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The Effect of Various Calcium and Phosphorus Sources on Productive and Egg Quality Performances of Spent Layers

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ABSTRACT: This study was conducted at the University of Maiduguri Poultry and Research farm, to investigate the effects of various calcium sources on the productive and egg quality performance of spent layers. A total of ninety (96) Black Harco layers at the age of 58 weeks were randomly assigned in to four different treatment and replicated two times with12 birds each in a completely randomized design (CRD). They were reared on varying calcium and phosphorus sources name bone meal, oyster shell, periwinkle shell and limestone for treatment T1,T2,T3 and T4. The study revealed that feed consumption and feed conversion Ratio did not differ (P<0.05) significantly among treatment groups. Egg weight, Albumen length and Haugh unit also did not differ significantly. However, albumen height, albumen width and albumen index and shell thickness differ significantly between treatment groups and was in favour of limestone. This indicates that the various Ca/P sources affect these parameters. The mortality record of 5.20% recorded was in treatment T3 and T4. The study concluded that the various Ca/P sources did not affect feed consumption and FCR but some egg quality factors.
KEY: Spent layers, calcium and phosphorus sources, egg quality, productive performance

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I. INTRODUCTION

With the rapid population growth and the acute shortage of animal proteins, the traditional and husbandry practice which is characterised by low productivity cannot meet the demand of the populace. It is therefore, necessary to look in to the various ways of enhancing animal production. To achieve this, efforts must be geared towards boosting poultry production. This is because of the numerous merits of poultry compared to other livestock species. Apart from their economic value, poultry products are a source of high quality protein which is dearly required by humans for growth and other essential body processes.

Commercial hybrids (Layers and broilers) all over the world are being propagated for production of eggs and meats. Their average production rate is usually close to 0.9 eggs per day (Kekeocha, 1985). However, as the age decreases, their egg production decreases. This situation is further aggravated during the second production cycle. Today's nutritionist needs an actual biological retention value for key minerals in order to access the true impact of dietary formulation on animal performance. Waldroup (1996) reported that although 12 minerals are considered essential minerals for poultry and swine, meeting the calcium and phosphorus needs of these animals is of great concern to nutritionist.

After one year of production, layers are culled and used for meat purpose without exploiting their full inherent potential, which can be exploited up to second production cycle (North and Bell, 1990). The factors like diseases and market rates usually reflect a miserable picture of annual flock replacement while rearing new pullets for profitable egg production. Moreover, keeping aged hens as such is uneconomical because of gradual decline in egg production with more erratic clutch cycles and poor feed efficiency in the relatively heavy layers. Therefore, pullets and spent layers must be managed effectively and efficiently in order to get maximum output and profitability (Kekeocha, 1985).

Calcium and phosphorus are considered the main minerals in diets of layers and breeder, due to their expressive participation in the metabolism and quality of the egg shell, the metabolic and structural function of these minerals in bone and eggshell formation, are essential in poultry production (Araujo *et al*., 2005).

The nutritional role of calcium is closely linked to that of phosphorus, it is known that the use efficiency of calcium and phosphorus are dependent on the quality and interrelations existing thus, it is of utmost importance to consider the relations between calcium and phosphorus in the evaluation on their requirements (Kout Elkloub *et al*., 2015). More than 70% of animal body ashes consist of calcium and phosphorus, present in the bones (McDowell *et al*., 1992).

The excess of calcium in the diets can cause antagonism at the absorption of minerals, influencing the maintenance of the homeostasis of these minerals. Deficiency in calcium and phosphorus might result in bad quality of the eggshell and reduction in the size and production of eggs (Kout Elkloub *et al*., 2015). However, very little research work has been conducted under local climatic conditions in the semi-arid region to exploit the production potential of spent layers to various calcium and phosphorus sources.

