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EFFECTS OF SILICON OXIDE SUPPLEMENTATION IN BROILER CHICKENS' DRINKING WATER ON PERFORMANCE AND LITTER QUALITY UNDER TROPICAL ENVIRONMENT

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ABSTRACT

The objective of this study was to determine the effects of silicon oxide in broiler chickens drinking water on performance and litter quality. A total of 120 day old mixed sex broiler chicks were randomly divided into 4 treatments and 3 replications, with 10 birds in each replicate. The birds were distributed into a completely randomized experimental design, with 4 silicon levels (0, 1.5, 2.0 and 2.5 mg of silicon oxide/100 kg body weight (BW)/day).Diets were maize and soybean meal based and formulated for starter (1–21 day), and finisher (24–49 day) phases. Birds were provided with water freely. The average daily temperature and relative humidity inside the poultry house were 35.9 °C and 36%, respectively. For the starter phase silicon oxide in broiler chickens' drinking water at 200mg/100kg body weight/d increased ($P < 0.05$) final body weight and average weight gain (991.00g and950.96g respectively) compared with the control (778.57 g and 738.54 respectively). The inclusion of 200 mg silicon oxide/100kg body weight/d in water improved feed conversion ratio compared to the controls ($P < 0.05$) and significantly reduced feed cost per kg gain. For the finisher phase, 10mg/100kg body weight/d and 15mg/100kg body weight/d had similar results for final weight, weight gain and feed cost per kg gain. However, inclusion of silicon in broiler chickens water improved litter quality. In conclusion, silicon oxide in broiler chickens drinking water at 1.5mg/100kg body weight/d enhanced growth performance, improved feed conversion ration and litter quality as well as reduced feed cost per kg gain at the starter and finisher phases respectively.

Keywords: Silicon oxide, Performance, Litter quality, Broiler, tropics

INTRODUCTION

Nutrition is an important determinant for optimum growth performance and general well being for broiler chickens. However, effect of the individual nutrient and minerals, other than essential amino acids, metabolizable energy, calcium, phosphorus amongst others, is little understood. Essential trace elements are required by animal especially the poultry, they act as catalyst or structural components of larger molecules, thus having specific function and are indispensable for survival (Yan *et al.*, 2010). However, marginal or severe trace element imbalance can be considered risky factors for several diseases of public health importance, but proof of cause and effect relationship will depend on a more complex understanding of basic mechanism of action and better analytical procedures and functional tests to determine marginal trace element status in animal.

Experimental diets may sometimes be formulated from purified or chemically defined ingredients. Under these conditions, silicon and boron may be inadequate and biological responses may occur with the addition of these elements to the diet (NRC, 1994 and Carlisle, 1980).Silicon which is one of the most important trace minerals is less used as a supplement in poultry feed industries

especially in the developing countries. Until now, there has been limited interest in terms of feeding silicon supplement to broiler chickens. Silicon dioxide is a highly pure and natural mineral, show promise in decreasing ammonia and improving litter quality (Tran *et al*., 2015). However, inclusion of silicon supplement in the diets of turkey according to the study conducted by University of Guelph, improved weight gain, feed conversion ratio, and also boosted litter quality through the reduction in nitrogen loss. When added to feed, the supplement acts like a catalyst by imparting its electromagnetic information on all forms of matter to normalize the vibration, restoring homeostatic (digestion, absorption, assimilation, metabolism) to their optimum, thus offering better growth and performance (Tran *et al*., 2015). In addition, silica increase dissolved oxygen in water and therefore helps reduce ammonia in litter and manure (Shariatmadari, 2008 and Scholey*et al*., 2018). It has also been reported that poor litter quality can increase the microbiological load in litter thereby exposing birds to increased challenges from parasites such as coccidia, other protozoa, fungi, enteric viruses, and environmental bacteria (Ritz *et al*., 2009).Some minerals have been reported to reduce ammonia release from poultry litter. Silicon dioxide, a highly pure and natural mineral, shows promise in decreasing ammonia volatilization and improving litter quality (Tran *et al*., 2015).

