

PERFORMANCE AND EGG QUALITY OF LAYING HENS FED VARYING DIETARY LEVELS OF CALCIUM SOURCE

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ABSTRACT

The study was conducted to determine the performance and egg quality of hens fed varying levels of calcium source. A total of seventy-two (72), sixteen (16) weeks old laying hens (weighing 1.2 ± 2.00kg) were randomly assorted into six (6) treatments groups: T₁, T₂, T₃, T₄, T₅ and T₆ with twelve (12) birds per treatment in a completely randomized experimental design with a 2x3 factorial arrangement. Two calcium sources (limestone, L and periwinkle shell, PS) were supplemented in the diets at different levels. The birds in T₁, T₂, T₃, T₄, T₅ and T₆ were fed basal diets of varying calcium (Ca) levels namely: 3.0% L, 3.75% L, 4.5% L, 3.0% PS, 3.75% PS and 4.5% PS for a period of twelve weeks. Feed intake, feed conversion ratio, hen day egg production, haugh unit, albumen height, egg shell weight, egg shell thickness, shape index, shell percentage, egg shell weight per surface area, specific gravity and albumen index were significantly (P<0.05) higher in T₄, T₅ and T₆ compared to T₁, T₂ and T₃. Based on the results obtained from the present study, it was possible to conclude that 3.75 calcium levels was appropriate for laying hens and the inclusion of periwinkle shell in layers ration as calcium source is more beneficial than limestone.

Keywords: Periwinkle shell, Limestone, Egg quality, Performance, Laying hens

INTRODUCTION

Calcium sources in the digestive system are an important factor for formation of eggs with optimum shell quality (Keshavarz *et al.*, 1993). Due to the high calcium requirements of layers, the knowledge on calcium sources that can replace or be used in association with calcitic limestone is essential in order to improve or to maintain performance and egg quality (Wang *et al.*, 2014). Additional sources of calcium have been introduced and are in practical use with birds, such as egg shell, oyster shell, limestone and others but there are few studies on the use of periwinkle shell as calcium sources for laying hens which currently has added to the environmental waste menace (Walk *et al.*, 2012a). For sustainable development, wastes should be recycled, reused and channeled towards the production of value added products (Abdulrahman *et al.*, 2014).

The periwinkle shell is very rich in calcium and can be manipulated to yield various calcium compounds. The shell is the hard, rigid outer calcium carbonate covering of certain animals (Ugoeze and Chukwu, 2015). Roth-Bassell and Clydesdale (1990) found a differential solubility of each calcium source tested at different pH. The mean values show that calcium carbonate and marble dust are the most soluble, bivalve shell, periwinkle shell and oyster shell are of medium solubility, while egg shell and snail shell dissolve more slowly with less than 50% solubility after 1 h in 0.1 N HCl. It was observed that the structures of the individual calcium sources tested were different. Calcium carbonate is more flaked in appearance, eggshell particles are in the form of a mesh while oyster shell and periwinkle shell is more of an arranged layer of rectangular blocks. A slow solubilisation is preferable to very rapid one, because the former more closely matches the prolonged duration of need for calcium supply to the shell gland in laying hens (Leeson and Summers, 2005). Therefore, proper sources of calcium and the levels are necessary for diets of laying hens due to how important the mineral is for not only egg shell synthesis and bone turnover but also for maintaining calcium homeostasis throughout the body and the circulating blood supply.

MATERIALS AND METHODS

Experimental site: The study was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka in Enugu State, South Eastern Nigeria.

Nsukka lies in the derived Savannah region, and is located at the point of intersection of Longitude 7° 12.5 'N and latitude 6° 45'E with a maximum plateau altitude of 443m and a minimum of 207m above sea level.

Experimental animals and managements: A total of seventy- two (72) laying hens were randomly assigned to six (6) treatments with twelve (12) birds per treatment. Each treatment was further divided into three (3) replicate groups with four (4) birds in each pen totaling eighteen (18) experimental units. Allocation of feeding trial began when they were seventeen (17) week old so as to get them acclimatized to the environment. Then their initial weight was taken and they were randomly selected and housed in deep litter pens in separate cells. Feed and water were supplied *ad libitum* to the birds. They were provided the same management conditions (Floor space, temperature, light, vaccination programme).