II. CHAPTER THREE

2.1 Material and Method

2.1.1. Study site

The experiment was conducted at the University of Maiduguri Poultry and Research farm. The University is located along Bama road in Borno State. The State capital Maiduguri, being in the semi-arid zone of Nigeria lies within latitude 11°15´ North and 13°5´ east. It has an altitude of about 354,000 meters above sea level. Borno state shares border with Adamawa state to the south, Yobe state to the West.

The climate of Borno State is hot and dry for a greater part of the year. The states ecological distribution lies in the Sahel savannah close to the Sahara desert and is characterised by high ambient temperature ranges between 20 to 41°C and mean rainfall distribution of 500-700mm per annum. The hottest months in this area is between the months of March to April. The rainy season in the state varies from place to place, but generally it lasts for about 3-4 months (120 days) in the North and more than 4 months in the South especially in Biu and Askira LGAs where the climate is a bit mild.

The vegetation of Borno is a grass land type characterised by trees in which Neem (*Azadirachta indica*) is the most abundant shrub and grasses such as Zana grass and Kayasu grass. The soil types which is sandy loam favours the cultivation of crops such as maize and groundnut during the farming season.

2.1.2. Experimental Design

At fifty eight weeks of age, the spent layers were randomly weighed and allotted to four (4) treatment groups. Each treatment was replicated in to two with 12 birds per replicate in a Completely Randomized Design (CRD). The treatments was tagged T_1, T_2, T_3, and T4. The birds were reared in battery cages and the experiments lasted for 8 weeks each.

2.1.3. Experimental Stock

A total of ninety (96) black Harco strain of layer chicken were used for this experiment. They were obtained at day old from ECWA hatchery Jos, Nigeria through the Maiduguri branch office. The layers were at their second year of laying when the experiment commenced.

2.1.4 Experimental Diets

The experimental diet used for this study formulated was layer mash containing different Ca/P sources as the test diets. Feeding and watering were ad libitum throughout the period of study. Treatment T1 was layer mash containing bone meal, T2 oyster shell, T3 periwinkle shell and T4 limestone. The diets used for this experiment are isonitrogenous and isocaloric except for different calcium and phosphorus sources.

2.2.0 Parameters Measured

2.2.1. Egg production

Throughout the period of study, eggs were collected twice daily, in the morning and evening i.e 8:00am and 5:00pm. Eggs were also examined for cracks, shellessness and other egg shell defects like rough shells, pale shell colour and abnormally long shaped eggs. The daily egg production record was taken and percent hen day egg production was determined for each replicate on weekly bases.

2.2.2 Feed consumption

The quantity of feed consumed by each group was determined on daily basis. This was done by feeding a known quantity of feed daily and the left over were collected and weighed the following day. The difference between the amounts fed and left over gives the quantity of feed consumed by the birds.

2.2.3 Egg weight

All eggs produced by each replicate group were weighed on weekly bases. The mean egg weight for each treatment group was determined by dividing the total egg weight for that treatment group by the total number of eggs.

2.2.4 Feed efficiency

Mean feed consumption per bird was calculated for each treatment group as well as mean egg weight. Feed efficiency was then expressed as the ratio of grams of feed consumed per grams of egg produced.

EGG QUALITY FACTORS

2.3.1. Albumen Index

The fresh laid eggs are first of all weighed individually and the weight recorded. The eggs were broken carefully and the content poured on a flat clean glass sheet. The albumen length and albumen width were measured using a vernier calliper. The albumen height is determined using spherometer. While taking the measurements, records were also taken. Finally, the albumen index was calculated as follows:

$$\text{Albumen index} = \frac{\text{Albumen length}}{\text{Albumen width}}$$

2.3.4 Percent Shell

The egg shells for each replicate were allowed to dry naturally at room temperature for 24 hours, then weighed on an electronic sensitive balance to determine the egg weight. The percent shell was calculated as:

$$\frac{\text{Percent shell weight}}{\text{Original weight of egg}} \times 100$$

2.3.5 Shell Thickness

The shell thickness was determined by taking three measurements i.e after the shell has been weighed from a treatment replicate, a micrometre screw gauge was used to take measurement at the proximal and distal ends of the shell, and then the average of the two measurements was taken as the shell thickness.

