Growth-enhancing, health impact and bacteria suppressive property of lanthanum supplementation in broiler chicken

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SUMMARY

The growth-enhancing, health implication and bacteria suppressive effects of lanthanum were investigated using a batch of 120 day old (Ross 308) broilers. Two basal diets (starter and finisher) were formulated to meet the broiler nutrient requirement for each phase. Each basal diet after mixing was divided into 4 equal portions. One portion was designated the control diet (Diet 1). The 2nd, 3rd and 4th portions, which were supplemented with lanthanum oxide (La_2O_3) at 100, 200 and 300 ppm were designated diets 2, 3&4 respectively. Lanthanum oxide contains about 85.3% La. Thus diets 1, 2, 3 and 4 contained 0, 85.3, 171 and 256ppm, respectively. Each diet was fed in three replicates per treatment to 30 birds arranged in 10 birds per replicate in a completely randomized design from day-old to 28d (starter) and 29–56d (finisher). Lanthanum addition led to 3-5% improvement in the total weight gain (TWG) over the control (P>0.05) with birds fed on diet containing 171ppm La having the highest value. The FCR were identical (2.52-2.38) but birds fed on 171ppm La-based diet had the most beneficial value (2.38) suggesting that La at 171ppm might be the most suitable dosage level required for enhanced productivity. Of the carcass 'fast food' cuts and the relative organs' weight measured only the relative weights of the heart, spleen and liver were significantly affected (P<0.05) with higher values observed in birds fed on La-based diets. Only the lactate dehydrogenase (LDH) of the serum enzymes and metabolites measured were significantly influenced by the dietary treatment. While MCH and MCV were only significantly (P<0.05) affected the PCV, RBC and Hbc were consistently enhanced in birds fed 85.3-171ppm La-based diets than those fed the control. Relatively lower counts of bacteria were obtained in nearly all the specimens examined under the 85.3ppm

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concentration, which seemed to imply that the optimum bacteria suppressive effects might likely, not be attained beyond this level.

Keywords**:** Broiler chickens, bacterial counts, biochemical indices, haematology, lanthanum, performance

INTRODUCTION

Feed additives including antibiotics used in food-producing animals were banned for use in the European Union at the beginning of 2006. Thus, efficient use of available resources is required, which can promote animal growth, among other things. Thus, legally allowed, safe and inexpensive feed additives, which are capable of enhancing animal performance, will be needed in order to maintain the state of health of farming animals and preserve their desired performance and to guarantee efficient use of resources (Redling 2006). This is more compelling especially in sub-Sahara Africa where there is acute shortage of animal protein.

Probiotics, prebiotics, organic acids and enzymes are already known as growth-promoting feed additives but rare earth elements though known in western countries, knowledge about their growth enhancing effects as well as their bacteria suppressive properties appears to be very limited in most under developed countries. Rare earth elements (REE) are 15 lanthanide elements with atomic numbers 57 (lanthanum) through 71 (lutetium), which are in group IIIA of the periodic table. Despite their name, the REE are in fact not really rare. In China, REE have been in use for over three decades as performance enhancers in agricultural plant production with remarkable results. Also, in animal production, positive results have been achieved by supplementing REE in animal diets under Western conditions (Shen et al 1991, Yang et al 2005, Rambeck et al 1999). However, negative effect of high concentrations of REE on growth performance was also reported (Kraatz et al 2004). It was also reported that proper concentrations of REE in diet can improve animal growth performance without affecting quality of products (Liu et al 2003, Redling 2006).

Earlier reports also showed that the effect of dietary REE varies with the animal species, the concentration and type of REE as well as the composition of individual REE (Redling 2006). These have been shown to be important factors influencing their performance-enhancing effects (He et al 2003, Redling 2006). Most of the reports on the effect of lanthanum in animal diets were mainly on the enhancement of animal growth with scanty report on its effect on haematological parameters, biochemical and bacteria suppressive properties especially under tropical conditions. Thus, the present study was designed to investigate the effect of lanthanum, an important family of rare earth elements, on

the haematological and biochemical parameters vis-à-vis performance of broilers under tropical condition. Also the bacteria suppressive effects of lanthanum were studied

MATERIAL AND METHODS

Experimental site and materials

The right to conduct this study was given by the Research Committee of the Department of Animal Production and Health of The Federal University of Technology, Akure (FUTA), Nigeria. The feeding trial was conducted at the Poultry unit of the Teaching and Research Farm of FUTA and the laboratory analyses were carried out at the Nutrition Laboratory of the Department of Animal Production and Health, and the Department of Biochemistry, FUTA.

