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Improving Poultry Production in Sub-Saharan Africa Through Poorly Recognized Source of Calcium

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ABSTRACT

Background and Objective: Chicken eggshells are nutrient-rich but often considered a poultry wastes in some developing countries, including Nigeria, due to lack of studies investigating their importance in livestock production. This study evaluated the effects of eggshell as a replacement for dicalcium phosphate (DCP) on growth performance, blood serum minerals and carcass characteristics of broiler chickens. **Materials and Methods:** A total of 90 one-day-old broiler chicks were used in this study. Birds were distributed in a completely randomized design with 3 treatments and 3 replicates with 10 birds per replicate. A basal diet was formulated to meet the nutritional requirements of the birds. Diet 1, 2 and 3 contained 100% DCP, 50% DCP+50% eggshell and 100% eggshell respectively. **Results:** Growth performance, serum minerals and organ weight of birds was not adversely affected by eggshell. **Conclusion:** Chicken eggshell is a potential source of Ca and can be used as replacement for DCP in poultry production in developing countries to reduce the cost of production and environmental pollution.

KEYWORDS

Calcium, eggshell, food security, serum mineral, poultry production

INTRODUCTION

Broiler production has expanded in the past two decades and feed remains the key constituent of overall costs of production, which may account for about 80% of the total cost of production[1]. For effective feed utilization, reduced production cost and higher economic gain, feed additives are used. These additives have established a great consideration for numerous purposes in poultry production[2].

Calcium is an important macronutrient for shell strength. It is the main mineral component of the eggshell. The fact that eggshells are by-products of livestock which are often discarded despite their importance in animal nutrition, their use for this study is justified. Similarly, this by-product often constitutes a source of environmental pollution, thus it is necessary to study their utilization. In developing countries, farmers may need to use proven non-conventional feed ingredients to reduce their cost of production as well as to ensure sustainability in livestock production. There is extensive documentation on bioconversion of agro-industrial by-products to reduce the cost of livestock production and environmental pollution[3-7].

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Calcium is one of the nutrients found in eggshells[8]. Calcium is very important for bone formation, blood clotting, muscle contraction and plays an important role in metabolic processes[9]. Eggshell is an organic source of calcium and phosphorus. However, it is considered waste in many parts of developing countries. Eggshell can be used to improve their calcium intake and livestock production. As a dietary manipulative strategy, eggshell can be used to compact food insecurity in areas such as Sub-Saharan Africa. Because studies investigating its usefulness in poultry production in Nigeria are limited. Hence, it becomes necessary to investigate its use in poultry production, perhaps it may reduce the cost of production and thereby prevent environmental pollution that may result from its indiscriminate accumulation in open spaces. This study was conducted to evaluate the effects of eggshell as a replacement for dicalcium phosphate (DCP) on growth performance, blood serum minerals and carcass characteristics of broiler chickens.

MATERIALS AND METHODS

Protocol approval and experimental site: The study protocol was approved by the Ethics and Animal Care Committee of the Department of Animal Science, University of Ibadan (ANSUI/ PS/02/24AOO). This experiment was carried out at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Oyo State, Nigeria.

Housing system and preparation: Deep litter housing system was used. Birds were confined for proper organization and distribution into manageable experimental units, for effective disease control and protection from the extreme weather conditions. Pens and surroundings of the pens were cleaned, washed and disinfected two weeks before the arrival of the chicks. Brooding materials were bought two days before the arrival of the chicks, dry wood shavings were spread on the brooding floor at about 6-8 cm high. All equipment were placed in order according to the standard arrangement of feeders and drinkers in an alternative form within the chick guard. Before the chicks' arrival, cool clean water mixed with multivitamins was placed into the water troughs. The birds were thereafter allowed to feed. The temperature of the brooding pen was regularly monitored and adjusted as required. Records of mortality, weight changes and feed intake were regularly maintained. Each day, left over feeds were removed, drinkers were cleaned and fresh feed and water were replaced. Wood shaving was changed weekly.

Preparation of test ingredient: Eggshell was sourced from a hatchery within Ibadan Metropolis in Southwest Nigeria, air-dried until constant weights were maintained and ground into fine powdery form using a mechanical blender. The mineral composition of raw and autoclaved eggshells is presented in Fig. 1[10].

