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Influence of rare earth elements on production performance in post peak layer chickens

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Abstract
A biological study was conducted to determine the effect of dietary supplementation of different levels of rare earth elements (lanthanum and cerium) on egg production, feed intake, feed efficiency and egg weight in laying hens. A total of 96 White Leghorn laying hens of 52 weeks of age were used in 8 weeks feeding trial. Birds were randomly allotted to three dietary treatments each with four replicates with 8 hens per replicate. Treatment groups consisted of basal diet supplemented with 0, 250mg (lanthanum 100mg and cerium 150 mg) and 500mg/kg (lanthanum 200mg and cerium 300 mg) of rare earth elements. Daily records of egg production and egg weight were maintained. Feed consumption of all three treatment and control groups was recorded every week and the mean feed intake per bird and feed efficiency per egg was calculated. The results of study showed that rare earth elements (lanthanum and cerium) supplemented at 250mg/kg of layers had significantly ($P<0.05$) decreased feed intake at first and second month, whereas in 500mg/kg experimental group feed intake had significantly ($P<0.05$) decreased in the first month but no significant changes was found in the second month of the trial. Hen day egg production, feed efficiency were significantly ($P<0.05$) increased in 250mg/kg, 500mg/kg experimental groups at first and second month of the trial. Significantly ($P<0.05$) increased egg weight were found in 250mg/kg rare earth elements supplemented groups at the end of first and second months, whereas in 500mg/kg experimental group, egg weight significantly ($P<0.05$) increased in the first month of the trial but no changes were found in the second month of the trial. Hence it was concluded that at low dose of rare earth elements, the birds had a significant effect in feed intake, hen day egg production, feed efficiency and egg weight.

Keywords: Egg production, feed efficiency, laying hen, rare earth element

1. Introduction

Rare earth elements (REE) are 15 lanthanide elements with atomic numbers 57 Lanthanum through 71 Lutetium, that are in group III A of the Periodic table. They are named in order of Lanthanum (La), Cerium (Ce), Praseodymium (Pr), Neodymium (Nd), Promethium (Pm), Samarium (Sm), Europium (Eu), Gadolinium (Gd), Terbium (Tb), Dysprosium (Dy), Holmium (Ho), Erbium (Er), Thulium (TM), Ytterbium (Yb), and Lutetium (Lu). The REE are represented by the single square of lanthanum in the main part of the Periodic table and listed in a separate sub-table below the main grouping. Yttrium (Y, atomic number 39) and scandium (Sc, atomic number 21) are also included in the group of rare earth elements. Cerium, Yttrium, Neodymium and Lanthanum are more common in the earth's crust than silver, gold or platinum. Their average content in the earth crust is approximately 0.015%, which matches with that of copper, lead and zinc and is much higher than that of tin, cobalt, silver and mercury [1].

A wide range of physiological and biochemical processes in human and animal system depends mostly on Ca^{2+}. Rare earth elements resemble calcium not only in size and bonding but also in coordination geometry and donor atom preference, which make them to replace Ca^{2+} specifically in various biological processes [2]. Calcium plays an important role in egg production, because it is an essential factor in the formation of the egg and belongs to the signaling system which can affect gastrointestinal motility, oviduct motility and the nervous system [3].

[4] Reported enhanced performance effects in terms of improved feed conversion, increased body weight, enhanced egg production and fertilization rate of hatching eggs in poultry after oral rare earth element supplementation. [5] Reported decreased incidence of damaged eggs by 1.5% and increased laying rate of 4.7% in breeding hens which were supplemented 100mg/kg of rare earth element in their diet.

Fertilization, hatching rate as well as the percentage of healthy chickens also increased in rare earth element supplemented groups.

Therefore the aim of this study was to investigate the effects of dietary rare earth elements on production performance indices of laying hens.

