Effect of Supplemental Lanthanum on the Growth Performance of Pigs

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ABSTRACT : A feeding trial was conducted on pigs to study the effect of La on their growth performance. Sixty barrows were randomly assigned to two groups (each of which included three replicates) and they were fed same basal diet supplemented with 0 or 100 mg/kg lanthanum (La) respectively for 30 d. Blood samples were collected and analyzed to study the growth hormone secretion pattern. La residues in selected organs were analyzed to test the safety level. The results showed that average daily gain and feed conversion ratio of pigs were increased by 12.95% ($p<0.05$) and 6.78% ($p<0.05$) respectively with the supplementation of La. Blood samples analysis showed that peak amplitude, base-line level and mean level of growth hormone in serum were elevated by 80.42% ($p<0.05$), 70.99% ($p<0.05$) and 64.91% ($p<0.05$) respectively. No significant difference of La residues was found in selected organs between the control and La-treated group. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 9 : 1360-1363)***

Key Words : Lanthanum, Pigs, Growth Performance, Growth Hormone, Residue

INTRODUCTION

Rare earth elements (REE) are 17 elements which include the lanthanides La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and the elements Sc and Y. They are widely used in metallurgy, chemical engineering, and electronics. In animal production, it was reported that a small content of REE in the feed could increase the body weight gain of beef cattle, sheep, pigs, rabbits, chicken and ducks (Shen et al., 1991, He and Xia, 1998, Yang et al., 2000). Furthermore, it was shown that REE could increase milk production of dairy cattle and egg production of laying hens (Yang et al., 1994, Lei et al., 2001). Feed conversion ratios (FCR) were also improved in many cases (Liu et al., 1995, Li and Zhu, 1998, Liu and Shan, 2001).

Rare earth elements have been administered to the animals by addition to feed or to drinking water. In weaned piglets with a body weight (BW) of about 7 kg, the average daily gain (ADG) was increased by 5% to 23% and FCR was improved by 4% to 19% with supplementation of REE (He and Xia, 1998). In piglets with a BW between 13 to 17 kg, improvements in ADG of 11% to 20% and FCR of 5% to 9% were reported (He and Xia, 1998; Li et al., 1992). In growing of 30 to 50 kg, REE reflected in an increased ADG of 9% to 13%, and the FCR were improved by 6% to 8% (He and Xia, 1998; Cheng et al., 1994). However, most of the experimental REE are in the form of mixture containing elements. The effects of supplementation from single element are lacking, which is very important to understand the mechanism of REE .In order to find out if single REE have performance enhancing effects, the present study was designed choosing La as REE material, which is the most common component in REE premix reported. Possible effects of La on ADG and FCR in pigs, as well as the contents of REE in the organs of the experimental pigs were investigated.

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MATERIALS AND METHODS

Experimental materials

Rare earth elements-La containing 99.7% of $LaCl_3.7H_2O$ was provided by Ganshu Rare Earth Elements Company. A total of 60 barrows (Duroc×Landrace ×Yorkshire) with an average BW of about 50 kg were selected from Longyou Yorkshire breeding farm. Complete diets were formulated to meet all nutrients or above requirements (NRC, 1998). Except for the content of REE-La, all diets within each experimental group were equal in digestible energy (DE), dry matter (DM), crude protein (CP), essential amino acids, minerals, trace minerals and vitamins. The composition of basal diets and their main contents are shown in Table 1.

Experimental design

Sixty growing barrows were randomly assigned by weight to two groups, each of which was replicated three times with ten pigs per replicate. Half of the pigs were fed with diets containing 100 mg/kg REE-La (279 mg/kg $LaCl_3.7H_2O$), the other half acted as control groups, receiving no REE-La. Feed was provided *ad libitum* and water was provided by automatic waterers. Average daily gain, average daily feed intake (ADFI), and FCR were collected for all pigs throughout the experimented period.

