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The Effect of Graded Levels of Magnesium Sulphate ($MgSO_4$) in Practical Broiler Starter Diets in the Humid Tropics

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Abstract: A total of 144 day-old Anak 2000 strain of broiler chicks were used in the study. A basal diet was formulated and supplemented at 0, 200, 400, 600 mg kg^{-1} of $MgSO_4$ to constitute four dietary treatments. The birds were randomly allotted to the four dietary treatment groups and replicated thrice (12 birds per replicate). The performance characteristics, nutrient digestion coefficients, Mg utilization coefficients and haematological and biochemical parameters of the birds were determined. Feed conversion ratio, crude protein retention, Mg utilization and blood parameters were highest in birds fed diet containing 400 mg kg^{-1} $MgSO_4$. There were significant ($p<0.05$) differences in the final body weight, weight gain, Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and crude protein retention. Liver Mg content, Mg intake and excretion increased significantly in a dosage dependent manner. Nutrients digestibility increased significantly as Mg levels increased from 0 to 400mg though, digestibility coefficients of Mg were significantly ($p>0.05$) depressed across treatments. However, serum Mg, Mg digestibility coefficient and tissue Mg residue were similar across treatment groups. The results showed that inclusion of 400 mg kg^{-1} supplemental $MgSO_4$ in practical broiler starter diets resulted in improved performance and nutrients digestibility of the birds.

Key words: Supernormal levels of $MgSO_4$, practical broiler starter diets, crude protein retention

INTRODUCTION

The growth of the Nigerian poultry industry has been found (Olomu, 1995) to be parallel to improved supply and utilization of micronutrients. The increase in demand and supply of these products (vitamin/mineral premix) has led to the appearance of many brands of premixes with marked differences in their vitamin and mineral profiles. Some of these are adulterated while others are neither balanced nor do they contain mineral level as projected by their compositional label. This adulteration dictates to some extent the quality of the premixes and the bioavailability of these minerals for necessary uptake by poultry. Tannin has a bonding property by chelating heavy metals like calcium, zinc and magnesium thereby making them unavailable in natural feedstuffs. This precipitates into a short fall in the amount needed by the birds. Hence, there is the need to supplement mineral levels in practical diets with soluble mineral salts to achieve better performance (Osborne *et al.*, 1982; Kubena *et al.*, 1989; Toyama, 1981).

Vitamin/mineral premix is an essential micro-ingredient in livestock feed as it supplies vitamins and minerals required by poultry in definite proportion. However, the bioavailability of magnesium components of premix islimited by the presence of a number of antinutritional factors in feedstuffs.

In poultry, chicks fed marginally deficient magnesium diets show symptoms of neuromuscular hyperirritability when disturbed. Such chicks show a brief convulsion and then enter a comatose state from which they usually recover. Sometimes death may occur. However, it should be noted that increased dietary levels of calcium and phosphorus accentuate magnesium deficiency (Olomu, 1995).

A great deal of literature concerning calcium and phosphorus requirements of broilers have been published with minimal research concerning requirements for magnesium and some other trace minerals (Scott *et al.*, 1982; Sullivan *et al.*, 1992; Perney *et al.*, 1993; NRC, 1994). However, Georgeievskii *et al.* (1990) observed a linear increase in weight of broiler chicken as a result of supplementation with 400-600 mg kg^{-1} MgO. The precise requirement for Magnesium (Mg) in practical broiler diets is not well defined (NRC, 1994). The present study was conducted to determine the effect of supernormal levels of Magnesium Sulphate ($MgSO_4$) in practical broiler starter diets on the performance, crude protein retention, digestibility coefficients, Mg utilization and blood characteristics of the experimental birds.

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MATERIALS AND METHODS

Experimental birds and management: A total of 144 unsexed day-old Anak 2000 strain of broiler chicks were obtained from a reputable hatchery in Ogun state, Nigeria. The birds were randomly allocated to 4 dietary treatments of three replications, each consisting of 12 birds. The birds were brooded for 2 weeks in a standard brooder. The litter was about 7cm deep to prevent hook burns. The pens were equipped with shallow feed trays and fountain drinkers for brooding chicks. The birds were fed and provided water *ad libitum*. The feeding lasted for 4 weeks.

Experimental diet: The experimental diets were introduced to the birds at day-old and fed the birds for 4weeks. The levels of supplementation of Magnesium Sulphate ($MgSO_4$) in the diets were as shown in Table 1 and the basal diet composition was as presented in Table 2. Diet 1(control) had 0 mg kg^{-1} $MgSO_4$ while diets 2, 3 and 4 had 200, 400 and 600 mg kg^{-1} inclusion levels of $MgSO_4$, respectively. The basal diet of 100kg was the same in all the treatments.

Chemical analysis: The proximate composition of feed and faeces was carried out using the method of AOAC (1995). Moisture contents were determined at 60°C for 26 h. The gross energy was determined using adiabatic calorimeter.

