Growth response, carcass quality, some haematological and biochemical parameters of broiler chickens fed on diets supplemented with lanthanum salts

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Abstract

An experiment was conducted with 180 one week old Arbor Acre broiler chickens to evaluate their growth response, carcass quality, haematological and biochemical variables when fed lanthanum supplemented diets. After a 7 d pre-trial period, the birds were randomly assigned to 9 dietary treatments. Dietary treatments included the unsupplemented basal diets and the basal diets supplemented with 100, 200, 300 or 400 mg/kg of either lanthanum chloride ($LaCl_3$) or lanthanum oxide (La_2O_3). A completely randomized design with factorial arrangement of treatments was used with 4 replicate pens of 5 chicks assigned to each dietary treatment. Feed and water were provided *ad libitum* throughout the 8 wk trial period. At the end of the experiment, 2 birds per replicate, representing 8 birds per treatment were randomly selected, weighed and slaughtered for carcass quality, haematological and biochemical measurements. There was no significant ($P \geq 0.05$) difference in the final live weight, daily weight gain and feed conversion ratio of the birds fed the control diet and those fed lanthanum supplemented diets. Birds fed supplemental Lanthanum salts had higher ($P \leq 0.05$) daily feed intake than those fed the unsupplemented diet. Feeding diets containing lanthanum salts did not significantly (P ≥ 0.05) alter the concentrations all the haematological and serum biochemical variables determined. It can be concluded that the inclusion of lanthanum salts in broiler diets did not improve performance parameters.

Index Terms: Broiler chickens, growth response, carcass quality, biochemical parameters, lanthanum salts

1. INTRODUCTION

The use of antibiotics as feed additives in animal production has been a source of health concern. In many developed countries, especially Europe, the use of antibacterial growth promoters in poultry and swine diets has been fully banned (Rambeck *et al.*, 2004) and the developing countries are contemplating of doing such. The full ban of antibacterial growth promoters seriously necessitates the development of alternative growth promoters. Recently, other alternative growth promoters such as pro- and prebiotics, enzymes, organic acids as well as herb extracts have been used (Wenk, 2003). A very new approach in this respect is the supplementation of animal feeds with rare earth elements (REE). The REE is the common name for the metallic elements of the lanthanide series, together with yttrium and scandium, which make up 0.016% of the earth's crust (Lei and Xueying, 1997). Many results have published in the literature, especially Chinese literature, on the growth promoting effect of REE in poultry. However, most of these results are conflicting. An improvement of 6.6-20.3% in body weight gain was observed in broiler chickens fed on diets supplemented with REE at 300, 400 and 500 mg/kg (Zhang and Shao, 1995). Xie and Wang (1998) observed an increase of 10.7% in body weight broiler chickens on 130 mg/kg REE and a decrease of 0.9%

when the concentration was increased to 195 mg/kg. Schuller (2002) did not observe any positive effects of REE supplementation at 75, 150 and 300 mg/kg on production parameters of broiler chickens. Growth rate and feed conversion were negatively affected with 300 mg/kg in the diet. Adu *et al*. (2011) reported an improvement in weight gain and feed efficiency utilisation when Lanthanum oxide was included in broiler diets at 100, 200 and 300 mg/kg. He *et al*., (2010) reported an improvement of 5% in growth rate and 3.4% in feed utilization when REE-citrate was added to broiler diets but addition of REE-chloride did not improve growth rate and feed utilization. The present study was designed to evaluate the growth response, carcass quality, haematological and biochemical parameters of broiler chickens fed on diets supplemented with lanthanum chloride and lanthanum oxide.