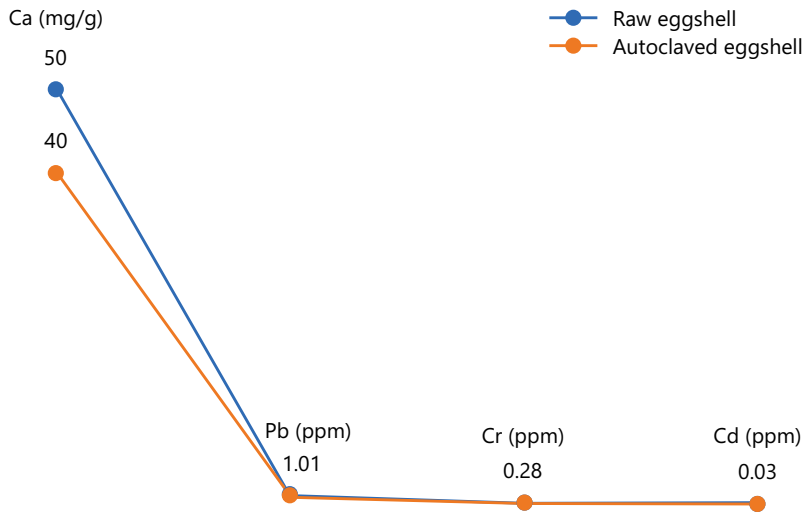

Fig. 1: Mineral composition of raw and autoclaved eggshells

Table 1: Gross composition of experimental diets of broilers

Ingredients	Diet 1	Diet 2	Diet 3
Maize	45.00	45.00	45.00
Groundnut cake	13.00	13.00	13.00
Soya bean meal	27.00	27.00	27.00
Wheat offal	6.00	6.00	6.00
Oil	6.25	6.25	6.25
DCP	1.50	0.75	-
Eggshell	-	0.75	1.50
Salt	0.30	0.30	0.30
Methionine	0.20	0.20	0.20
Lysine	0.20	0.20	0.20
Broiler Premix*	0.30	0.30	0.30
Oxytet	0.05	0.05	0.05
Toxin binder	0.10	0.10	0.10
Enzyme	0.10	0.10	0.10
Total	100.00	100.00	100.00
Crude protein	24.15	24.15	24.15
ME (kcal/kg)	3359.01	3359.01	3359.01

Diet 1 contained 100% DCP+0% eggshell, Diet 2 contained 50% DCP+50% eggshell, Diet 3 contained 100% eggshell+0% DCP, *2.5 kg contained 8,000,000 I.U. vitamin A, 1,600,000 I.U. vitamin D3, 15,000 I.U. vitamin E, 2000 mg vitamin K, 3000 mg vitamin B2, 20 g vitamin C, 20,000 mg niacin, 6000 mg pantothenic acid, 1500 mg vitamin B6, 10,000 mg vitamin B12, 500 mg folic acid, 400 mg biotin, 150,000 mg choline chloride, 100 mg cobalt, 600 mg copper, 10,000 mg iodine, 20,000 mg iron, 90,000 mg manganese, 100 mg selenium, 20,000 mg zinc and 1300 mg antioxidant

Experimental birds, design and diets: A total of 90 one-day-old broiler chicks (average weight 40±0.5 g) were distributed in a completely randomized design with 3 treatments, each having three replicates with 10 animals per replicate. A basal diet was formulated to meet the nutritional requirements of the birds. Diet 1 contained 100% DCP+0% eggshell, which served as the control diet. Diet 2 contained 50% DCP+50% eggshell. Diet 3 contained 100% eggshell+0% DCP (Table 1). The study lasted six weeks.

Data collection: Average daily feed consumption for birds in each experimental unit was measured and recorded by determining the difference between the feed intake and the left-over feed. Body weight gain, feed intake and feed conversion ratio was calculated weekly throughout the period of the experiment.

At the end of experiment, three birds were randomly selected from each treatment. Blood samples (5 mL) were collected from the jugular vein of the birds with sterile needle into well sterilized bottles for the analysis of serum biochemical parameters. The blood samples were allowed to clot before centrifugation for maximum yield. The serum assay was done using the commercially available radox® kit. Serum biochemistry parameters were mineral concentrations (calcium, magnesium, potassium and phosphorus).

At the end of the experiment, three birds were randomly selected from each treatment; the birds were starved, slaughtered and eviscerated. The live weights of the birds were measured and recorded before slaughtering. Bled weight was measured and recorded before dressing the birds. Thereafter, fully dressed weights of the carcasses were also recorded. Carcasses of the birds were then separated into their primal cuts, the primal cuts and the organs were individually weighed and expressed as a percentage of the live weight of the carcass. The dressing percentage and percentage weight of the body parts in relation to the live weights of the birds were calculated using the formula below:

$$\text{Relative weight} = \frac{\text{Weight}}{\text{Live weight}} \times 100$$

Statistical analysis: All data generated were subjected to a One-way Analysis of Variance (ANOVA), with the help of the General Linear Model procedure of the Statistical Analysis System (SAS)[11]. Significant means were separated using Duncan's Multiple Range Test. Statistical significance was set at $p<0.05$[12].