The requirements for trace minerals are often fulfilled by concentrations present in conventional feed ingredients. However, soils vary in their content of trace minerals, and plants vary in their uptake of minerals. Consequently, feedstuffs grown in certain geographic areas may be marginal or deficient in specific elements. Thus, poultry diets may require supplementation to ensure adequate intake of trace minerals. The Present study was conducted to evaluate the efficacy of silicon oxide in drinking water on performance and litter quality of broiler chickens reared under tropical environment.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm of Kabba College of Agriculture, Ahmadu Bello University, Kabba, Kogi State, Nigeria in December, 2019. The study area is located within the Southern Guinea Savannah agro-ecological zone and the coordinate of the study area is Latitude 07° 51.128' N and Longitude006° 04.273' E. It has an annual rainfall of 1500mm and rain starts between late April and early May to mid October. The dry season begins around the middle of November, with cool weather that ends in February. This is followed by relatively hot-dry weather between March and April just before the rain begins. The minimum daily temperature is from 14^{o}C-23^{o}C during the cool season while the maximum daily temperature is from 19^{0}C-36^{0}C during the hot season. The mean relative humidity during dry and wet seasons is 15% and 36%, respectively.

Birds, housing, experimental design and diets

In this experiment, 120day old, mixed sex broiler chicks from Abor Acre strain were allotted to 4 dietary treatments in a completely randomized design. Each treatment was replicated 3 times with 10 chicks per replicate. The chicks were reared on a deep litter system (1.5 x 1.5cm). Heat and light were provided throughout the brooding period. Birds were housed in an environmentally controlled room initially maintained at 35°C and provided with 12 h light daily, and water *ad libitum*. The temperature was gradually lowered 4°C /week, reaching 23°C by the end of Week 3 and maintained at this temperature throughout the remaining study. Routine vaccinations (gumboro and lasota) and all necessary

medications were administered as follows. Day 1-5 Neoteramycine + vitalyte in water orally, day7, first dose of gumboro, day 14, NDV-Lasota, day 21, second dose of gumboro; day24 coccidiostat in water. Feed and water were provided *ad libitum*. The diets were isocaloric and isonitrogenous and formulated to meet the nutrient requirements of the broiler chicks during starter and finisher periods (Table 1) according to the National Research Council requirements (NRC, 1994). The average maximum temperature was 35.9°C, while the average minimum temperature recorded was 22.5°C. The average maximum relative humidity was 36.18%, and the average minimum relative humidity was 15.00%. Diets formulated were maize and soybean meal base, for starter (1–21d) and finisher (24– 49d) phases. However, the treatments for the starter and finisher phases involve the level of 0.0, 1.5, 2.0 and 2.5mg silicon oxide to make up the 4 dietary treatments. At the beginning of each phase, representative feed samples were taken for proximate analysis Table 2. The proximate analyses of the diets were determined according to the Association of Official Analytical Chemists (1990).

Performance and litter quality

At the end of the experimental period (21 d and 49 d) respectively, the weight gain, feed intake and feed conversion ratio were calculated. The birds, the offered feed and the feed residue were weighed at the beginning and end of the starter (1–21 d) and finisher (24–49 d) periods. Mortality was recorded daily for the correction of performance parameters and to calculate viability. At the end of each phase, litter samples were visually scored on a scale of 1 to 5 (1 driest to 5 wettest) adapted from Hooge*et al*. (2012) with some modifications, as follows:

1. Dry, friable material throughout the pen.

2. Predominantly dry material and mostly acceptable but with some areas of wet shavings.

3. Poor quality litter material with a large proportion of wet areas.

4. Unacceptable litter quality, wet but with a few areas of dry material remaining.

5. All litter wet and soggy, no dry areas left.

Statistical analysis

Data were analyzed as completely randomized design using the General Linear Model Procedures (GLM) of the Statistical Analysis Software package. Significant difference between treatments means were separated using Duncan Multiple Range Test (SAS, 2002).

Experimental Model

$Y_{ij} = \mu + T_i + e_{ij}$

Y_{ij} = performance of j^{th} animal fed i^{th} levels of silicon oxide inclusion

μ = Overall mean

T_i = i^{th} effect of treatment at varying levels of silicon oxide inclusion

e_{ij}= Random residual error

Table1: Ingredients contained in the basal diets for broilers chickens and its calculated nutrient content