Table 1.0 Composition and Calculated Analysis of Experimental Layer Mash

	TREATMENTS GROUP			
Ingredients	**T1**	**T2**	**T3**	**T4**
Maize	50.00	50.00	50.00	50.00
Wheat offal	21.00	21.00	21.00	21.00
Soya bean meal	8.00	8.00	8.00	8.00
Groundnut cake	6.00	6.00	6.00	6.00
Fish meal	5.00	5.00	5.00	5.00
Bone meal	9.00	-	9.00	
Oyster shell	-	9.00	-	-
Periwinkleshell meal	-	-	9.00	-
Limestone	-	-	-	9.00
Mineral premix	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Nacl	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20
Total	**100**	**100**	**100**	**100**
Calculated analysis				
Crude protein	17.12	17.12	17.12	17.12
Crude fibre	4.58	4.58	4.58	4.58
ME (kcal/kg)	2620.10	2620.10	2620.10	2620.10
Calcium	3.69	3.51	3.78	3.51
Total Phosphorus	1.66	0.31	0.32	0.31

ME: Metabolisable Energy

IV. RESULT AND DISCUSSION

4.1 PRODUCTIVE PERFORMANCE

4.1.1 Feed Intake

Feed consumption for the different treatment groups is shown in table 2. There was no significant differences ($P<0.05$) observed among the different groups. However, feed consumption shows irregular pattern. It decreases when birds were at 60 weeks of age and increase afterward. The reason for such might be due to the temperature fluctuation during the period of study. In the first and second week there was no significant ($P<0.05$) difference between the oyster shell group (T2) and periwinkle shell group (T3) in feed consumption. The birds in limestone group recorded significantly lower feed consumption in the 3rd week. The reason for low feed consumption in the limestone group (T4) may be as a result of magnesium from dolomitic limestone which is less available than magnesium carbonate which depressed feed intake. This result agreed with the work of Hess and Britton (1996) which showed that hens fed limestone responded by reduction in feed intake.

Table 2: Mean Weekly Feed Consumption of Spent Layers Fed Different Calcium and Phosphorus Sources

	TREATMENT GROUPS				
WEEKS	**T1**	**T2**	**T3**	**T4**	**SEM**
58	100.70	108.00	108.10	98.80	2.42
59	95.50	91.40	99.10	95.50	1.58
60	88.90	98.90	98.90	87.70	3.05
61	114.3	111.30	112.80	108.00	1.35
62	99.40	106.90	107.10	101.10	1.86
63	109.80	111.80	110.10	101.10	2.89
64	107.30	107.50	105.40	101.20	1.46
65	93.50	92.60	104.50	95.30	2.73

SEM: Standard Error Mean

4.1.2 Mean Hen Day Egg Production

The mean hen day egg production in shown in table 3. Hen day egg production was observed to be higher for oyster shell group (T2) followed by limestone (T4), then periwinkle shell group (T1). The reason for low hen day egg production in treatment (T1) may be as a result of high total phosphorus which interferes with feed consumption and subsequently reduction in egg production. However, mean hen day egg production shows no significant difference ($P<0.05$) between treatment groups. This shows that treatment did not affect egg production. This is in line with the report of Hess and Britton (1996) who reported no significant difference in egg production when hens were fed calcium diets. The result in the present study is also in accordance with the findings of Neijat *et al.* (2011) who reported that the overall egg production (% hen day) not statistically different between chickens fed diet containing calcium.