RESULTS AND DISCUSSION

The effect of eggshells as a replacement for DCP on growth performance, carcass characteristics and serum minerals of broiler chickens are presented in Table 2-4. The feed conversion ratio of the chickens according to their treatment is presented in Fig. 2. Growth performance and serum minerals of the experimental animals were not significantly affected. The live weight, the bled weight and the eviscerated weight of birds fed Diet 3 were significantly lower ($p<0.05$) than those fed the control diet (Diet 1), but similar to birds fed Diet 2. Organ weights were not significantly different across treatments.

Table 2: Effect of eggshell as replacement for DCP on growth of broiler chickens

Parameters (g/bird)	Diet 1	Diet 2	Diet 3	SEM
Final weight	926.70	862.70	964.30	55.13
Weight change	886.70	822.70	924.30	55.13
Feed intake	2464.20	2286.60	2255.20	88.98

Diet 1 contained 100% DCP+0% eggshell, Diet 2 contained 50% DCP+50% eggshell and Diet 3 contained 100% eggshell+0% DCP

Table 3: Effect of eggshell as replacement for DCP on carcass characteristics of broiler chickens

Parameters g/bird	Diet 1	Diet 2	Diet 3	SEM
Live weight	1754.25^{a}	1666.75^{ab}	1505.50^{b}	30.83
Bled weight	1691.25^{a}	1593.25^{ab}	1444.00^{b}	27.78
Eviscerated weight	1526.25^{a}	1296.25^{b}	1144.00^{b}	28.90
Lung weight	7.00	7.50	7.50	0.33
Kidney weight	9.50	9.00	9.75	0.37
Intestine weight	119.00	125.00	132.25	2.01
Liver weight	45.25	45.00	35.50	1.26
Heart weight	8.00	8.75	8.50	0.23
Spleen weight	1.75	1.75	1.75	0.17
Full gizzard weight	49.50	48.00	49.75	2.09
Empty gizzard weight	37.00	34.00	36.25	1.67

Diet 1 contained 100% DCP+0% eggshell, Diet 2 contained 50% DCP+50% eggshell and Diet 3 contained 100% eggshell+0% DCP

Table 4: Effect of eggshell as replacement for DCP on serum minerals of broiler chickens

Parameters (Ug/L)	Diet 1	Diet 2	Diet 3	SEM
Calcium	21.53	21.60	21.53	0.19
Magnesium	1.25	1.22	1.21	0.01
Potassium	15.18	15.58	13.68	0.31
Phosphorus	11.14	10.66	10.49	0.14

Diet 1 contained 100% DCP+0% eggshell, Diet 2 contained 50% DCP+50% eggshell and Diet 3 contained 100% eggshell+0% DCP

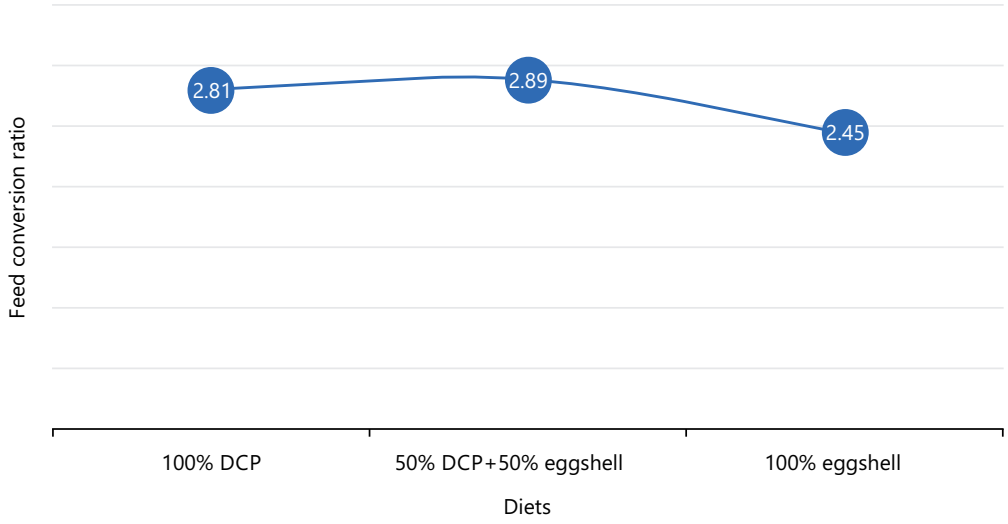

Fig. 2: Feed conversion ratio of broiler chickens fed eggshell as a replacement for DCP

Body weight is an important factor in selection, production and animal performance[13]. In the present study, no difference was observed across the experimental diets. Rezvani *et al*.[14] earlier reported improved weight gain with broiler chickens fed eggshells at 1.52% in starter feed and 1.45% in finisher feed. However, Hassan *et al*.[10] observed no significant differences in the performance indices measured when eggshell was used up to 100% as replacement for DCP in laying hens.