Experimental diets: Two calcium sources (limestone and periwinkle shell) were supplemented in the diets at different levels as shown in Table 1. The birds in T₁, T₂, T₃, T₄, T₅ and T₆ were fed isocaloric-isonitrogenous basal diets of varying calcium (Ca) levels namely: 3.0% L, 3.75% L, 4.5% L, 3.0% PS, 3.75% PS and 4.5% PS for a period of twelve weeks. The crude protein level used for the diet formulation was 16% and 2700cal/kg metabolizable energy according to the recommended requirements of laying hen.

Table 1: Percentage composition of the experimental diet

Feed ingredient (kg)	Limestone			Periwinkle		
	3.0 T ₁	3.75 T ₂	4.5 T ₃	3.0 T ₄	3.75 T ₅	4.5 T ₆
Maize	45.96	45.96	45.96	45.96	45.96	45.96
Soybean meal (SBM)	15.44	15.44	15.44	15.44	15.44	15.44
Fish Meal	2.00	2.00	2.00	2.00	2.00	2.00
Wheat offal	19.68	13.33	7.64	18.67	12.57	6.45
Palm kernel cake (PKC)	6.64	10.79	14.73	7.38	11.44	15.53
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Dicalcium phosphate	1.39	1.39	1.39	1.39	1.39	1.39
Limestone	7.89	9.87	11.84	0.00	0.00	0.00
Periwinkle shell	0.00	0.00	0.00	8.16	10.20	12.23
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100

Data collection: Birds were individually wing-tagged in order to monitor individual body weight as well as the group body weight at the start (17 wk) to finish (30 wk) post hatch. Body weight was obtained by weighing hens at the beginning and at the end of the experimental period. Fifty-four (54) eggs (3 eggs per replicate) were randomly selected at the end of the experiment for egg quality analysis. Each egg was carefully broken and the shell dried after which the egg shell was weighed in using an electronic balance.

Statistical analysis: The data obtained were subjected to Analysis of Variance (ANOVA) in a completely Randomized Design (CRD) experimental design with a 2x3 factorial arrangement and the significant differences in means were separated using Duncan New Multiple Range Text (Duncan, 1955).

RESULTS AND DISCUSSION

Productive Performance: The results of the effect of dietary calcium sources and levels on the performance of laying hens are presented in Table 2. The result reveals no significant ($p > 0.05$) differences on the initial body weight, final body weight, total weight gain, average daily weight gain and egg weight but feed intake, feed conversion ratio and hen day egg production were significant ($p < 0.05$) among treatments. The result showed a negative impact $T_1 > T_2 > T_3 > T_4 > T_5 > T_6$ on increasing dietary calcium on birds' intake. This implies that excess calcium has a neutralizing effect in the intestines that

caused a rise of intestinal pH. This caused deficiency by formation of insoluble calcium phosphate in the digestive tract and impairs metabolic functions (Kheiri and Rahmani, (2006) that caused the birds to refrain from eating. Feed conversion ratio in this experiment is higher in the treatments (2.98-3.85) than the results reported by Pelicia *et al.* (2009) who depicted 2.08-2.19. Feed conversion ratio significantly improved by incorporating 3.00% and 3.75% calcium in the diet during the overall period as compared to the group fed diet containing 4.50% calcium. Improved Feed conversion ratio with decreased dietary calcium was associated with the capacity of the birds to maintain optimal egg production with an increase in their feed intake. These results proved that in calcium low diets, there is higher calcium utilization due to higher efficiency of intestinal absorption. So, birds improve the utilization of dietary calcium within their physiological limits as a form of compensation.