Table 4: Mean Hen Day Egg Production of Spent Layers Fed Different Calcium and Phosphorus Sources

	TREATMENT GROUPS				
WEEKS	**T1**	**T2**	**T3**	**T4**	**SEM**
58	44.60	57.40	53.50	52.90	2.33
59	46.90	56.50	49.30	49.90	2.05
60	46.40	63.00	50.50	54.70	3.07
61	51.70	60.10	52.30	56.50	1.70
62	51.10	61.80	49.90	57.70	2.43
63	51.10	57.10	53.50	49.30	1.46
64	49.90	64.80	49.90	51.10	3.15
65	52.90	58.90	58.90	46.40	2.38

SEM: Standard Error Mean

4.1.3 Egg Production

Percent egg production in the present study is shown in Table 5. The percent egg production ranged between 50.75 to 54.88%. The result showed no significant ($P<0.05$) difference among the treatment group. The result in the present study is in agreement with the findings of Hamilton et al. (1985) who reported that egg production in treatment 3 (reducedphosphorus with 50% limestone and 50% oystershell as the calcium source) was significantlyhigher ($P < 0.05$) than in treatment 2 (reducedphosphorus with limestone as calcium source)but not in treatment 1. Reduction of phosphorusalone (treatment 2 vs. treatment 1) didnot improve egg production, but replacementof limestone with oyster shell (treatment 3 vs.treatment 2) improved egg production. The highest percent egg production observed in treatment T1(Bone meal group) disagreed with the findings of Hamilton *et al*. (1985)who found increased egg production with oystershell supplementation. These findings, however,do not agree with other investigations [Florescu *et al.* 1986, Cheng and Coon, 1990]that did not find any difference in egg productionwith different calcium sources including 4.5%oyster shell meal or limestone replacement withoyster shell, respectively. Lack of response inegg production due to different calcium and phosphorusin spent layers diets agreed with other publishedreports (Antillon 1976, Keshavarz 1986, Perez and Dela, 1987).

4.1.4 Mean Egg Weight

The trend of egg weight for the different treatment groups are presented in table 4. The highest values for egg weight was recorded for periwinkle shell group (T3). The lowest value was obtained from bone meal group (T1). No significant ($P<0.05$) difference was observed between the treatment groups.

4.1.5 Feed Conversion Ratio

The feed conversion ratio reported in the present study showed that treatment T2 (oyster shell group) was observed to be higher. Poorest record was observed in the birds fed with bone meal. There was no significant effect observed in feed conversion ratio between all the treatment groups in the fifth week of the study. This may be as a result of high ambient temperature that affected feed consumption that affected the feed consumption of the birds.

Table 5: Effects of Dietary Calcium and Phosphorus Sources on Productive Performance of Spent Layers.

	Treatment/ Diets					
Parameters	**T1(0.1)**	**T2(0.2)**	**T3(0.3)**	**T4(0.4)**	**SEM**	**LOS**
Egg production	54.88	52.52	54.39	50.75	0.76	NS
Feed conversion ratio	1.83	1.91	1.90	2.01	0.91	NS
Feed consumption(g)	99.13	99.92	102.66	102.06	2.58	NS
Mortality	-	-	2.100	3.100	1.300	

SEM: Standard error mean, NS: Non significant g/b/d: gram/bird/day

4.2 EGGS QUALITY FACTORS

4.2.1 Eggshell Thickness

The mean values for shell thickness is summarized in table 5. Significance difference ($P<0.05$) exist in treatment 4 and 1 with bone meal group performing better. This results is similar to the findings of Ahmad and Balander, (2004) who reported that partial replacement of calcium source, limestone with oyster shell improved egg shell quality, also in accordance with the findings of Swiatkieewicz *et al.* (2015) who reported that early laying hens show no effect on egg shell quality but substitution of fine particle limestone with large particle size limestone increases egg shell thickness, density and breaking strength at 69 weeks of age. The result is also in agreement with the report of Skrivan *et al*. (2010) who's report showed that the substitution of fine dietary limestone can increase shell weight, shell thickness and shell calcium level both in younger (24 to 36 weeks of age) and older (56-68 weeks of age) without any effect on shell breaking strength.

