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Effect of silicon oxide supplementation in broiler chickens' drinking water on performance and litter quality under tropical environment

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Abstract

The present study was conducted to determine the effect of silicon oxide in broiler chickens drinking water on performance and litter quality. A total of 120, one-day old mixed sex broiler chicks were randomly divided into 4 treatments and 3 replications, with 10 birds in each replicate in a completely randomised experimental design, with 4 silicon levels (0.00, 1.50, 2.00 and 2.50 mg of silicon oxide/litre of water. Corn-soya based diets were formulated at the starter (0–4 weeks) and finisher (5–8weeks) phases and were supplied ad libitum with free access to water. The average daily temperature and relative humidity inside the poultry house were 35.9 °C and 36%, respectively. At the starter phase, chicks administered 2.00mg silicon oxide/litre of water had significantly ($p<0.05$) higher final body weight (991.00g) and average weight gain (950.96g) compared to chicks without silicon oxide 778.57 g and 738.54g. The inclusion of 2.00 mg silicon oxide/litre of water improved feed conversion ratio compared to the control group ($p < 0.05$) and significantly reduced feed cost per kg gain. For the finisher phase, chickens administered 2.00mg silicon oxide/litre of water had the best results for final weight, weight gain and feed cost per kg gain. Also, inclusion of silicon oxide in broiler chickens water improved litter quality as predominantly dry material but with some areas of wet shavings was observed. In conclusion, silicon oxide in broiler chickens drinking water at 2.00mg/litre of water enhanced growth performance, improved feed conversion ratio 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 in 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 (Nääs *et al.*, 2012). 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 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 Longitude 006° 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°C- 23°C during the cool season while the maximum daily temperature is from 19°C- 36°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, 120, one-day 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 and all necessary medications were administered as follows. 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 (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%. Corn-soya bean meal base diets were formulated for starter (0 – 4 weeks) and finisher (5 – 8 weeks) phases. The treatments were administered at level of 0.00, 1.50, 2.00 and 2.50mg silicon oxide to make up the 4 dietary treatments. The proximate analyses of the diets are shown in Table 2 and were determined according to the Association of Official Analytical Chemists (1990).

Table1: Ingredients contained in the basal di et for broiler 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, 0.108m g. 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 Chlo ride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1 mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

Performance and litter quality

At the end of the starter and finisher phases 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 (0– 4 weeks) and finisher (5 – 8 weeks) phases. 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; and 5. All litter wet and soggy, no dry areas left.

Statistical analysis

Data were analyzed 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 2001).

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

Table2: Proximate composition of broiler 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 Table 3. 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 ratio compared to the control treatment. This finding was in accordance with the study conducted by Tran *et al*, (2015) 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 disagreed with the findings of Sgavioli *et al*. (2011), who did not observe any significant effect of silicon oxide addition in the drinking water on performance although performance was not impaired. The improved performance observed in this study may be as a result of the balanced ration 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 increased with supplemental silicon oxide across the treatment 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 ratio and mortality. These results disagreed with the finding of Sgavioli *et al*. (2011) that drinking water supplemented with the silicon product did not significantly affect broiler performance (feed and water intake, weight gain and feed conversion ratio). Chickens administered water supplemented with silicon oxide had better performance compared to the control treatment without silicon oxide. However, the results for final weight, weight gain and average weight gain for chickens on 2.00mg/ litre of water were similar to those obtained in chickens on 1.50mg/litre of water. This was similar to the findings of Tran *et al*. (2015) that supplementation of silicon oxide had positive effects on daily body weight gain and feed conversion ratio (FCR) during the finisher phase. Although the dietary treatment had no significant effect on feed conversion ratio, however broiler chickens on treatment 3 (2.00mg/litre of water) had numerically the better FCR. Chickens administered with 1.50, 2.00, 2.50mg/litre of water had similar feed cost per kg weight gain at the finisher phase. 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 Incharoen *et al*. (2016) that supplementation of silicon oxide reduced litter pH which consequently 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

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

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

Growth phase	0.00	1.50	2.00	2.50	SEM
Starter	3.10	3.02	2.03	2.48	1.67
Finisher	3.99	3.09	2.00	2.06	1.57

SEM = Standard Error of Means

Conclusion

Drinking water supplementation with silicon oxide improved body weight gain, litter quality, feed conversion ratio and feed cost per kg weight gain. Drinking water supplemented with 2.00mg silicon oxide/litre of water 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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