2. MATERIALS AND METHODS

Two sources of lanthanum (La) salts, $LaCl_3$ and La_2O_3, were investigated. Corn-soybean meal basal diets were formulated for starter (7-35 d) and finisher (35-63 d) to meet their nutrient requirements (NRC, 1994). The compositions of the basal diets are presented in Table 1. A total of 180 day-old Arbor Acre broiler chicks fed commercial broiler starter diet for a 7 d pre-trial period were randomly assigned to 9 dietary treatments. Dietary treatments included the unsupplemented basal diets and the basal diets supplemented with 100, 200, 300 or 400 ppm of either $LaCl_3$ or La_2O_3. A completely randomized design with factorial arrangement of treatments was used with 4 replicate pens of 5 chicks assigned to each dietary treatment. Feed and water were provided *ad libitum* throughout the 8 wk trial period. The growth performance data were determined between 7 and 63 days. During this period, weekly body weight and feed consumption were recorded. Feed conversion ratio was calculated from the body weight and feed consumption data. At the end of the experiment, 2 birds per replicate, representing 8 birds per treatment were randomly selected, weighed and slaughtered for carcass quality measurements. Blood samples were collected from the birds for the analyses of haematological and biochemical parameters, plasma proteins and enzymes. For haematological determinations, blood samples were collected into sample tubes containing anticoagulant as described by Lamb (1981). Plasma was harvested by centrifuging the blood samples at 3000 rpm for 15 min in centrifuge machine. The heparinized plasma samples were stored at -20^{0}C in sample tubes until further analysis. Haematological parameters determined included erythrocyte sedimentation rate, packed cell volume, red blood cell, haemoglobin, leucocyte, neutrophill, monocyte, basophil and eosinophil. Plasma samples were analyzed for proteins (total proteins and albumin), glucose, creatinine and cholesterol concentration. Total protein, albumin, glucose, creatinine and cholesterol were determined in the Autoanalyzer, Microlab 200 using commercial kits (Randox Laboratories Ltd., Ardmore Diamond Road, Crumlin, Co. Antrim, United Kingdom, BT29 4QY). The globulin fraction was calculated by subtraction of albumin level from total protein level. Data collected were subjected to one way analysis of variance (ANOVA) according to the General Linear Model Procedures of SAS (2008). When analysis of variance indicated a significant, Duncan's multiple range test (Duncan, 1955) was used to compare treatment means. The model included main effects of lanthanum source, level and their interaction.

3. RESULTS

The productive performance of broiler chickens fed lanthanum salts is presented in Table 2. The results showed that there was no significant ($P \geq 0.05$) difference in the average final body weight, daily weight gain and feed conversion ratio of the birds fed the control diet and those birds fed lanthanum supplemented diets. Also there was no significant ($P \geq 0.05$) effect of lanthanum source and level on the average final body weight and daily weight gain. Feed conversion efficiency was significantly ($P \leq 0.05$) influenced by level of lanthanum supplementation. Birds fed on diets supplemented with either $LaCl_3$ or La_2O_3 at 100 ppm had better ($P \leq 0.05$) feed conversion efficiency than their counterparts on other levels of lanthanum supplementation. Source by level interaction effect ($P \leq 0.05$) was observed on the average final body weight, daily weight gain and feed conversion ratio. Average total feed intake and daily feed intake were significantly ($P \leq 0.05$) influenced by lanthanum supplementation. Birds on diets supplemented with lanthanum salts consumed more feed than their counterparts on the control diet. There was a significant ($P \leq 0.05$) effect of lanthanum source, level and source with level interaction on average total feed intake and daily feed intake. Birds fed on $LaCl_3$ consumed more ($P \leq 0.05$) feed than birds fed La_2O_3.

Results of carcass yield and selected organs are summarized in Tables 3 and 4. Statistical analysis showed that there was no significant ($P \geq 0.05$) effect of lanthanum source, level and source with level interaction on all the carcass and organ traits determined. Table 5 shows the haematological profiles of broiler chickens as influenced by lanthanum supplementation. There was no significant ($P \geq 0.05$) effect of lanthanum supplementation on all the haematological parameters measured. The serum biochemical profiles of broiler chickens fed lanthanum supplemented diets are shown in Table 6. Feeding diets containing lanthanum salts did not significantly ($P \geq 0.05$) alter the concentrations of total protein, albumin, cholesterol, creatinine and glucose in broiler chickens.

