cleaned of albumen under slowly running water and air-dried for two days before their weights were taken. The egg weight, yolk weight and shell weight 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. Percentage shell weights were measured by finding the ratio of the shell weight to the egg weight, expressed in percentage as shown (eqn. 1):

$$\% \text{ Shell weight} = \frac{\text{Shell weight} \times 100}{\text{Egg weight}} \quad \text{(eqn.1)}$$

Egg mass (EM) was calculated as follows (eqn. 2):

$$EM = \frac{HDP}{100} \times \text{Egg weight} \quad \text{(eqn. 2)}$$

Where HDP = Hen-day production

Egg yolks were carefully separated from the egg albumen with yolk separator (spoon). Yolk weight percentage which is the ratio of the yolk weight to the egg weight was calculated as (eqn. 3):

$$\% \text{ Yolk weight} = \frac{\text{Yolk Weight}}{\text{Egg Weight}} \times \frac{100}{1} \quad \text{(eqn. 3)}$$

Albumen heights in millimeter were taken with the aid of optical pin, mathematical dividers and a ruler which was used for the calculation of Haugh Units (eqn. 4).

$$\text{Haugh unit} = 100\log(AH + 7.57 - 1.7(EW^{0.37})) \quad \text{(eqn. 4)}$$

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. Significant means were separated using Duncan Multiple Range Test (DMRT) of the same package.

Table 2: Performance characteristics of two breeds of layers fed diets containing different levels of praseodymium

Breed	Level (ppm)	Initial weight (g)	Final weight (g)	Total weight gain (g)	Daily weight gain (g)	Total feed intake (g)	Daily feed intake (g)	Feed conversion ratio	Hen-day production (%)
Dominant Black		1253.6±0.97	2000.3±0.34^{a}	746.6± 1.03^{a}	5.9±0.09^{a}	1910.8±0.65	112.4±0.01	2.98±0.00^{a}	85.6±0.37^{a}
Bovan Nera		1254.4±0.58	1978.5±1.05^{b}	724.1± 1.21^{b}	5.8±0.01^{b}	1909.1±0.64	112.3±0.01	3.07±0.01^{b}	84.7±0.26^{b}
Dominant Black	0	1253.6±1.99	1995.0±0.00	741.4 ± 1.99	5.9±0.02	1902.3±0.26	111.9±0.00	2.99±0.01	85.9±0.10
	50	1253.6±2.44	2000.5±0.24	746.9 ± 2.51	5.9±0.02	1902.3±0.26	111.9±0.00	2.97±0.01	86.0±0.09
	100	1254.0 ±1.66	2004.9±0.68	750.9 ± 1.79	6.0±0.01	1919.5±1.31	112.9±0.01	2.97±0.01	84.5±1.45
	150	1253.4±0.60	2000.6±0.26	747.3 ± 1.61	5.9±0.01	1917.6±1.33	112.8±0.01	2.98±0.01	85.9±0.11
Bovan Nera	0	1254.4±0.93	1967.6±0.88	713.3 ± 1.08	5.7±0.01	1917.6±1.33	112.8±0.01	3.12±0.01	81.2±0.82
	50	1254.1±1.41	1964.8±0.47	709.5 ± 1.10	5.6±0.01	1902.3±0.26	111.9±0.00	2.99±0.01	85.9±0.10
	100	1255.2±1.09	1994.4±0.26	740.3 ± 1.40	5.9±0.01	1902.3±0.26	111.9±0.00	3.12±0.00	86.0±0.10
	150	1254.0±1.16	1987.4±0.76	733.4 ± 1.39	5.8±0.01	1917.6±1.33	112.8±0.01	3.04±0.01	85.8±0.11
Inclusion									
0		1254.0±1.09	1981.3±1.60^{d}	727.3±1.94^{b}	5.8±0.02^{b}	1909.1±0.91^{b}	112.3±0.01^{b}	3.06±0.01^{c}	83.5±0.49^{a}
50ppm		1253.8±1.40	1984.8±2.29^{c}	730.2± 2.55^{b}	5.8±0.02^{b}	1902.3±0.18^{c}	111.9±0.00^{c}	2.98±0.01^{a}	85.2±0.74^{a}
100ppm		1254.6±0.99	1997.4±0.39^{a}	743.6± 1.48^{a}	5.9±0.01^{a}	1909.1±0.94^{b}	112.3±0.01^{b}	3.05±0.01^{c}	85.9±0.07^{a}
150ppm		1253.7±0.98	1994.0±0.85^{b}	740.3± 1.31^{a}	5.9±0.01^{a}	1909.1±0.95^{a}	112.3±0.01^{a}	3.01±0.01^{b}	85.9±0.08^{b}
Statistical Significance									
Breed		0.4919	<0.0001	<0.0001	<0.0001	0.6444	0.6444	<0.0001	0.0485
Inclusion level		0.9420	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Breed *Inclusion level		0.9953	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dom*0 vs Bov*0		0.7168	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dom*50 vs Bov*50		0.8736	<0.0001	0.0249	0.0249	1.0000	1.0000	0.0281	0.4781
Dom*100 vs Bov*100		0.5304	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.3069
Dom*150 vs Bov*150		0.7529	<0.0001	<0.0001	<0.0001	1.0000	1.0000	0.0001	0.4615