INGREDIENTS	BASAL DIET (STARTER)	BASAL DIET (FINISHER)
Maize	53.76	56.33
Soya bean cake	27.00	13.00
GNC	13.74	22.70
Palm oil	1.50	3.41
Bone meal	2.50	2.50
Limestone	0.50	1.00
Common Salt	0.30	0.30
Methionine	0.20	0.21
Lysine	0.20	0.25
Vit-min-Premix[1]	0.30	0.30
Total	**100.00**	**100.00**
Calculated Analysis		
ME (Kcal/kg)	3030	3000
Crude Protein (%)	23.01	21
Crude Fibre (%)	3.73	3.34
Ether Extract (%)	5.84	5.84
Calcium (%)	1.27	1.32
Phosphorus (%)	0.83	0.83
Methionine (%)	0.56	0.54
Lysine (%)	1.28	1.14

Starter phase=[1]Vitamin mineral premix provide per kg of diet. Vit. A, 13,340 i.u; Vit. D_3, 2680 i.u; Vit. E, 10 i.u; Vit. K, 2.68 mg; Calcium pantothenate, 10.68mg; Vit. $B_{12,}$ 0.022mg, Folic acid, 0.668mg; Choline choride, 400mg; Chlorotetracyline, 26.68mg; manganese, 13mg; iron, 66.68mg; Zinc, 53.34mg; Copper, 3.2mg; Iodine, 1.86mg; Cobalt, 0.268mg; Selenium, 0.108mg. Finisher phase:**Biomix Premix Supplied per kg of diet: Vit. A, 10,000iu; Vit.D_3, 2000iu; Vit E, 23mg;Vit. K, 2mg: Vit.B1,1.8; Vit. B_2, 5.5mg; Niacin, 27.5mg; Pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg: Folic acid, 0.75mg; Biotin, 0.06mg; Choline Chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1 mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

Table2: Proximate composition of boiler starter and finisher chickens fed diets

	Starter Diet	Finisher Diet
DM	92.24	89.98
Crude Protein	22.86	20.78
Crude Fibre	6.97	5.67
Ether Extract	4.67	5.55
Ash	6.56	7.01
Nitrogen Free Extract	51.18	50.97

RESULTS AND DISCUSSION

The results for the effect of silicon oxide in drinking water on performance of broiler chicks are presented in Table3. Silicon oxide in drinking water significantly ($p < 0.05$) increased weight gain, average daily body weight gain and improved feed conversion ratio (FCR) compared with control (Table 3). A linear increase in final weight, weight gain and feed conversion ratio was also observed as the levels of silicon oxide in water increased and began to drop at treatment 4. However, Supplementation of silicon oxide in water presented to chicks had no significant ($p>0.05$) effects on feed intake and mortality. It was observed that 2.00mg in drinking water of chicks had the overall best results in terms of the final weight gain, average daily weight gain and improved feed conversion ration compared to the control treatment. This finding was in accordance with the study conducted by Tran *et al*,(2015), who reported that supplementation of 2.00mg silicon oxide had positive effects on daily body weight gain and feed conversion ratio (FCR) during the grower and finisher phases. However, this result disagrees with the findings of Sgavioli*et al*., (2016), who reported no significant effect of silicon oxide addition on performance although performance was not impaired by adding the tested silicon product in the drinking water. The improved performance observed in this study may be as a result of the balanced ratio fed in combination with the genotype of the chicks. Silicon oxide might have the potential to improve nutrient digestibility as evident in the improved feed conversion ratio of broiler chicks in this study. Leg deformity was not noticed across the treatment groups. This is similar to the result of Short *et al*. (2011) who reported that dietary silicon supplements had the capacity to reduce lameness in broilers. However, Silica based supplements might, therefore, has the potential to improve poultry welfare. The feed cost per kg weight gain in this study was positively correlated with feed intake and body weight across the treatments groups.