4. DISCUSSION

Previous results on the use of REE in broiler chicken diets are conflicting. Zhang and Shao (1995) observed an improvement of up to 20% in body weight gain of broiler chickens fed diets supplemented with REE at 300, 400 and 500 mg/kg. Xie and Wang (1998) observed an increase of 10.7% in body weight broiler chickens on 130 mg/kg REE and a decrease of 0.9% when the concentration was increased to 195 mg/kg. While feeding REE-citrate to broiler chickens, Halle *et al*., (2003) had shown that body weight gain increased by 7% with REE supplementation. Yang *et al*., (2005) reported an improvement of about 13.1% compared to the control when REE was included into broiler diets at 300, 400 and 500 mg/kg. Adu *et al*., (2011) reported an improvement of up to 9% in weight gain and feed efficiency utilisation when lanthanum oxide was included in broiler diets at 100, 200 and 300 mg/kg. He *et al*., (2010) reported an overall improvement of 5% when REE-citrate was included in broiler diets but did not observe any significant increase in growth performance when REE-chloride was used. However, Schuller (2002) did not observe any positive effects of REE supplementation at 75, 150 and 300 mg/kg on production parameters of broiler chickens. Growth rate and feed conversion were negatively affected with 300 mg/kg in the diet. Although there was no negative effect observed even at 400 mg/kg, the results presented in this study clearly demonstrated that supplemental lanthanum salts did not significantly improve body weight gain and feed utilization. The present results confirm the findings of Schuller (2002) and part of Halle *et al*., (2003) who did not observe any positive effect of supplementing broiler chicken diets with REE on body weight gain and feed conversion efficiency. Birds fed supplemental lanthanum salts had higher feed intake and this may probably be attributed to the fact that the inclusion of lanthanum salts in the feed gives such a characteristic aroma and birds are believed to possess very sensitive sensory organs that can easily pick up the aroma emanating from their feed thus stimulate higher feed consumption (McKinnon, 1985).

The carcass and organ characteristics of broiler chickens fed lanthanum salts showed no significant difference and this finding is in agreement with the earlier studies of Kehe *et al*., (1992), He *et al*., (2010) and Adu *et al*., (2011) who did not find any effect of REE supplementation on carcass and organ traits. Non-significant differences were observed in virtually all the haematological variables determined for birds fed on diets supplemented with lanthanum salts. The present results corroborate those reported by He *et al*., (2010) and Adu *et* a.,l (2011). The implication of this is that dietary REE has no detrimental effect on survivability of broiler chickens. Total serum protein, albumin and globulin concentrations observed are within the normal range reported for chickens (Prabhakaran *et al*., 1996). There were no differences between the birds fed on diets supplemented with lanthanum salts and those birds on the control diet. Similar results have been reported by Adu *et al*., (2011). In terms of serum cholesterol and glucose concentrations, lanthanum salts showed no significant effect however, level of supplementation significantly influenced the concentrations of these parameters. A closer look at the values obtained reveals that these values were not consistent and did not follow any particular trend unlike those reported by Adu *et al*., (2011). Adu *et al*., (2011) reported that blood glucose decreased with increasing levels of REE in broiler diets. Conversely, Xu *et al*., (1999) found increased glucose concentrations, whereas glucose levels remained unchanged in other feeding experiments performed on pigs (Ming *et al*., 1995; He *et al*., 2001).

5. CONCLUSION

It can be concluded from this study that the inclusion of lanthanum salts in broiler diets did not improve growth performance and feed utilization. Also there was no deleterious effect of feeding lanthanum on haematological and serum biochemical variables of the chickens.

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Table 1: Gross composition of the standard diet

Ingredients	Broiler Starter(%)	Broiler Finisher(%)
Maize	56.00	63.00
Soybean meal	20.00	20.00
Groundnut cake	17.30	10.30
Fish meal (72%)	1.00	1.00
Oyster shell	1.00	1.00
Bone meal	3.00	3.00
Lysine	0.85	0.85
Methionine	0.35	0.35
Salt	0.25	0.25
Broiler Premix	0.25	0.25
Total	100.00	100.00
Calculated		
Crude Protein (%)	22.51	20.06
Crude Fibre (%)	3.30	2.90
Energy (Kcal/ kg)	2.95	3.00

Table 2: Performance characteristics of broiler chickens fed on diets supplemented with lanthanum salts