One hundred and twenty day-old unsexed broiler chicks (Ross 308) were purchased from a reputable hatchery in Ibadan. The feed ingredients used for the feed mixing were purchased from BeeJay Feedmill in Akure, Nigeria. The lanthanum oxide was obtained from BDH Chemical Ltd, Poole, England.

Experimental Diets

Two basal experimental diets with their gross and analyzed compositions as presented in Table 1 (Broiler Starter and Finisher) were used for the trial. All the basal diets were formulated based on NRC (1994) tables of feedstuffs and met the nutrient requirements of broiler chickens. The starter diet was mixed in one batch. Thereafter, it was sub divided into four equal portions. One portion was designated the control (diet 1) and the remaining three portions were designated diets 2, 3 and 4, respectively. In addition, lanthanum oxide (La_2O_3) was added to the four diets at 0, 100ppm, 200ppm and 300ppm, respectively and each diet were thoroughly mixed. Lanthanum oxide contains about 85.3% La. Thus diets 1, 2, 3 and 4 contained 0, 85.3, 171 and 256ppm, respectively. Also, the second basal diet (finisher) was also mixed in one batch and the remaining mixing procedures were identical to those of the starter. In all, eight diets were used for the trial.

Animal Management and Experimental Layout

A batch of one hundred and twenty day-old unsexed broiler chicks (120) used for the experiment was electrically brooded. The brooding temperature varied from 35^{o}C at day old to 29^{o}C at 3rd week of age and kept at ≈25^{o}C thereafter. The chicks were placed on the experimental diets from the day of arrival. Thirty (30) unsexed chicks were randomly assigned to each of the experimental dietary treatment in ten (10) chicks per replicate of three. The design of the trial was a completely

randomize design arrangement. The chicks were fed with their respective experimental diets according to a two phase feeding system from day 1 to 28 and day 29 to 56. During the experiment all the chickens were provided with water and feed *ad libitum*. The birds were raised using common management practice for broilers.

Table 1. Gross composition (%) for the experimental diets

Ingredient	Basal Diet 1 (Starter)	Basal Diet 2 (Finisher)
Maize	48.5	54.5
Maize offal	7.00	7.00
Soy bean	16.0	17.0
Groundnut cake	16.5	12.0
Fish meal	4.00	2.00
Soy oil	3.50	3.00
Bone meal	2.50	2.50
Oyster shell	1.00	1.00
Premix*	0.50	0.50
Lysine	0.10	0.10
Methionine	0.10	0.10
Salt	0.30	0.30
Total	100	100
Calculated		
Crude protein %	23.0	20.0
ME MJ/kg	13.0	13.1
Lysine %	1.12	1.00
Methionine %	0.54	0.42
Available P %	0.76	0.68
Ca %	1.61	1.48
Analyzed		
Crude protein %	22.8	19.1
Crude fibre %	3.83	4.23
Ash %	7.24	7.01

*Contained vitamins A (4,000,000iu); D (800,000iu); E (14,000iu); K (760mg); B_{12} (7.6mg); Riboflavin (2800mg); Pyridoxine (1250mg); Thiamine (880mg); D Pantothenic acid (4400mg); Nicotinic acid (18,000mg); Folic acid (560mg); Biotin (45.2mg); and Trace elements as Cu (3200); Mn (25600mg); Zn (16,000mg); Fe (12800mg); Se (64mg); I_2 (320mg) and other items as Co (160mg); Choline (190,000mg); Methionine (20,000mg); BHT (2,000mg) and Spiramycin (2,000mg) per 1.0kg

Criteria of response

The initial group weight per replicate was measured and the weight changes were measured as the difference between the initial weight and the final weight. The feed consumption was recorded in replicate and the feed conversion ration calculated as a ratio of feed consumption to weight gain of the birds per replicate. At age 56days, the birds were starved for 3hrs to temporarily empty their crops and 5 birds per replicate were randomly selected, weighed and slaughtered. The blood

was then allowed to flow freely into sample bottles containing a few mg of Ethylene diaminetetraacetic acid (EDTA) and also into clean centrifuge test tubes. The samples in the bottles containing EDTA were subsequently processed for hematological studies. The packed cell volume (PCV) was estimated by spinning about 75µl of each blood sample in heparinised capillary tubes in a hematocrit microcentrifuge for 5 min, and the total red blood cell (RBC) and erythrocyte sedimentation rate (ESR) were determined as described by Lamb (1981). The hemoglobin concentration (Hbc) was estimated using the cyano-methemoglobin concentration method; the differential counts were estimated as described by Lamb (1981). The mean cellular hemoglobin concentration (MCHC), mean cellular hemoglobin (MCH) and mean cell volume (MCV) were also calculated as described by Lamb (1981).