2. Materials and Methods

A total of 96 White Leghorn layers of 52 weeks of age were randomly assigned to three dietary treatment groups for 8-week feeding trial and the experiment was conducted at the Poultry Farm Complex, Department of Poultry Science, Veterinary College and Research Institute, Namakkal, Tamil Nadu. Laying hens were randomly assigned to three treatments with four replicates per treatment, and there were 8 hens in each replicate. The layers were reared in cages in gable roofed open sided, elevated platform house. All the birds were provided with uniform cage floor, feeder and water space and were reared under standard management conditions throughout the experimental period. The experimental layer diets (table 1) were formulated according to the breeder's specification (Venkateshwara Hatcheries Private Limited). Basal diet supplemented with 0, 250 (La 100mg, Ce 150mg) and 500mg/kg (La 200, Ce 300 mg) of REE. Daily records of egg production and egg weight were maintained. Feed consumption of all three treatment groups was recorded every week and the mean total feed consumption per bird and feed efficiency per egg was calculated. Egg production was expressed as an average hen-day production and feed efficiency was calculated for gram of feed per egg.

2.1 Feed Consumption

Feed consumption of all three treatment groups was recorded every week and the mean total feed consumption per bird was calculated.

2.2 Egg Production

The egg production was recorded daily during the entire experimental period. Hen day egg production (HDEP) was calculated.

$$\text{HDEP} = \frac{\text{Total number of eggs produced on a day}}{\text{Total number of hens present on that day}} \times 100$$

2.3 Feed Efficiency

Feed efficiency was calculated and expressed as

$$\text{FCR (g of feed / egg)} = \frac{\text{Feed consumed (g)}}{\text{Number of egg produced}}$$

2.4 Egg Weight

Egg weight (g) was recorded daily during the experimental period with an accuracy of 0.01 g and mean egg weight was calculated.

3. Statistical analysis

The data collected were analysed using SPSS® 20.0 software package. Post hoc analysis was done by Duncan's multiple descriptive significant difference. All the statistical procedures were performed based upon [6].

4. Results and Discussion

The mean (± S.E.) feed intake, hen day egg production, feed efficiency and egg weight are presented in table 2. The mean daily feed intake of REE supplemented groups T2, T3 were significantly ($p<0.05$) lower compared to control during 53 to 56 weeks of age. Moreover, in 57 to 60th weeks of age, the experimental group T2 consumed less feed ($p<0.05$) when compared to T1, T3 groups.

These findings of the present study are in agreement with [7] who reported decreased feed intake by supplementation of high (800 mg/kg) level of citrate-bound rare earth elements in weaned piglets. However, [8] and [9] reported no significant difference in feed intake between treatment groups supplemented with lanthanum oxide and cerium oxide at different levels in layers respectively.

In the post peak laying phase from 53 to 60 weeks, REE had positive influence on HDEP. The mean hen day egg production was significantly ($p<0.05$) higher in T2, T3groups compared with T1 group from 53rd to 60th weeks age of layers. These findings of our study are in agreement with [8] and [9] observed hen day egg production was significantly higher in layers supplemented with rare earth elements lanthanum oxide and cerium oxide respectively at 300 – 400 mg/kg of diet. [10] Reported improved total egg production by 12-15 per cent and prolonged the peak egg production by addition of rare earth elements (60 mg/kg) in laying ducks. Similarly, increase laying rate by 4.7 per cent due to supplementing REE (100 mg/kg) was observed in broiler breeder birds [5]. The increased egg production might be due to REE which resembles the element Ca they might have acted as cofactors to replace Ca in various biological processes in laying hens [11]. Calcium plays an important role in egg production, because it is an essential factor in the formation of the egg and oviduct motility [3].

The mean feed efficiency at 53rd to 60th week of age had better ($p<0.05$) feed efficiency in T2 and T3 groups compared to T1. In general, the REE supplemented layers consumed 3 to 6 g of less feed per egg compared to basal diet (T1) groups. The better feed efficiency recorded in the present study is in agreement with [8-9] reported that feed efficiency was better in layers supplemented with rare earth elements (lanthanum oxide and cerium chloride) at 300 to 400 mg/kg of diet. However, [12] reported no significant effect on feed conversion rate by supplementing REE citrate premix at the level of 200mg/kg of diet in weaned piglets compared to control piglets.

The mechanism of how REE could improve animal performance is not known. [2, 13] reviewed the literature on the study of REE and concluded that La supplementation could improve the secretion of gastric acid in isolated mice stomach, which could enhance nutrient digestibility. Enhanced digestibility and absorption of nutrients would result in birds performance. The reduced feed consumption and improved feed efficiency in REE supplemented groups could be attributed to the increase in the intestinal enzyme activities and digestive fluids [14] thus finally contributing to better egg production performance seen in REE fed layers.