Table1: Level of supplementation of $MgSO_4$

	Diets			
	1	2	3	4
Basal diet (kg)	100.00	100.00	100.00	100.00
$MgSO_4$ (mg kg^{-1})	0.00	200.00	400.00	600.00

Table 2: Composition (%) of the basal diet

Ingredient	%
Maize	41.70
Wheat offal	13.00
Soyabean meal	24.00
Fish meal	1.50
Groundnut cake	11.70
Rice bran	4.50
Bone meal	2.40
Oyster shell	0.50
Salt	0.25
*Vit./min. premix	0.25
Methionine	0.10
Lysine	0.10
Total	100.00

Proximate composition	CP (%)	CF (%)	EE (%)	Mg (%)	ME (MJ kg^{-1})**
Determined	23.76	5.56	6.03	0.086	11.99

*Vitamin/trace mineral mix (Agricare-mix®-pfizer) for broiler starter chicken to supply per kg feed of: vit.A,1800iu; vit.D_3,2500iu; vit.E,14iu; vit.B_2,12mg; vit.B ,44mg; vit.B ,28mg; chloride,480mg; Mn,120mg; Fe,70mg; Cu, 10mg; I, 2.2mg; Se, 0.2mg; Zn,45mg; Co, 0.02mg. **ME (MJ kg^{-1}) - Calculated

Metabolic trials: At the expiration of 4 weeks, 3 birds per replicate were selected randomly and housed together in a metabolic crate for metabolic trial. Three days acclimatization period was observed followed by a day fasting before the commencement of the trial. Feed intake and total faecal output were recorded for 4 days while the wet faecal output were oven dried to constant weight. The procedure of Vogtmann *et al.* (1975) was used in calculating the percentage digestibility of protein, fat, crude fibre and nitrogen-free extract. After the metabolic trials, the birds used were slaughtered and the liver and thigh tissue excised for Mg analysis.

Blood sampling: At the end of the experiment, blood samples were taken into an EDTA (Ethylene Diamine Tetra- Acetate) bottle for blood plasma analysis. The parameters analyzed for were: Packed Cell Volume (PCV), Haemoglobin (Hb), total protein, albumin, globulin, calcium, potassium, phosphorus and magnesium levels. The levels of the minerals were determined by the method described by Noller and Bloom (1978) and estimated using the method described by Ceirwyn (1996).

Statistical analysis: The data obtained were subjected to Analysis of Variance in a Completely Randomized Design (CRD). The means that were significantly ($p<0.05$) different were compared using Duncan's Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The proximate composition of the diet presented in Table 2 was within the recommended values for birds in the humid tropics (NRC, 1994).

The parameters shown in Table 3 were significantly ($p<0.05$) different. There was a linear reduction in the feed intake as the levels of $MgSO_4$ increased. Weight gain differs significantly ($p<0.05$) across treatments. The highest weight was observed at 400 mg kg^{-1} $MgSO_4$ supplementation while the lowest weight gain was obtained at 600 mg kg^{-1} $MgSO_4$ supplementation. This was contrary to the observation of Georgievskii *et al.* (1990) that body weight gain of broiler chicken increased with increasing level of MgO up to 400 mg kg^{-1} and 600 mg kg^{-1}. Although, daily water intake was not measured in this study, the reduced feed intake could be due to increase in water intake. The increase in water intake precipitated into watery droppings which were observed in diets containing 400 mg kg^{-1} and 600 mg kg^{-1} $MgSO_4$ (Olomu, 1995). The feed conversion ratio showed no clear-cut trend, but ranged from 1.83 to 2.06. The best feed conversion ratio of 1.83 was recorded in the diet

Table 3: Performance characteristics of broiler starter fed diets supplemented with $MgSO_4$

	Diets				
	Inclusion levels of $MgSO_4$ (mg kg^{-1})				
Parameter	0.00	200.00	400.00	600.00	SEM^{1}
Initial body weight (g)	40.33	40.00	40.00	40.00	1.44
Final body weight (g)	696.67^{d}	716.67^{c}	790.00^{a}	720.00^{b}	9.24
Daily wt^{2}. gain/bird (g)	26.21^{b}	25.78^{b}	27.87^{a}	24.45^{c}	0.68
Daily feed intake/bird (g)	53.73^{a}	51.81^{b}	50.37^{c}	50.01^{c}	0.43
FCR^{3}	2.06^{a}	2.01^{b}	1.83^{d}	2.05^{c}	0.08
PER^{4}	2.11^{a}	2.07^{b}	2.18^{a}	1.85^{c}	0.03
Percent mortality	2.08	2.84	2.84	2.08	1.94

^{abcd} Means along the same row with different superscripts differ significantly ($P<0.05$) ^{1} Standard error of mean ^{2} weight ^{3}feed conversion ratio ^{4}protein efficiency ratio

Table 4: Nutrient digestion coefficients

	Diets				
	Inclusion levels of $MgSO_4$ (mg kg^{-1})				
Parameter	0.00	200.00	400.00	600.00	SEM^{1}
Dry matter digestibility (%)	60.39^{d}	72.82^{b}	77.35^{a}	70.40^{c}	10.20
Crude protein retention (%)	52.11^{c}	55.28^{b}	62.32^{a}	51.00^{d}	10.41
Crude fibre digestibility (%)	29.18^{b}	30.14^{b}	34.00^{a}	26.64^{c}	2.73
Ether extract digestibility (%)	64.68c	71.55^{a}	77.36^{a}	60.58^{d}	12.45
Ash digestibility (%)	27.87^{d}	34.61^{c}	39.01^{b}	49.88^{a}	9.57