The samples in the test tubes without EDTA were allowed to coagulate for about 6 h. The serum was separated into sterile universal bottles and kept deep-frozen at -18^{o}C prior to its analysis for serum biochemical indices. The serum Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Alkaline phosphatase (ALP),Total bilirubin (TB), Lactate dehydrogenase (LDH) and Total protein (TP) were estimated using diagnostic kits (Randox Laboratories Ltd, UK test kits).

After bleeding, the chicken carcasses were immediately opened to obtain samples of the gut, spleen and the liver for bacterial load estimation as described by Lamb (1981). Thereafter, the carcasses were plucked, eviscerated and weighed, dissected into chest and hind parts and weighed. Giblets (liver, heart and gizzard), pancreas and spleen were separated, individually weighed and expressed in gram per kilogram body weight

Chemical and statistical analysis

The proximate composition of the ingredients used before the feed formulation and the test diet samples were analyzed by the methods of AOAC (1990). Data collected were subjected to statistical analysis using analysis of variance (ANOVA) of SPSS 15 (2006) package. The significant treatment means were compared using the Duncan option of the same software.

RESULTS AND DISCUSSION

Table 2 shows that the final weight (FW), total weight gain (TWG), total feed intake (TFI) and feed conversion ratio (FCR) of birds fed the control diet were not significantly (P>0.05) different from those fed the La-based diets. Though not significant (P>0.05), the FW (2.04 – 2.08 kg/bird) of birds fed the La-based diets were consistently higher than those fed the control diet (1.98 kg/bird) with birds fed on diet containing

171ppm La having the highest value. The same trend was observed for TWG. The TFI of the birds varied: 4.85 – 5.11kg/bird with birds fed diet containing 85.3ppm La having the highest value.

Table 2: Performance of broilers fed diets supplemented with lanthanum oxide

Parameters	Diet 1 La: 0 ppm	Diet 2 La: 85.3ppm	Diet 3 La: 171ppm	Diet 4 La: 256ppm	±SEM*
Initial weight (g/bird)	40.0	40.0	40.0	40.0	0.00
Final weight (kg/bird)	1.98	2.07	2.08	2.04	0.08
Total weight gain (kg/bird)	1.94	2.03	2.04	2.00	0.08
Total feed Intake (kg/bird)	4.88	5.11	4.85	5.04	0.22
Feed conversion ratio	2.51	2.52	2.38	2.52	0.14
Mortality (%)	4.80	4.80	0.00	9.50	0.02

±SEM* Standard Error of Mean

The present findings suggest that contrary to the earlier report by Zhu et al (1992) and Xie and Wang (1998), supplementation of broiler diets with La at 85.3-256ppm could only lead to numerical improvement in the body weight gain. In different studies, Zhu et al (1992) reported 5.70% increase in the body weight gain in broilers fed diet supplemented REE up to 900ppm while Shen et al (1991) reported 12.0-12.4% body weight gain when supplementation was between 50ppm and 600ppm. In a related study, Xie and Wang (1998) supplemented the diets of one-week-old broilers with REE at 0, 65,130 and 195ppm and reported increased average body weight gain of 6.30% and 10.7% for birds fed supplemental 65 and 130ppm, respectively. Contrary to these findings, the present study showed that supplementation of La (85.3-256ppm) led to between 3% and 4.90% improvement in the TWG over that of the birds fed on the control but this was not statistically significant. The present finding is in agreement with the report of Böhme et al (2002) who reported that REE did not present any performance enhancing effects. The reason for the disparity observed in our result and those previously reported might not be unconnected with the breed effect, concentration and purity of the REE, and the environmental factors, which explain in part while this study was carried out in tropical environment. Thus, the accreditation of rare earth-based feed additives will only be accorded in sub-Sahara Africa if it is possible to achieve effective improvements, similar to those in China, in animal growth and feed conversion under Western conditions. So far several investigations on the performance enhancing effects of rare earths on various animal species, including pigs, chickens, quails, calves and fish, have been

conducted in Western countries, predominantly in Germany and Switzerland. Although in pigs and poultry, application of rare earths to animal diets has shown performance enhancing effects in many studies, there is still an uncertainty among scientists as to its efficacy. Thus the utilization of rare earths as feed additive to animal husbandry is still controversial.