For the finisher phase, the effect of silicon oxide on performance of broiler finisher chickens is presented on Table 4. Dietary treatments had significant ($p<0.05$) effects on final weight, weight gain, average daily weight gain and feed cost per kg gain. However, the dietary treatments had no significant ($p>0.05$) effects on feed intake, average feed intake, feed conversion ration and mortality. These results disagrees with the finding of Sgavioli*et al*., (2016) who reported that drinking water supplementation with the silicon product did not significantly affect broiler performance (feed and water intake, weight gain and feed conversion ratio).Chickens presented with water supplemented with silicon oxide had the best results in terms of final weight, weight gain, average daily weight gain and feed conversion ratio compared to the control treatment without silicon oxide. However, the results obtained for final weight, weight gain and average weight gain for chickens on 2.00mg/kg is similar to the chickens on 1.50mg/kg. The result obtained is similar to the findings of Tran *et al*., (2015), who reported that supplementation of silicon oxide had positive effects on daily body weight gain and feed conversion ratio (FCR) during the finisher phase. It was observed that dietary treatment had not significant effect on feed conversion ratio but broiler chickens on treatment 2 had numerically the best FCR. The best feed cost per kg weight gain for broiler finisher chickens was observed in treatment 2. Litter quality was visually scored at the end of the two growth phases Table 5. Generally there were no significant ($p>0.05$) differences for litter quality for both starter and finisher phases. However, it was observed that the visually scored litter samples were predominantly dry material and mostly acceptable but with some areas of wet shavings. This result is consistent with the

findings of Tran *et al*, (2015) who reported that supplementation of silicon oxide reduced litter pH which decreased the conversion of NH_4^+ to NH_3 thereby reducing nitrogen losses from litter.

Table 3: Performance of broiler starter chicks fed graded levels of silicon oxide in drinking water (0- 4 Weeks)

	Silicon Oxide (g/kg)				
Parameters	**0.00**	**1.50**	**2.00**	**2.50**	**SEM**
Initial weight (g)	40.04	40.01	40.05	40.02	0.04
Final weight(g)	755.03^{b}	866.93^{b}	991.00^{a}	778.57^{b}	45.32
Weight Gain (g)	745.00^{b}	826.92^{b}	950.96^{a}	738.54^{b}	45.32
Ave daily gain (g)	31.04^{b}	34.46^{b}	39.62^{a}	30.77^{b}	1.89
Feed Intake (g)	1614.19	1489.00	1514.67	1526.11	80.62
Feed Intake (g/b/d)	67.26	63.11	63.11	63.59	3.35
FCR	2.16^{b}	1.82^{a}	1.59^{a}	2.09^{b}	0.13
Feed cost/kg gain (₦/kg)	133.50^{b}	128.33^{b}	111.20^{a}	159.24^{c}	7.26
Mortality (%)	1.41	1.75	0.00	0.00	1.94

a, b,c = Means with different superscript on the same row differ significantly (P<0.05)
SEM = Standard Error of Means
FCR = Feed conversion ratio

Table 4: Performance of broiler finisher chickens fed graded levels of silicon oxide in drinking water (5- 8 Weeks)

	Silicon Oxide (g/kg)				
Parameters	**0.00**	**1.50**	**2.00**	**2.50**	**SEM**
Initial weight (g)	711.99	711.33	712.33	712.00	0.82
Final weight(g)	2193.33^{c}	2680.00^{ab}	2740.00^{a}	2540.00^{b}	84.01
Weight Gain (g)	1481.34^{c}	1968.67^{ab}	2027.81^{a}	1828.00^{b}	83.93
Ave daily gain (g)	61.72^{c}	82.03^{ab}	84.49^{a}	76.17^{b}	3.50
Feed Intake (g)	4559.45	4414.03	4352.63	4523.69	115.67
Feed Intake (g/b/d)	189.98	183.92	181.36	188.49	4.82
FCR	3.10	2.24	2.15	2.47	0.18
Feed cost/kg gain (₦/kg)	65.94^{b}	52.17^{a}	56.56^{a}	59.47^{ab}	3.80
Mortality (%)	1.34	1.67	0.00	3.42	2.37

a, b,c = Means with different superscript on the same row differ significantly (P<0.05)
SEM = Standard Error of Means

FCR = Feed conversion ratio

Table 5: Visual Scoring of Litter Quality at each Growth Phase

	Silicon Oxide (g/kg)				
Growth phase	**0.00**	**1.50**	**2.00**	**2.50**	**SEM**
Starter	3.10	4.02	4.03	2.68	1.67
Finisher	3.00	3.02	3.99	3.10	1.57

SEM = Standard Error of Means

CONCLUSION AND APPLICATIONS

In conclusion drinking water supplementation with silicon oxide increased body weight gain. It also did improve litter quality, feed conversion ration and feed cost per kg weight gain. Drinking water supplemented with 2.00mg and 1.50 mg silicon oxide/100kg body weight/d had the best performance at the starter and finisher phases respectively. Further study should be conducted to evaluate the mechanism of gastrointestinal uptake of silicon in broiler chickens.

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