Means within the same column bearing different superscripts differ significantly ($p \leq 0.05$; $p \leq 0.01$; $p \leq 0.001$; $p \leq 0.0001$)

RESULTS

The performance characteristics of the two breeds of layers is shown in Table 2, egg qualities in Table 3 while Table 4 shows the phenotypic and genetic correlations of the qualities of eggs. From Table 2, there was significant ($p \leq 0.05$) difference between the breeds for final weight (FW), total weight gain (TWG), daily weight gain (DWG), feed conversion ratio (FCR), and hen-day production (HDP) with the Dominant Black breed having the higher values for these parameters except for FCR. In contrast, there was no significant difference ($p \geq 0.05$) between the breeds for total feed intake (TFI) and daily feed intake (DFI). The interaction between breed and the inclusion levels of Praseodymium on the performance characteristics of the birds was significant ($p \leq 0.05$), with the highest mean values of FW, TWG, DWG, TFI and DFI observed for interaction between Dominant Black and 100 ppm (2004.88±0.68, 750.90±1.79, 5.96±0.01, 1919.47±1.31, and 112.91±0.01 g) (Table 2) . The highest mean value of HDP was recorded for interactions between Bovan Nera with 100 ppm (Table 2). Meanwhile, the best value of FCR was observed in the interaction between Dominant Black and both 50 and 100 ppm (2.97±0.01).

Also, there was significant difference ($p \leq 0.05$) in performance characteristics of the laying hens at different levels of praseodymium inclusion. The highest values for each performance characteristics investigated were observed at the different levels of inclusion of praseodymium: for 100 ppm praseodymium inclusion level, the highest value was observed in the FW, TWG, DWG, and HDP (1997.44±0.39 g, 743.61±1.48 g, 5.90±0.01 g, and 85.93±0.07 % respectively) while at 150 ppm praseodymium inclusion level, the highest value was in the TFI and DFI (1909.10±0.95 and 112.30±0.01 g). Meanwhile, the best FCR (2.98±0.01) was recorded at 50 ppm. Furthermore, the correlation between the interactions of breed with the same corresponding praseodymium inclusion levels showed significant difference ($p \leq 0.05$) for FW, TWG, DWG, and FCR at all the inclusion levels. Also, there was significant ($p \leq 0.05$) difference in the TFI and DFI of the two breeds fed 0 ppm and 100 ppm praseodymium inclusion levels. Meanwhile, significant difference ($p \leq 0.05$) was only observed in the control for the HDP of the two breeds.