Durings 53rd to 56th week the mean egg weight was significantly ($p<0.05$) higher in layers fed rare earth elements compared to control group but 57th to 60th week, 250mg/kg rare earth elements fed experimental group had significantly ($p<0.05$) increased egg weight, whereas in 500mg/kg REE fed experimental groups no changes was found . The present results concur with the finding of [15] who observed improved ($p<0.05$) individual egg weight (0.5 to 1.33 g) in layers supplemented with REE mixture at 400 to 500 mg/kg of diet.

However, [8] reported that no significant effect on egg weight in lanthanum oxide supplemented (100 to 400 mg/kg) layers. Similarly, [9] reported no change in egg weight when supplementing cerium oxide (100 to 400 mg/kg) in layer chicken diet compared to control birds.

Table 1: Ingredients and nutrient composition of experimental layer diet (DM %)

Ingredients	Kg/100 kg diet
Maize	50.5
DORB	13.5
SFOC	6.0
SOYA	17.5
Calcite/LSP	5.5
Grit	5.0
Di calcium phosphate	1.5
Methionine	0.164
Lysine	0.117
NSP Enzyme	0.05
Salt	0.137
Nutrient compositions (%)	
Crude protein	16.67
Crude fibre	6.4
Calcium	4.0
Ether extract	3.0
Available phosphorus*	0.41
Lysine*	0.89
Methionine*	0.45
Metabolizable Energy* (kcal/kg)	2550

* Calculated values

Additives and supplements (per 100 kg): Vitamin premix ([1]Hyblend) - 10 g, trace mineral ([2]Ultra TM) - 100 g, toxin binder - 25 g, Vitamin B-complex ([3]Meriplex) - 10 g, liver stimulant (hepatocare) - 25 g, choline chloride (60 %) - 50 g, oxytetracycline (10 %) - 50 g

[1]Hyblend – nutritional value per gram- vitamin A - 82500 IU, vitamin B2 - 50 mg, vitamin D3 - 12000 IU, menaphthone sodium bisulphate and vitamin K (stabilized) - 10 mg.

[2]Ultra TM - Each 5kg contains manganese - 270 g, zinc - 260 g, iron - 100 g, iodine - 10 g, copper - 10 g, cobalt - 5 g, selenium - 1.5 g

[3]Meriplex - each gram contains vitamin B_1 - 8 mg, vitamin B_6 - 16 mg, vitamin B_{12} - 80 mcg, vitamin E_{50} - 80 mg, niacin - 120 mg, folic acid - 8 mg, calcium D pantothenate - 80 mg, calcium - 86 mg.

Table 2: Mean (± SE) feed intake (g/bird/day) hen day egg production (%) feed efficiency (g/ egg) egg weight (g) of White Leghorn layers fed different levels of REE

Treatment	Age in weeks							
	Feed intake (g/bird/day)		Hen day egg production (%)		Feed efficiency (g/ egg)		Egg weight (g)	
	53-56	57-60	53-56	57-60	53-56	57-60	53-56	57-60
T1 Control	109.57^b ±0.24	109.76^b ±0.16	80.89^a ±0.72	79.45^a ±0.76	135.76^b ±1.23	138.55^b ±1.37	55.15^a ±0.06	54.90^a ±0.10
T2 250 mg REE (La 100 mg +150 mg Ce)	108.26^a ±0.19	108.50^a ±0.15	83.20^b ±0.71	82.30^b ±0.67	130.39^a ±1.16	132.08^a ±1.15	56.24^b ±0.33	55.98^b ±0.27
T3 500 mg REE (La 200 mg +300 mg Ce)	108.57^a ±0.16	109.48^b ±0.12	82.17^{ab} ±0.69	82.71^b ±0.84	132.41^a ±1.17	132.73^a ±1.28	55.38^{ab} ±0.41	55.15^a ±0.29

Means within a column with different superscript differ significantly (P<0.05)

5. Conclusion
In conclusion the results of the experiment revealed that the mean daily feed intake of low dose REE supplemented group were significantly (p<0.05) lower compared to control and egg production, feed efficiency, egg weight was significantly increased (p<0.05) in REE groups. Based on the results of this study, it can be recommended to supplement laying hens feed with low level of rare earth elements.

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