Though values for the FCR lacks statistical difference (P>0.05), while all the birds appeared to have utilized their diets almost identically (2.52-2.38), birds fed on La-supplemented diet at 171ppm/kg feed appeared to utilize their diet better than those fed on the control and other test diets, suggesting that the inclusion of La at 171ppm/ kg feed could be the likely or most suitable dosage level required to wield influence on the physiologic mechanism necessary for enhanced productivity. Also Table 2 showed that bird fed La supplementation at 171ppm/kg feed led to 5.60% improvement in the FCR. This was lower than 12.4-12.8% (Shen et al 1991), 10.3-15.1% (Xie and Wang, 1998) and 13.1% (Yang et al 2005) earlier reported.

Table 3. Carcass traits and Relative organs' weight of broilers fed diets supplemented with lanthanum oxide (g/kg body wt.)

Carcass (g/kg body wt.)	Diet 1 La: 0 ppm	Diet 2 La: 85.3ppm	Diet 3 La: 171ppm	Diet 4 La: 256ppm	±SEM*
Chest	191	177	203	189	14.3
Back	184	185	209	196	11.5
Thigh	60.2	58.6	55.7	59.5	5.12
Drum Stick	54.7	62.9	54.1	58.9	5.54
Shank	21.2	23.8	19.4	23.3	2.23
Wing	41.1	41.2	39.2	42.2	2.86
Organs' weight (g/kg body wt.)					
Heart	4.10^{b}	4.90^{a}	4.40^{b}	5.30^{a}	0.51
Lungs	6.30	5.60	5.60	6.40	1.33
Spleen	0.70^{a}	0.70^{a}	0.50^{b}	0.80^{a}	0.14
Liver	17.7^{b}	15.8^{b}	19.9^{a}	15.8^{b}	1.98
Gizzard	17.3	17.4	16.1	20.9	2.91
Pancreas	1.90	1.60	2.20	2.00	0.34

[ab]Means in the same row for each parameter with different superscripts are significantly different (p<0.05). ±SEM* Standard Error of Mean.

Table 3 shows that there were no significant differences (P>0.05) observed between carcass traits of birds fed control diet and those fed La-based diets suggesting that neither the control diet nor the La supplemented diets significantly affected the carcass 'fast food' cuts. Thus, it could be inferred that identical carcass traits are attainable by

feeding either the control diet or the La supplemented diets. Also, of the relative organs' weight measured only the relative weights of the heart, spleen and liver were significantly (P<0.05) affected by the dietary treatments. The birds fed on diet containing 256ppm La had the highest relative weight of the heart (5.30g/kg body weight) but this was not significantly (P>0.05) different from those fed the 85.3ppm La supplemented diet (4.90 g/kg body weight) but both were significantly (P<0.05) higher than those fed the control diet (4.10 g/kg body weight) and 171ppm La supplemented diet (4.40 g/kg body weight). The relative weights of the spleen and liver of birds though were significantly (P<0.05) influenced by the dietary treatment but did not follow a particular trend. While the relative weight of the spleen of birds fed the control diet (0.70 g/kg body weight) was not significantly different from those birds fed on 85.3 and 256 ppm La supplemented diets (0.70-0.80 g/kg body weight), it was significantly higher than those fed on 171 ppm La based diet (0.50 g/kg body weight). Also, the relative weight of the liver of birds fed on the control diet (17.7 g/kg body weight) and 171ppm La supplemented diet (19.9 g/kg body weight) were not significantly (P>0.05) different but both were significantly (P<0.05) higher than those fed 85.3 and 256ppm La based diets (15.8 g/kg body weight). This, thus suggest that the observed changes could not be attributed to the La supplementation in the diets.