Source	Level (ppm)	Average initial weight (g/bird)	Average final weight (g/bird)	Average daily weight gain (g/bird/day)	Average total feed intake (g/bird)	Average daily feed intake (g/bird/day)	Feed conversion ratio (FCR)
Control	0	64.0	2211.2^{abc}	38.3^{abc}	5309.5^{d}	94.8^{d}	2.48^{ab}
$LaCl_3$	100	64.1	2311.3^{abc}	40.1^{abc}	5970.5^{b}	106.6^{b}	2.67^{abc}
$LaCl_3$	200	64.1	2507.7^{ab}	43.6^{ab}	6489.8^{a}	115.9^{a}	2.67^{abc}
$LaCl_3$	300	64.0	2283.9^{abc}	39.6^{ab}	6444.0^{a}	115.1^{a}	2.92^{c}
$LaCl_3$	400	63.9	2369.4^{abc}	41.2^{abc}	5582.0^{c}	99.7^{c}	2.43^{ab}
La_2O_3	100	63.8	2604.5^{ab}	45.4^{ab}	5568.8^{c}	99.4^{c}	2.21^{a}
La_2O_3	200	63.9	2070.2^{c}	35.8^{c}	6172.8^{a}	110.2^{a}	3.10^{c}
La_2O_3	300	63.9	2209.2^{abc}	38.3^{abc}	5972.5^{b}	106.7^{b}	2.81^{bc}
La_2O_3	400	64.3	2294.3^{abc}	39.8^{abc}	5990.3^{b}	106.9^{b}	2.78^{bc}
SEM		0.37	250.51	4.47	84.32	1.50	0.31
Source							
$LaCl_3$		64.0	2368.1	41.1	6121.6^{a}	109.3^{a}	2.67
La_2O_3		64.0	2294.6	39.8	5926.1^{b}	105.8^{b}	2.72
Level							
100		64.0	2457.9	42.8	5769.6^{c}	103.0^{c}	2.44^{a}
200		64.1	2289.0	39.7	6331.3^{a}	113.1^{a}	2.89^{b}
300		64.0	2246.5	39.9	6208.3^{b}	110.9^{b}	2.86^{b}
400		64.0	2331.6	40.5	5786.1^{c}	103.3^{c}	2.61^{ab}
Significance							
Source		NS	NS	NS	*	*	NS
Level		NS	NS	NS	*	*	*
Source x Level		NS	*	*	*	*	*

SEM = Standard error of means; ^{abcd} Means with different superscripts are significantly ($P \leq 0.05$) different; NS: Not significant at $P \geq 0.05$;
* Significantly different at $P \leq 0.05$; $LaCl_3$ = Lanthanum chloride; La_2O_3= Lanthanum oxide.

Table 3: Carcass yield (g/kg live weight) of broiler chickens fed on diets supplemented with lanthanum salts

Source	Level (ppm)	Live weight (g)	g/kg live weight									
			Dressed weight	Eviscerated weight	Breast muscle	Drumsticks	Thighs	Back	Chests	Wings	Shank	Head
Control	0	2388.1	2266.9	1684.5	166.2	248.8	287.0	404.7	478.8	197.9	85.4	55.4
$LaCl_3$	100	2504.4	2353.6	1997.5	198.9	250.8	286.4	397.8	564.8	209.5	71.5	56.6
$LaCl_3$	200	2348.3	1754.5	1657.7	151.0	211.6	244.3	348.3	429.0	183.9	82.5	45.4
$LaCl_3$	300	2249.9	2096.2	1758.1	175.4	233.9	254.5	373.8	449.9	182.9	81.3	50.5
$LaCl_3$	400	2412.8	2252.3	1903.2	182.1	252.9	279.9	400.8	501.2	188.6	80.6	51.3
La_2O_3	100	2313.8	2131.2	1788.1	174.8	226.0	277.1	378.3	462.9	161.2	73.6	49.7
La_2O_3	200	2378.3	2226.5	1873.5	180.1	250.0	282.7	398.5	499.9	185.3	83.1	53.5
La_2O_3	300	2373.3	2188.0	1838.4	158.0	251.9	262.2	396.6	450.6	203.3	89.5	53.8
La_2O_3	400	2447.0	2333.6	1949.7	187.9	254.8	266.8	402.2	517.4	203.8	88.5	58.1
SEM		379.20	339.30	304.92	37.87	43.41	36.20	64.50	93.21	24.06	13.61	11.87
Source												
$LaCl_3$		2378.9	2114.2	1829.1	176.9	237.3	266.3	380.2	486.2	191.2	79.0	51.0
La_2O_3		2378.1	2219.8	1862.4	176.4	245.7	272.2	393.9	482.7	188.4	83.7	53.8
Level												
100		2409.1	2242.4^{ab}	1892.8	187.7	238.4	281.7	388.1	513.9	185.4	72.6	53.2
200		2363.3	1990.5^{b}	1769.6	165.6	230.8	263.5	373.4	464.4	184.6	82.8	49.5
300		2311.6	2142.1^{ab}	1798.2	168.0	242.9	258.4	385.2	450.3	193.1	85.4	52.2
400		2429.9	2292.9^{a}	1926.4	185.0	253.9	273.4	401.5	509.3	196.2	84.6	54.7
Significance												
Source		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Level		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Source x Level		NS	*	NS	NS	NS	NS	NS	NS	*	NS	NS