Table 3 presents the 32 weeks egg quality traits of the two breeds of layers fed different levels of praseodymium. It could be seen that the two breeds differed significantly ($p \leq 0.05$) for albumen height (AH), shell weight (SW), shell thickness (ST), Haugh unit (HU) and percentage shell weight (%SW), with Bovan Nera having the higher mean values (7.25±0.07 mm, 5.84±0.04 g, 0.37±0.00 mm, 84.88±0.41, and 9.80±0.06 % respectively). Although there was no significant ($p \geq 0.05$) difference between the breeds for other egg qualities, Bovan Nera, however, had higher values for these qualities except for albumen weight (AW). There was a highly significant ($p \leq 0.01$) difference in the breed interactions with the inclusion levels on the egg qualities of the birds except AW and SW, with the highest mean values noticed for the interaction between Bovan Nera and 100 ppm (36.73±1.05 and 5.92±0.10 g). The highest mean values were observed in the interaction between Bovan and 150 ppm for yolk weight (YW), AH, ST, HU and percentage yolk weight (%YW) (18.18±0.23 g, 7.95±0.09 mm, 0.40±0.01 mm, 88.91±0.59, and 30.18±0.25 % respectively). Meanwhile, the highest mean values for the remaining egg qualities investigated (i.e. EW and EM), where observed in the interaction between Dominant and 50 ppm (61.43±0.05 g and 55.33±0.14 respectively); and %SW was noticed in the interaction between Dominant and 150 ppm (9.97±0.12 %).

Also, there was a highly significant ($p \leq 0.01$) difference in the different levels of praseodymium inclusion for all the egg qualities except EW, AW and EM with the highest mean values (EW, 59.90±0.57 g; AW, 36.53±0.59 g; and EM, 54.03±0.54) observed in the dietary treatment with no supplemental praseodymium. However, a comparison of the dietary effects at 150 and 100 ppm levels of praseodymium inclusions showed no significant difference ($p \geq 0.05$). From the correlation between interactions of the breeds with corresponding praseodymium inclusion level, it could be deduced that the qualities of eggs produced by the interaction of Bovan Nera with 50 ppm were significantly different ($p \leq 0.05$) from those produced by the interaction of Dominant Black with 50 ppm. In contrary, the egg qualities of the two breeds without praseodymium in their diets did not differ significantly ($p \geq 0.05$) except in SW, ST and %SW. Moreover, at 100 ppm for the two breeds, no statistical difference ($p \geq 0.05$) was noticed in the qualities of their eggs when considering EW, AW, EM, and %SW; while at the 150 ppm, the EW, AW, SW, EM, and %SW were not different significantly.

Table 3: Egg quality traits at 32 weeks of age for two breeds of layers fed diets containing different levels of praseodymium