Table 4. Serum biochemical indices of broilers fed diets supplemented with lanthanum oxide

Indices	Diet 1 La: 0 ppm	Diet 2 La: 85.3ppm	Diet 3 La: 171ppm	Diet 4 La: 256ppm	±SEM*
AST (iu/l)	48.2	60.3	64.8	88.7	0.03
ALT (iu/l)	2.47	2.89	2.77	2.63	0.03
ALP (iu/l)	146	118	119	198	0.05
TB (g/dl)	0.19	0.10	0.05	0.58	0.02
LDH (iu/l)	342^{a}	242^{b}	142^{c}	161^{c}	0.04
TP (g/dl)	4.91	5.19	8.85	6.26	0.04

[abc]Means in the same row for each parameter with different superscripts are significantly different (p<0.05). ±SEM* Standard Error of Mean. AST; Aspartate aminotransferase, ALT; Alanine aminotransferase, ALP; Alkaline phosphatase, TB; Total bilirubin, LDH; Lactate dehydrogenase and TP; Total protein.

Furthermore, this study was characterized by irregular trend in dosage response with respect to AST, ALP, ALT, TP, LDH and TB (Table 4). However, LDH was significantly (P<0.05) influenced. The LDH of birds fed the control diet (342iu/l) was significantly (P<0.05) higher than those observed for birds fed the test diets (142–242iu/l). LDH catalyzes the inter-conversion of pyruvate and lactate with concomitant inter-conversion of NADH and NAD^{+}. It converts pyruvate the final

product of glycolysis to lactate when oxygen is absent or in short supply and it performs the reverse reaction during the Cori cycle in the liver. At high concentrations of lactate, LDH exhibits feedback inhibition and the rate of conversion of pyruvate to lactate is decreased. So also LDH is a sensitive cardiac marker. Thus, from this study, La-supplementation rather than inhibiting liver function unlike the control diet improved the functionality of the liver as well as protect the heart against myocardial infarction in the experimental birds fed La-supplemented diets. Also, the values of AST, ALT, ALP, TB and TP of birds fed the La-based diets were not statistically different (P>0.05) from those fed the control, which suggest that feeding La as feed additive might not post any adverse health challenge to the birds, especially as it relates to liver as increased activities of these enzymes in the serum are well-known diagnostic indicators of liver injury (Oboh and Akindahunsi 2005).

Table 5. Hematological variables of broilers fed diets supplemented with lanthanum oxide

Indices	Diet 1 La: 0ppm	Diet 2 La: 85.3ppm	Diet 3 La: 171ppm	Diet 4 La: 256ppm	±SEM*
ESR mm/hr	2.33	1.67	1.67	3.0	0.75
PCV %	27.3	28.3	28.7	25.3	1.63
RBC × 10^6/mm^3	2.06	2.25	2.31	1.47.	0.42
Hbc g/100ml	9.10	9.43	9.53	8.43	0.54
MCHC (%)	33.3	33.3	33.2	33.2	0.13
MCH (pg)	4.62^{ab}	4.37^{ab}	4.15^{b}	5.72^{a}	0.72
MCV μm^3	1.39^{a}	1.31^{ab}	1.25^{b}	1.39^{a}	0.22
Leucocyte %	59.7	59.7	57.7	59.7	3.79
Neutrophill (%)	24.3	28.0	23.7	23.3	2.43
Monocytes (%)	13.3	13.7	15.3	13.3	2.82
Basophill (%)	2.00	2.67	2.00	2.33	0.47
Eosinophill (%)	0.67	1.0	1.33	1.33	0.47

[ab]Means in the same row for each parameter with different superscripts are significantly different (p<0.05). ±SEM* Standard Error of Mean. ESR; Erythrocyte sedimentation rate, PCV; Packed cell volume, RBC; Red blood cell, Hbc; Hemoglobin concentration, MCHC; Mean cellular hemoglobin concentration, MCH; Mean cellular hemoglobin and MCV; mean cell volume.