Serum minerals are trace minerals that are essential nutrients. They play critical role in enzymes, hormones and cell functions. They are involved in several physiological, digestive and biosynthetic processes within the body[15,16]. In this study, the experimental birds were not different across treatments. A previous study by Schaafsma and Beelen[17] also reported that eggshell powder had no adverse effects on experimental piglets, regarding magnesium and crude fat digestibility.

The difference in live weight, bled and eviscerated weights may be due to other factors and this result may need to be verified with further studies. In this study, eggshell-supplemented diets are not statistically different, although 100% inclusion lowered the live weight, bled and eviscerated weights when compared with the control diet. The internal organs showed no significant variance.

In human calcium enrichment strategies, chicken eggshell powder has been recommended and used in human nutrition for decades. A high percentage of Ca has been reported, a significant amount of Sr, as well as controlled low levels of Pb, Cd and Al, which makes it superior to other natural sources of Ca which may be polluted by the aforementioned elements[18]. A research study focused on osteoporotic bone structure using ovariectomized rats observed that eggshell powder as a treatment enhanced bone strength, significantly increased plasma calcium level, relative volume of trabecular bone, secondary osteon population density and reduced bone resorption; leading the authors to the conclusion that chicken eggshell powder more effectively ameliorated bone loss in ovariectomized rats than precipitated calcium carbonate[19].

Chicken eggshell is a cheap source of poultry waste materials, available at home, hatcheries and food industries and it contains up to 94% calcium carbonate, 1% magnesium carbonate and 1% calcium phosphate and it contains about 39% elemental calcium, which makes it an effective source of dietary calcium[20]. It has been noted that half of a chicken eggshell, which contains about 2.7 g of calcium, can meet an adult's daily requirements for calcium[21]. Previous studies have shown that chicken eggshell improves femoral neck bone density[22] and is more efficient than calcium carbonate in improving bone mass in women, indicating its importance in human nutrition[23].

Kobus-Cisowska *et al*.[24] reported that the use of hen eggshell in bread spread affected none of the tested physicochemical, rheological or sensory factors and did not affect storage stability. In another study, it was observed that an eggshell inclusion level of about 6% did not negatively affect the flavour of biscuits[25]. Platon *et al*.[26] also suggested that white bread can be fortified with eggshell powder up to the acceptable level of 2%. In a recent study, it was reported that mineral concentrations increased considerably when eggshell powder was supplemented, mainly in the calcium content of biscuits, with a significant reduction in the calorie value. The 5% inclusion in biscuits resulted in a higher calcium absorption rate, resulting in no undesirable sensory changes up to 10% inclusion level[8]. Bread formulation with eggshell at 10% inclusion level has been reported to improve calcium assimilation compared to bread with conventional formulation[27]. In addition, eggshell has been suggested to improve calcium and ash content and water absorption capacity in calcium extracted from eggshell-formulated bread[28].

The importance of chicken eggshells in Sub-Saharan Africa is underutilized, as a waste material, it is discarded or accumulated indiscriminately, causing an environmental nuisance to public health. The apparent absorbability of Calcium from eggshells was also found to be as good as the one from $CaCO_3$ in piglets[17]. However, in developing countries such as Nigeria, the beneficial effects of this

considered-waste-nutrient-rich resource are not known, hence, its use in livestock production is limited. It is hoped that the present study will enlighten poultry farmers about the benefits of using eggshells in poultry farming and develop their interest in the use of eggshells in poultry production, thereby improving their livelihood through reduced cost of production, which may eventually improve food security in developing countries combating with food insecurity, especially for nutritious poultry products.

CONCLUSION

In this study, it is observed that 50 and 100% inclusion level of eggshell as replacement for DCP did not influence growth performance and serum minerals of broiler chickens. It also did not influence the organ weight of the experimental chickens. Eggshell as a replacement for DCP at 50% inclusion level compared well to the control diet for live, bled and eviscerated chickens. It may thus be concluded that eggshells can partially replace DCP in poultry production. Chicken eggshell is considered a poultry waste material, although it is a potential source of calcium that can improve poultry production in developing countries where the cost of feed ingredients is a major concern to livestock production.

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