SEM = Standard error of means; NS = Not Significant ($P \geq 0.05$); * = Significant ($P \leq 0.05$); $LaCl_3$ = Lanthanum chloride; La_2O_3 = Lanthanum oxide.

Table 4: Weight of selected organs (g/kg body weight) of broiler chickens fed on diets supplemented with lanthanum salts

Treatment	Level (ppm)	Heart	Lung	Kidney	Liver	Gizzard	Bursa	Spleen	Pancreas
Control	0	9.4	13.2	12.7	39.9	34.2	0.54	1.44	3.1
$LaCl_3$	100	9.4	14.5	11.9	40.4	38.4	0.46	1.66	4.3
$LaCl_3$	200	8.9	10.1	8.7	36.1	34.7	0.48	1.23	2.8
$LaCl_3$	300	8.1	11.0	9.6	39.9	32.9	0.53	1.40	3.8
$LaCl_3$	400	9.2	12.2	12.1	39.4	34.2	0.46	1.23	3.8
La_2O_3	100	7.7	11.1	12.3	36.1	25.8	1.09	1.61	3.9
La_2O_3	200	8.1	11.6	12.6	42.4	34.9	0.66	1.84	3.8
La_2O_3	300	8.7	11.6	14.5	34.8	28.2	2.40	1.69	3.4
La_2O_3	400	9.1	13.3	11.8	50.6	36.0	0.69	1.61	3.8
SEM		1.62	2.54	4.51	11.86	8.41	1.54	0.58	0.86
Source									
$LaCl_3$		8.9	12.0	10.6	39.0	35.1	0.48	1.38	3.7
La_2O_3		8.4	11.9	12.8	40.0	31.2	1.20	1.69	3.7
Level									
100		8.6	12.8	12.1	38.3	32.1	0.78	1.64	4.1
200		8.5	10.9	10.7	39.3	34.8	0.57	1.54	3.3
300		8.4	11.3	12.1	37.4	30.6	1.47	1.55	3.6
400		9.2	12.8	12.0	45.0	35.1	0.58	1.42	3.8
Significance									
Source		NS	NS	NS	NS	NS	NS	NS	NS
Level		NS	NS	NS	NS	NS	NS	NS	NS
Source x level		NS	NS	NS	NS	*	NS	NS	NS

SEM = Standard error of means; NS = Not Significant ($P \geq 0.05$); * = Significant ($P \leq 0.05$); $LaCl_3$ = Lanthanum chloride; La_2O_3 = Lanthanum oxide.

Table 5: Some haematological parameters of broiler chickens fed on diets supplemented with lanthanum salts