Egg Quality: The results of the effect of dietary calcium sources and levels on the egg qualities of laying hens are presented in tables 3. However, haugh unit, albumen height, egg shell weight, egg shell thickness, shape index, shell percentage, egg shell weight per surface area, specific gravity and albumen index were highly significant ($p < 0.01$) among treatments. Generally, the higher specific gravity value observed in T₆ (1.09 ± 0.01) is related to thicker eggshell and shell weight per unit of surface area which is a desirable characteristic in the egg industry. The highest eggshell thickness was obtained from eggs of hens in T₆. The increase in eggshell thickness may be because of the presence of the coarse particles of periwinkle shell. This shows that the larger particles (PS) should remain in the gizzard (an acidic environment) longer than limestone, thereby having greater calcium retention. Therefore, the acidity would help to dissociate the CaCO₃ into ionic calcium, hence producing more available calcium for absorption. The more calcium that is available to the shell gland during egg shell synthesis, the thicker the egg shells would ultimately be. Shell weight was found to be 4.95-5.36g and this is lower than the estimates reported by Mankpondji *et al.* (2012) who recorded 6.58-6.05g. Variations in this response could be due to the type of the diet, breed, and age of the bird or the prevailing environmental conditions. According to the United States Department of Agriculture (USDA), a Haugh Unit of 72 and above (score AA) is acceptable and indicates freshness in egg. Thus, the Haugh Unit obtained from all the group is an indication that eggs produced by hens fed both limestone and periwinkle shells were of standard quality

CONCLUSION

From the results of this study, a slower solubilization of sources of calcium would make calcium available during the time of the eggshell calcification and diminish bone calcium mobilization. Thus, at the calcium level 3.75 (T₄), the laying hens had the best feed conversion ratio which corresponds to a higher hen day egg production. Therefore, it is possible to conclude that 3.75 calcium levels was appropriate for laying hens and that periwinkle shell could be included in the laying diet as a satisfactory calcium source.

TABLE 2: Interactions of Dietary Calcium sources and Levels on the Productive Performance of Laying Hens

Parameters	Interaction						P.value
	T ₁ 3.00	Limestone T ₂ 3.75	T ₃ 4.50	T ₄ 3.00	T ₅ 3.75	Periwinkle shell T ₆ 4.50	
IBW (g)	1210.00 ± 5.00	1250.00±2.88	1240.00 ± 9.40	1233.30 ± 14.24	1235.00 ± 10.10	1236.70 ± 9.27	0.11 ^{NS}
FBW (g)	1501.70±23.01	1571.71±49.03	1532.70±18.11	1569.00±48.68	1545.70±14.45	1590.00±18.02	0.28 ^{NS}
TWG (g)	291.67±18.27	321.67±49.92	292.67±27.22	335.67±37.61	310.67±11.55	353.33±27.28	0.49 ^{NS}
ADWG (g)	4.62±0.28	5.10±0.79	4.64±0.43	5.33±0.59	4.93±0.18	5.60±0.43	0.49 ^{NS}
FI (g)	7688.30±307.24 ^a	7498.90±124.76 ^a	6868.10±259.48 ^b	7089.40±226.86 ^{ab}	7555.00±143.79 ^a	6091.70±237.91 ^c	0.02*
FCR	3.34±0.42 ^b	3.28±0.44 ^b	3.78±0.11 ^a	2.91±0.24 ^{bc}	2.52±0.05 ^c	3.93±0.09 ^a	0.04*
EggWT (g)	50.81±1.50	50.19±0.91	50.46±1.16	49.20±0.99	49.31±1.18	44.90±1.27	0.11 ^{NS}
HDEP (%)	28.02±2.90 ^b	24.32±3.85 ^b	17.41±0.81 ^d	25.76. ±0.94 ^b	39.41±1.50 ^a	21.42±1.73 ^c	0.02*

a,b,c,d– Means in the same row with different superscripts are significant at 5 or 1 % (* $P < 0.05$; ** $P < 0.01$), NS- Not significant. IBW: Initial body weight, FBW: final body weight, TWG: total weight gain, ADWG: average daily weight gain, FI: feed intake, FCR: feed conversion ratio, Eggwt: egg weight, HDEP: hen day egg production.