Breed	Level	Egg weight (g)	Yolk weight (g)	Albumen weight (g)	Albumen height (mm)	Shell weight (g)	Shell thickness (mm)	Haugh unit	Egg mass	Percentage shell weight	Percentage yolk weight
Dominant		59.6±0.34	16.4± 0.11	35.8±0.32	6.2±0.16[b]	5.6±0.04[b]	0.34±0.00[b]	73.4±1.84[b]	53.8±0.32	9.4±0.09[b]	27.6±0.24
Bovan Nera		59.7±0.39	16.6±0.15	35.8±0.42	7.3±0.07[a]	5.8±0.04[a]	0.37±0.00[a]	84.9±0.41[a]	53.9±0.36	9.8±0.06[a]	27.8±0.24
Dominant	0	59.6±0.85	15.8±0.23	36.4±0.57	6.6±0.06	5.5±0.09	0.33±0.01	81.2±0.46	53.7±0.82	9.3±0.20	26.5±0.35
	50	61.4±0.05	16.5±0.02	36.3±0.01	3.6±0.38	5.4±0.04	0.30±0.01	43.0±4.45	55.3±0.14	8.7±0.06	26.8±0.03
	100	58.5±0.72	17.5±0.23	34.9±0.54	7.8±0.09	5.5±0.08	0.38±0.01	88.5±0.55	52.8±0.65	9.5±0.20	30.1±0.62
	150	58.9±0.74	15.7±0.23	35.7±1.02	6.7±0.08	5.9±0.07	0.36±0.00	81.7±0.59	53.3±0.70	9.9±0.12	26.7±0.43
Bovan Nera	0	60.2±0.77	15.5±0.26	36.7±1.05	6.6±0.07	5.9±0.10	0.35±0.01	81.0±0.51	54.3±0.72	9.8±0.12	25.9±0.48
	50	58.1±0.82	16.9±0.23	34.4±0.59	7.8±0.11	5.6±0.07	0.37±0.01	88.4±0.63	52.6±0.77	9.7±0.15	29.2±0.24
	100	60.2±0.77	15.5±0.26	36.7±1.05	6.6±0.07	5.9±0.10	0.35±0.01	81.0±0.51	54.3±0.72	9.8±0.12	25.9±0.48
	150	60.3±0.70	18.2±0.23	35.4±0.46	8.0±0.09	5.9±0.08	0.40±0.01	88.9±0.59	54.4±0.64	9.8±0.11	30.2±0.25
Inclusion											
0		59.9±0.57	15.7±0.17[b]	36.5±0.59	6.6±0.05[b]	5.7±0.07[a]	0.34±0.00[b]	81.1±0.34[b]	54.0±0.54	9.6±0.12[a]	26.2±0.30[b]
50ppm		59.8±0.45	16.7±0.12[a]	35.4±0.31	5.7±0.31[c]	5.5±0.04[b]	0.33±0.01[b]	65.7±3.39[c]	54.0±0.42	9.2±0.10[b]	28.0±0.18[a]
100ppm		59.3±0.53	16.5±0.20[a]	35.8±0.59	7.2±0.07[a]	5.7±0.07[a]	0.37±0.01[a]	84.8±0.56[a]	53.6±0.49	9.7±0.12[a]	28.1±0.46[a]
150ppm		59.6±0.51	17.0±0.21[a]	35.6±0.55	7.3±0.09[a]	5.9±0.05[a]	0.38±0.00[a]	85.4±0.58[a]	53.8±0.47	9.9±0.08[a]	28.5±0.31[a]
Statistical Significance											
Breed		0.8605	0.1805	0.9777	<0.0001	<0.0001	<0.0001	<0.0001	0.7958	<0.0001	0.3209
Inclusion level		0.8618	<0.0001	0.4139	<0.0001	<0.0001	<0.0001	<0.0001	0.8982	<0.0001	<0.0001
Breed *Inclusion level		0.0014	<0.0001	0.0831	<0.0001	0.0604	<0.0001	<0.0001	0.0060	0.0004	<0.0001
Dom*0 vs Bov*0		0.6066	0.5509	0.7485	0.8790	0.0023	0.0277	0.7719	0.5874	0.0267	0.3338
Dom*50 vs Bov*50		0.0001	0.0474	0.0016	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	<0.0001
Dom*100 vs Bov*100		0.1008	<0.0001	0.1244	<0.0001	0.0018	0.0324	<0.0001	0.1200	0.1680	<0.0001
Dom*150 vs Bov*150		0.1797	<0.0001	0.7785	<0.0001	0.7696	<0.0001	<0.0001	0.2298	0.2193	<0.0001

Means within the same column bearing different superscripts differ significantly ($p \leq 0.05$; $p \leq 0.01$; $p \leq 0.001$; $p \leq 0.0001$)

Table 4: Phenotypic (above the diagonal) and genetic (below the diagonal) correlations of the qualities of eggs of layers at 32 week