Treatment	Level (ppm)	ESR (mm/hr)	PCV (%)	RBC ($10^6/mm^3$)	Hb (g/100ml)	Lymphocytes (%)	Monocytes (%)	Heterophils (%)	Basophils (%)	Eosinophols (%)
Control	0	4.25	23.8	2.89	7.90	58.5	13.3	24.5	2.25	1.50
$LaCl_3$	100	3.75	24.8	3.12	8.25	57.8	13.8	25.3	2.00	1.25
$LaCl_3$	200	2.50	27.0	4.83	8.98	59.5	12.5	24.8	2.50	0.75
$LaCl_3$	300	3.25	25.8	4.07	8.60	60.8	12.8	23.5	2.00	1.00
$LaCl_3$	400	3.25	25.5	3.80	8.50	58.5	13.3	24.8	2.50	1.00
La_2O_3	100	4.75	24.8	2.92	8.25	58.5	14.3	24.3	2.25	0.75
La_2O_3	200	3.25	25.5	3.85	8.50	58.3	13.8	24.5	2.25	1.25
La_2O_3	300	5.00	23.0	2.59	7.65	60.5	10.8	25.5	2.25	1.00
La_2O_3	400	3.25	25.8	3.54	8.60	56.5	14.3	25.3	2.50	1.50
SEM		1.22	1.96	1.27	0.65	3.76	2.87	2.47	0.47	0.57
Source										
$LaCl_3$		3.19	25.8	3.96	8.58	59.2	13.1	24.6	2.25	1.00
La_2O_3		4.06	24.8	3.23	8.25	58.5	13.3	24.9	2.31	1.13
Level										
100		4.25	24.8	3.02	8.25	58.2	14.1	24.8	2.13	1.00
200		2.88	26.3	4.34	8.74	58.9	13.2	24.6	2.38	1.00
300		4.13	24.4	3.33	8.13	60.6	11.8	24.5	2.13	1.00
400		3.25	25.6	3.67	8.55	57.5	13.8	25.0	2.50	1.25
Significance										
Source		NS	NS	NS	NS	NS	NS	NS	NS	NS
Level		NS	NS	NS	NS	NS	NS	NS	NS	NS
Source x level		NS	NS	NS	NS	NS	NS	NS	NS	NS

SEM = Standard error of means; ESR = Erythrocyte sedimentation rate; PCV = Packed cell volume; RBC = Red blood cell; Hb = Haemoglobin; NS = Not Significant ($P \geq 0.05$); $LaCl_3$ = Lanthanum chloride; La_2O_3 = Lanthanum oxide.

Table 6: Some serum biochemical indices of broiler chickens fed on diets supplemented with lanthanum salts

Treatment	Level (ppm)	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Alb/Glo	Cholesterol (mg/dl)	Creatinine(g/dl)	Glucose (g/dl)
Control	0	37.7	22.4	15.3	1.48	140.9	1.03	168.6
$LaCl_3$	100	44.2	27.1	17.1	1.65	131.8	1.13	175.9
$LaCl_3$	200	48.6	26.9	21.7	1.24	125.9	1.00	154.1
$LaCl_3$	300	39.3	22.6	16.7	1.41	152.8	1.00	177.2
$LaCl_3$	400	42.6	25.4	17.2	1.48	120.0	1.00	155.5
La_2O_3	100	43.3	25.2	18.1	1.58	151.8	0.93	192.2
La_2O_3	200	47.5	26.4	21.1	1.26	146.2	1.03	154.6
La_2O_3	300	50.4	28.4	22.0	1.35	120.9	0.90	156.7
La_2O_3	400	41.1	23.9	17.2	1.39	131.5	1.00	153.2
SEM		4.78	4.58	3.30	0.44	11.27	0.09	16.37
Source								
$LaCl_3$		43.7	25.5	18.2	1.45	132.7	1.03	165.7
La_2O_3		45.6	26.0	19.6	1.40	137.6	0.97	164.2
Level								
100		43.8	26.2	17.6	1.62	141.8	1.03	184.1
200		48.0	26.6	21.4	1.25	136.0	1.02	154.4
300		44.9	25.5	19.4	1.38	136.9	0.95	167.0
400		41.8	24.6	17.2	1.43	125.8	1.00	154.4
Significance								
Source		NS	NS	NS	NS	NS	NS	NS
Level		NS	NS	NS	NS	*	NS	*
Source x Level		NS	NS	NS	NS	NS	NS	NS

SEM = Standard error of means; Alb/Glo = Albumin-Globulin ratio; NS = Not Significant ($P \geq 0.05$); * = Significant ($P \leq 0.05$); $LaCl_3$ = Lanthanum chloride; La_2O_3 = Lanthanum oxide.