Blood represents a means of assessing clinical and nutritional health status of animals in feeding trials and the hematological variables most commonly used in nutritional studies include PCV, Rbc, Hbc, MCHC, MCV and clotting time (Aletor and Egberongbe 1992). In the present study (Table 5) only the MCH and MCV were significantly (P<0.05) affected of the entire hematological indices measured. In general the

PCV, RBC and Hbc were consistently enhanced in birds fed 85.3-171ppm La supplemented diets than those fed the control diets while the differential counts did not follow a particular trend. However, the values observed for PCV, RBC and Hbc were consistently lower in birds fed 256ppm La supplemented diets suggesting a possible adverse effect of feeding higher concentration of La to broilers and further confirming that the tolerable level of La in the diet of broiler could be 171ppm. Furthermore, the MCH was highest in birds fed 256ppm La supplemented diet (5.72pg) but were not significantly different (P>0.05) from those fed the control and 85.3ppm La diet. The same trend was observed for MCV. The relevance of MCHC, MCH and MCV measurement lies in their use in the diagnosis of anaemia and an index of the capacity of bone marrow to produce RBC (Aletor and Egberongbe 1992). With regard to the blood physical properties, the erythrocyte sedimentation rate (ESR) was similar for all treatments. It is believed that the frictional resistance of the surrounding plasma, which holds the cells in suspension and the gravitational pull on the erythrocyte, mostly determines the ESR. The present findings with respect to ESR tend to suggest that the La-based diets did not give rise to acute general infection as high values of sedimentation rates could precipitate acute general infections and malignant tumours (Frandson 1986). However, while the PCV and RBC values compared favourably with those reported for broilers fed leaf protein concentrate-based diets, the values of Hb and MCHC were higher (Agbede and Aletor 2003).

Table 6. Estimated Bacteria load (x104 cfu/ml) of broilers fed diets supplemented with lanthanum

Indices	Diet 1 La: 0 ppm	Diet 2 La: 85.3ppm	Diet 3 La: 171ppm	Diet 4 La: 256ppm	±SEM*
Gut	107	98.3	115	112	13.7
Liver	74.7	71.3	110	89.3	32.8
Spleen	73.3^{b}	40.0^{c}	108^{a}	87.0^{b}	31.7

[ab]Means in the same row for each parameter with different superscripts are significantly different (p<0.05). ±SEM* Standard Error of Mean.

The estimated bacteria load ($x10^4$ cfu/ml) of broilers fed diets supplemented with lanthanum are presented in Table 6. Only the bacterial load of the spleen isolates of birds were significantly different (P<0.05). The phenomenon linking the performance-enhancing effects of supplemental La to its presumed bacterial suppressive-like influence underscored the necessity for the bacterial culture and the subsequent estimation of the micro floral population. The result as generated from the bacterial counts of the gut, liver and spleen obviously reflects varying degrees of alterations in microbial population. Regardless of the trend,

the disproportionate numerical values of this finding were in tandem with the reported change in the microbial status of litter recycled in 2-3 flocks (Arias and Koutos 2006). Relatively lower counts of bacteria were obtained in nearly all the specimens examined under the 85.3ppm La concentration. This seemed to imply that the optimum suppressive effects might likely, not be attained beyond the given dietary level (85.3ppm). According to the proposals by Fiddler et al (2003), orally applied REE are poorly absorbed in the gastrointestinal tracts. Such little amount, which probably becomes available for intermediate metabolism (Redling 2006), might have been responsible for the eventual insignificant microbial load ($P>0.05$) impacted on both the gut and the liver (La: 85.3-256ppm). It will therefore be recalled that the efficacy of antibiotics relates to their capacity to create an acid environment through a decrease in the pH level (Ou et al 2000). However, the peculiar outright elimination associated with the antibiotic definition may not have been promoted in this study; this was on account of the relative quantum of micro-flora which was obtained under this test element at different dosages. Rather, the La differential supplementation levels may have facilitated the development of a desirable microbial balance by inducing the suppression of sensitive (unfavourable) strains (Hughes and Heritage 2001), and a concomitant multiplicity of beneficial species in a symbiotic or mutual relationship with their host (Ou et al 2000, Feldman 2003, Flachowsky 2003, Rambeck and Wehr 2005).

CONCLUSIONS

The present study showed that contrary to some reports, the Lanthanum addition to broiler diets could lead to numerical improvement in the total weight gain (TWG) and that La supplementation at 171ppm might be the most suitable dosage level required for enhanced productivity. Also, the supplementation of La could prevent the heart against myocardial infarction in broilers and could generally enhance the health status of the broilers. Relatively lower counts of bacteria were obtained in nearly all the specimens examined under the 85.3ppm concentration, which seemed to imply that the optimum bacteria suppressive effects might likely, not be attained beyond this level.

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