Traits	EW	YW	AW	AH	SW	ST	HU	EM	%SW	%YW
EW		0.02950 ns 0.7963	0.12742 ns 0.2663	0.01662 ns 0.8844	0.23683* 0.0356	0.03449 ns 0.7643	0.14307 ns 0.2084	-0.0695 ns 0.5425	0.70776*** <0.0001	-0.15781 ns 0.1648
YW	0.03563 ns 0.7552		-0.13706 ns 0.2315	0.01622 ns 0.8871	-0.05830 ns 0.6098	-0.13513 ns 0.2382	0.24379* 0.0304	-0.17108 ns 0.1317	-0.15909 ns 0.1614	-0.05424 ns 0.6349
AW	0.38344** 0.0005	-0.13027 ns 0.2525		0.20789 ns 0.0678	0.36619** 0.0010	0.97615*** <0.0001	-0.21871 ns 0.0544	0.28660* 0.0110	0.26555* 0.0188	-0.16871 ns 0.1398
AH	0.08437 ns 0.4598	0.38701** 0.0004	-0.16929 ns 0.1358		0.01796 ns 0.8752	0.21804 ns 0.0552	-0.00953 ns 0.9335	0.75266*** <0.0001	0.05958 ns 0.6019	0.05893 ns 0.6060
SW	0.57171*** <0.0001	0.15532 ns 0.1717	0.31986** 0.0041	0.39287** 0.0003		0.36911** 0.0009	-0.09095 ns 0.4254	0.05408 ns 0.6359	0.22749* 0.0438	-0.09955 ns 0.3827
ST	0.26302* 0.0192	-0.29840** 0.0076	0.95763*** <0.0001	-0.33448** 0.0026	0.19543 ns 0.0843		-0.28074* 0.0128	0.33218** 0.0030	0.23123* 0.0417	-0.15571 ns 0.1734
HU	0.40285** 0.0002	0.57396*** <0.0001	0.00424 ns 0.9704	0.59086*** <0.0001	0.40855** 0.0002	-0.27457* 0.0143		-0.65152*** <0.0001	-0.58215*** <0.0001	0.07504 ns 0.5110
EM	-0.28609* 0.0106	-0.16878 ns 0.1031	-0.17855 ns 0.1154	0.55555*** <0.0001	0.06153 ns 0.5901	-0.08238 ns 0.4704	-0.32428** 0.0036		0.44302*** <0.0001	-0.01644 ns 0.8856
%SW	0.71463*** <0.0001	-0.41767** 0.0001	0.39862** 0.0003	-0.36059** 0.0011	0.26783* 0.0170	0.48873*** <0.0001	-0.34068** 0.0021	-0.03082 ns 0.7875		-0.17378 ns 0.1256
%YW	-0.18003 ns 0.1124	-0.00484 ns 0.9662	-0.07903 ns 0.4888	0.22191* 0.0494	-0.11254 ns 0.3234	-0.08564 ns 0.4530	0.04022 ns 0.7249	0.23243* 0.0393	-0.19391 ns 0.0868	

* denotes significant variation ($p \leq 0.05$); ** denotes significant variation ($p \leq 0.01$); *** denotes significant variation ($p \leq 0.0001$)
ns denotes no significant difference ($p \geq 0.05$)

EW = Egg weight; YW = Yolk weight; AW = Albumen weight; AH = Albumen height; SW = Shell weight; ST = Shell thickness; HU = Haugh unit;
EM = Egg mass; %SW = Percentage shell weight; %YW = Percentage yolk weight

Table 4 shows the phenotypic and genetic correlations of the qualities of eggs at 32 weeks. For the phenotypic correlations among the internal qualities of the eggs, the relationship between HU and other qualities were all negative and not significant except for HU and YW (0.24) which was positive and significant ($p \leq 0.05$). Despite that some of the relationships between %YW and other internal qualities are positive, it must be pointed out that none of them was significant ($p \geq 0.05$). The lowest relationship was found between HU and AW (-0.22) while the highest relationship existed between HU and YW (0.24). Furthermore, the relationship was generally positive in the phenotypic correlations between the external qualities, except for EM and EW (-0.07) which was the weakest relationship and was not significant ($p \geq 0.05$). Although, the relationship between EM and EW (-0.29) was also the weakest for the genetic correlation, it differed significantly ($p \leq 0.05$). Meanwhile, %SW and EW had the highest significant relationship ($p \leq 0.05$) with coefficient values of 0.708 and 0.715 for the phenotypic and genetic correlations respectively. Also, for the genetic correlations of the internal qualities of the eggs, there were positive relationships between HU and other internal qualities. In addition, the relationships between %YW and other internal egg qualities were not significant ($p \geq 0.05$) except %YW and AH which had a significant positive correlation. The relationship was generally positive for the external qualities with the exception of few cases.

DISCUSSION

Effect of breed on Performance Characteristics

The results from the study showed that there were differences in body weight and HDP of the breeds of chickens used in the experiment. These differences in breed performance could be due to genetic makeup of the individual bird and environment provided for their gene expression. Dominant Black breed had a better performance for body weight compared to Bovan Nera. Body weights of selected lines of chickens are associated with appetite (McCarthy and Siegel, 1983), and changes in feed intake and feed efficiency that correspond with changes in body weight were observed in this study. These have been demonstrated in other studies (Barbato *et al.*, 1983; and Marks, 1991). Moreover, the higher HDP of Dominant Black showed that the breed would produce more eggs and be more profitable in commercial production than the Bovan Nera. The same observation was made by Oluyemi and Roberts (2007) who stated that egg production is affected by the breed of layers reared. Also, the authors observed that egg size varied with age and strain of birds.