TABLE 3: Interactions of Dietary Calcium Sources and Levels on the Egg Qualities of Laying Hens

Parameters	Interaction						P.value
	T ₁ 3.00	Limestone T ₂ 3.75	T ₃ 4.50	T ₄ 3.00	T ₅ 3.75	Periwinkle shell T ₆ 4.50	
ESW (g)	4.51 ± 0.11 ^c	4.95 ± 0.05 ^b	5.10 ± 0.01 ^{ab}	5.13 ± 0.69 ^{ab}	5.36 ± 0.22 ^a	5.45 ± 0.07 ^a	0.00**
EST (mm)	0.38 ± 0.00 ^b	0.36 ± 0.01 ^b	0.32 ± 0.01 ^c	0.36 ± 0.00 ^b	0.36 ± 0.01 ^b	0.41 ± 0.01 ^a	0.00**
ESI (%)	74.18 ± 0.64 ^c	77.48 ± 0.24 ^b	76.42 ± 0.81 ^b	76.51 ± 0.62 ^b	79.68 ± 0.27 ^a	77.33 ± 0.58 ^b	0.00**
ESA (cm ²)	75.83 ± 1.70	75.16 ± 1.02	75.46 ± 1.26	74.04 ± 1.13	74.16 ± 1.34	69.11 ± 1.48	0.11 ^{NS}
SHELL %	10.78 ± 0.18 ^{ab}	9.91 ± 0.26 ^c	9.02 ± 0.40 ^d	10.45 ± 0.14 ^{bc}	10.83 ± 0.21 ^{ab}	11.44 ± 0.33 ^a	0.00**
EWSA (mm/cm ²)	60.17 ± 2.39 ^c	66.09 ± 1.51 ^b	69.37 ± 0.71 ^{ab}	72.08 ± 0.71 ^a	72.10 ± 1.82 ^a	74.16 ± 1.62 ^a	0.00**
SG	1.06 ± 0.00 ^c	1.06 ± 0.01 ^c	1.05 ± 0.00 ^d	1.08 ± 0.00 ^{bc}	1.08 ± 0.01 ^{bc}	1.09 ± 0.01 ^a	0.00**
HU (%)	86.88 ± 3.00 ^{cd}	86.09 ± 2.30 ^d	94.73 ± 1.00 ^{ab}	89.21 ± 1.35 ^{bcd}	91.99 ± 1.96 ^{abc}	96.99 ± 0.35 ^a	0.01**
ALB. H (mm)	7.11 ± 0.54 ^{cd}	6.71 ± 0.18 ^d	8.55 ± 0.22 ^{ab}	7.44 ± 0.22 ^{bcd}	8.00 ± 0.44 ^{abc}	9.00 ± 0.09 ^a	0.01**
ALB. I (%)	5.26 ± 0.42 ^b	5.91 ± 0.43 ^b	7.73 ± 0.30 ^a	5.94 ± 0.22 ^b	6.94 ± 0.37 ^a	7.83 ± 0.19 ^a	0.00**
YOLK. H (cm)	1.47 ± 0.02	1.37 ± 0.02	1.53 ± 0.04	1.54 ± 0.01	1.55 ± 0.02	1.57 ± 0.08	0.27 ^{NS}
YOLK. I (%)	39.39 ± 0.71	37.57 ± 0.43	40.42 ± 1.59	40.53 ± 0.40	41.07 ± 0.91	43.16 ± 1.92	0.58 ^{NS}

a,b,c,d– Means in the same row with different superscripts are significant at 5 or 1 % (* $P < 0.05$; ** $P < 0.01$), NS- Not significant. ESW: egg shell weight, EST: egg shell thickness, ESI: shape index, ESA: egg surface area, SHELL %: shell percentage, EWSA: egg shell weight per surface area, SG: specific gravity, HU: haugh unit, ALB.H: albumen height, ALB.I: albumen index, YOLK.H: yolk height and YOLK I: yolk index.

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