4.2.2 Haugh Unit

The mean value for Haugh unit is presented in table 6. There was no significant difference ($P<0.05$) observed among all the treatments. The findings in the present study was contrary to the report of Haugh (1973) who reported that the weight of an egg is directly related to the Haugh unit and agrees with the report of Hill *et al*., (1980). Reports are further substantiated by Verheyen and Ducuypere (1991) who found that Haugh unit value decreases with increase in age of birds. The result is also in agreement with the report of Wang *et al.* (2014) who reported increased Haugh unit ($P<0.01$) when ducks were fed large particle size diets containing oyster shell and limestone but contrary with the findings of Houndonougbo (2012) who reported similarity in Haugh unit and albumen height of eggs in layer hens supplemented with snail shell or oyster shells in the last laying phase indicating no effect of the shell supplementation on the internal characteristic of eggs.

4.2.3 Albumen Height

The trend of albumen height for the different treatment groups are presented in table 4. The highest values for egg weight was recorded for limestone group (T4). Other sources of calcium and phosphorus does not differ significantly ($P<0.005$). This shows that differences was observed between the treatment groups. The study is in accordance with the report of Bistter *et al.,* (1981), which reported that partial replacement of limestone with oyster shell improved different aspects of egg quality including specific gravity and that of limestone alone with reduced phosphorus did not decrease plasma phosphorus. The result in the present study is also similar to the findings of Wang *et al.* (2014) who reported that large particle size of limestone increase albumen height, shell content and breaking strength of tibia and concluded that it provide superior productive performance and egg quality.

4.2.3 Egg Weight

Egg weight in the present study ranged between 61.30 to 64.10g. There was no significant difference ($P<0.05$) observed among all the treatments. The result is in accordance with the report of Cheng and Coon (1990) who reported that treatments were not significantly different from each other. Lack of difference in egg weights by different calcium and phosphorus sources is in agreement with Cheng and Coon (1990), who concluded through a series of experiments that switching from limestone to oyster shell, in short-term laying trials, showed no significant differences in eggshell quality or layer performance including egg weight. The increase in egg weight with the age of the hen is well documented. These results are also in agreement with those of Keshavarz (1986) who found no significant difference in egg weight when hens were fed reducing phosphorus levels from 0.46 to 0.24% with 3.5 to 5.5% calcium.

Table 6: Effects of Dietary Calcium and Phosphorus Sources on Egg Quality Characteristics of Spent Layers.

	Treatment/ Diets					
Parameters	**T1(0.1)**	**T2(0.2)**	**T3(0.3)**	**T4(0.4)**	**SEM**	**LOS**
Egg weight	61.30	64.10	61.30	63.00	0.58	NS
Albumen height(mm)	4.90[b]	4.80[b]	4.70[b]	5.10[a]	0.04	*
Albumen width(mm)	6.70	7.50	7.30	7.50	0.07	*
Albumen length(mm)	8.70	8.70	8.80	8.70	0.10	NS
Albumen index	1.40	1.10	1.20	1.10	0.04	*
Percent shell(mm)	8.00	8.70	8.80	8.70	0.01	*
Shell thickness (mm)	0.30	0.30	0.30	0.30	0.003	*
Haugh unit	65.60	62.50	61.60	66.60	1.37	NS

Mean in the same row with different superscripts are significantly different (=P<0.05)
SEM: Standard error mean
NS: Non significant
mm: Millimetre

V. CONCLUSION

It can be concluded that none of the four different sources of calcium and phosphorus performed better in term of feed consumption and feed conversion ratio. On contrary, shell thickness for limestone (T4) was superior to that of bone meal (T1).

It is therefore recommended that layers diet can be formulated with limestone as calcium and phosphorus sources which were shown to have increased shell thickness in spent layers followed by oyster shell. Since spent layers produce heavier eggs with thinner shells.

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