Effect of Praseodymium Inclusions on Performance Characteristics

It has been demonstrated in this study that praseodymium inclusions in the diets of birds influenced the performance of the hens in terms of increased body weight and improved feed conversion rate, which is in agreement with the results of other researchers (Zhou, 1994; Wu *et al.,* 1994). This study also showed that praseodymium inclusion at 100 ppm would be most appropriate for egg production by layers as the highest egg production was recorded at this level. Although there were significant differences among the inclusion levels, the results on Table 2 suggest that praseodymium inclusion at 50 ppm would be profitable when considering the body weight with regards to best feed conversion rate when birds were given this level of inclusion (i.e. 50 ppm of praseodymium). Moreover, the HDP was positively influenced by the inclusion of praseodymium. This was in consonance with the results of Shen *et al.* (1991) who observed that REEs enhanced egg production in laying hens. Hence, this reveals the influence of the environment on the performance of layer birds as the overall performance of animal depends not only on the genetic makeup of the animal but also the environment which include the nutrition.

Effect of Breed on Egg Qualities

The experiment revealed that Bovan Nera produced eggs with better qualities than the Dominant Black, which is supported by the conclusion of Halaj and Grofik (1994) that genotype is one of the most important factors influencing not only egg weight but also other egg quality traits. The observed variations between these two breeds may also be attributed to genetic involvement (including breed or strain) between breeds (Kgwatalala *et al.,* 2013). Shell quality, particularly shell thickness is an important trait that breeders of layers incorporate into their breeding programme to reduce egg breakage (Yakubu *et al.,* 2008). Similarly, it was found that shell weights of Bovan Nera eggs were different from those of Dominant Black which was not surprising because different breeds of laying hens vary significantly in egg shell quality (Curtis *et al.*, 1985). Both the shell thickness and weight of Bovan Nera eggs were higher than those of Dominant Black.

Effect of Praseodymium Inclusion on Egg Qualities

The result showed that individual egg weight was significantly enhanced when praseodymium was included compared to the control group. This was in consonance with the opinion of Zhang *et al.* (2005). Also, best results for production of eggs with better qualities were obtained when praseodymium was supplemented at a rate of 100 ppm.

Genetic and Phenotypic Correlation of the Qualities of Eggs

Genetic and phenotypic correlations of the internal qualities of eggs in this study were moderately high and positive except for 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, albumen weight (AW) which had the strongest relationship with the EW for all the weeks of study. This agreed with the study of Kul and Seker (2004). Also, Stadelman (1986) observed a positive correlation value of 0.26 between the egg weight and the shell thickness (ST) which was also noticed in the genetic correlation at week 32 of this study where the phenotypic correlation between EW and ST was low, and the genetic correlation was moderate, implying that heavier eggs tended to have thicker shells (Silversides and Scott, 2001).

The percentage shell weight in the total egg had a positive linear correlation with the increase in egg weight. This implies that as the percentage shell weight increased, the egg weight also increased which is at variance with the observation of Ozcelik (2002). This deviation may have been caused by the nutrition or other environmental factors. The eggshell quality can be determined using the egg weight values due to the positive and significant correlation between them. Also, egg weight is genetically linked to the shell, albumen, and yolk weights although each has different heritability (Washburn, 1979). With their relationship, EW can be used to predict AW and vice versa. Also, the implication of this is that genetic improvement could be made possible by direct selection for any of the measurements as the responses were correlated.

CONCLUSION

Egg parameters were positively correlated both genetically and phenotypically except in some traits. The albumen weight and height could be used to predict the egg weight and Haugh unit, respectively. The two breeds of layers performed well. However, in terms of body weight and hen day production, Dominant Black was better than Bovan Nera but Bovan Nera produced eggs with better qualities. Eggs of Bovan Nera might therefore be healthier than those of Dominant Black because of their higher Haugh units. Also, praseodymium improved the performance characteristics, especially the feed conversion ratio, as well as the examined egg quality traits of the layers.

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