^{abcd} Means along the same row with different superscripts differ significantly ($p<0.05$) ^{1}standard error of mean

Table 5: Magnesium utilization coefficients

	Diets				
	Inclusion levels of $MgSO_4$ (mg kg^{-1})				
Parameter	0.00	200.00	400.00	600.00	SEM^{1}
Daily Mg intake/bird (mg)	0.13^{d}	10.49^{c}	20.27^{b}	30.13^{a}	6.44
Daily Mg retention (mg kg^{-1})	0.09^{c}	5.63^{b}	11.74^{a}	16.64^{a}	3.60
Daily Mg excretion (mg kg^{-1})	0.04^{d}	4.86^{c}	8.53^{b}	13.49^{a}	2.85
Magnesium digestibility (%)	96.24	96.36	98.24	97.18	0.46
Tissue (flesh)Mg (mg kg^{-1})	21.04	20.96	25.11	28.70	1.85
Liver Mg (mg kg^{-1})	30.77^{c}	49.36^{c}	120.11^{b}	142.33^{a}	26.97

^{abcd} Means along the same row with different superscripts differ significantly ($p<0.05$) ^{1}standard error of mean

containing 400 mg kg^{-1} $MgSO_4$ supplementation. The table also showed that there was no significant ($p>0.05$) difference in percentage mortality. Hence, the mortality recorded could not be attributed to treatment effect. Table 4 showed that there were significant ($p<0.05$) differences in all the parameters determined across treatments. The digestibility coefficients for dry matter, crude protein retention, ether extract and ash did not follow any specific trend with increasing levels of $MgSO_4$ supplementation from 200 to 600 mg kg^{-1}. Crude protein retention contributed to the blood total protein hence, a gradual reduction in blood total protein indicated a decline in the efficiency of protein utilization. Higher supplementation of $MgSO_4$ at 600 mg kg^{-1} reduced the crude fibre digestibility indicating an inverse relationship between Mg digestibility and digestibility coefficient of crude fibre. Also, the table revealed the highest digestible nutrients in 400 mg kg^{-1} $MgSO_4$ supplementation except in ash digestibility. The Mg utilization coefficients presented in Table 5 showed significant ($p<0.05$) differences in the parameters considered except in Mg digestibility and tissue Mg. Increasing $MgSO_4$ supplementation resulted in increasing values across treatments except in Mg digestibility. The highest Mg digestibility was recorded in diet 3 (400 mg kg^{-1} $MgSO_4$). The values for the haematological parameters shown in Table 6 revealed that the blood magnesium, blood potassium, PCV, Hb, blood total protein were significantly ($p<0.05$) different across treatments and showed highest values in the diet containing 200 mg kg^{-1} $MgSO_4$. The values obtained were within the normal ranges reported by Mitruka and Rawnsley (1977). An increase in the level of potassium with increasing levels of $MgSO_4$ as expected was reported by Perney ***et al.*** (1993) but there was a decrease. The decrease may have resulted from the increased absorption rate of magnesium by the birds at the level above 200 mg kg^{-1} $MgSO_4$ thereby causing toxicity or nutrient antagonism (Scott *et al.*, 1982; Sullivan *et al.*, 1992). The blood total protein is an indication of reduction or increase in quality of total protein in an animal diet, hence,

Table 6: Haematology and blood chemistry of the birds

Parameter	Diets: Inclusion levels of $MgSO_4$ (mg kg^{-1}) 0.00	200.00	400.00	600.00	SEM[1]
Haemoglobin (g dL^{-1})	8.10[a]	8.30[a]	5.80[b]	5.30[c]	0.13
Packed cell volume (%)	24.00[a]	25.00[a]	17.00[b]	16.00[b]	0.43
Calcium (mg dL^{-1})	4.60[a]	4.80[a]	3.30[b]	3.10[b]	0.11
Phosphorus (mg dL^{-1})	2.00[a]	2.10[a]	1.40[b]	1.30[b]	0.10
Magnesium (mg dL^{-1})	1.20	1.24	1.26	1.29	0.03
Potassium (mmol L^{-1})	2.30[a]	2.40[a]	1.70[b]	1.50[b]	0.12
Albumin (mg dL^{-1})	23.00[a]	24.00[a]	17.00[b]	16.00[b]	0.50
Globulin (mg dL^{-1})	15.00[a]	16.00[a]	10.00[b]	10.00[b]	0.50
Total protein (mg dL^{-1})	38.00[b]	40.00[a]	27.00[c]	26.00[c]	0.50

[abc] Means along the same row with different superscripts differ significantly ($p<0.05$) [1]standard error of mean

a gradual reduction in the blood total protein showed a decline in the quality and efficiency of protein utilization with increasing levels of $MgSO_4$. The study thereby showed that 400 mg kg^{-1} of $MgSO_4$ was sufficient for practical broiler starter.

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