Table 1. Composition and nutritive value of basal diets

Ingredients (%)	
Corn	62.0
Soybean meal	16.8
Rapeseed meal	8.0
Wheat bran	4.0
Rice bran	4.0
Fish meal	2.0
Bone meal	1.8
Calcium carbonate	0.4
Salt	0.3
Premix[1]	0.7
Chemical composition (% as feed)[2]	
Digestible energy (kcal/kg)	3,155
Crude protein	17.10
Calcium	0.76
Phosphorus	0.50
Lysine	1.05
Methionine	0.42

[1] Contained per kg diet: Cu 25 mg; Zn 100 mg; Fe 140 mg; Mn 40 mg; Se 0.1 mg; I 0.3 mg; V-A 6,660 IU;V-D_3 660 IU; V-E 88 IU; V-K 4.4 mg; V-B_2 8.8 mg; D-pantothenic acid 24.2 mg; niacin, 33 mg; choline chloride 330 mg.
[2] All of the data are analytic values except digestible energy.

Table 2. Effects of REE-La on the growth performance of growing pigs[1]

	REE-La (mg/kg)		S.E.M[2]
	0	100	
Initial weight (kg)	54.69	54.75	0.67
Final weight (kg)	74.30	76.90	0.91
ADG (g/d)	653.67a	738.33b	13.54
ADFI ($kg.pig^{-1}.d^{-1}$)	2.21a	2.33b	0.03
FCR (g/g)	3.39a	3.16b	0.02

[1] Values are presented as means; n=30 for ADG, n=3 for ADFI and FCR per treatment. Means in a row with different letters differ significantly.
[2] Standard error of the mean.

Sample collections

Before the termination of feeding experiment, 4 pigs of similar BW were selected from the control and REE-La treated group each. Blood samples were taken via auriculares at 15 min intervals for 3 h. Blood samples were allowed to clot at 4°C for 48 h. Serum was collected and stored at -80°C.

At the end of the feeding trial, 10 pigs from each group were chosen for slaughter. Pigs were stunned by electric shock and then killed by exsanguinations. The longissimus muscle, liver, kidney, spleen and pancreas were removed and frozen**.** Tissues were rinsed with deionized water after thawing. One-inch-square samples were cut from the center portion of the thawed tissues with care to stay away from excess fat and veins for analysis of the REE-La content.

Laboratory analysis

Porcine serum samples were thawed in room temperature and growth hormone (GH) levels were determined with the RIA kit (Northern Immune Technic Institute, Isotopes Company, China) in a beta-counter (Packard 8500, USA). REE-La content in samples collected were determined using the method reported by Li (1988).

Table 3. Effects of REE-La on GH level in serum

	REE-La (mg/kg)		S.E.M[2]
	0	100	
Peak amplitude (ng/ml)	3.43a	6.19b	0.67
Base-line level (ng/ml)	1.13a	1.94b	0.11
Mean level (ng/ml)	1.89a	3.11b	0.19

[1] Values are presented as means; n=4 per treatment. Means in a row with different letters differ significantly.
[2] Standard error of the mean.

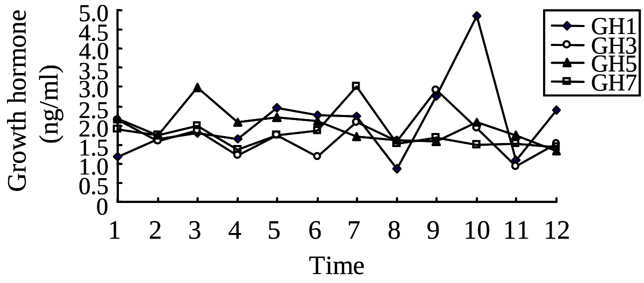

Figure 1. GH secretion pattern of control group; 1, 3, 5, 7 are pig number. Pigs were bled at 15 minintervals for 3 h. Growth hormones in serum were were determined with the RIA kit.

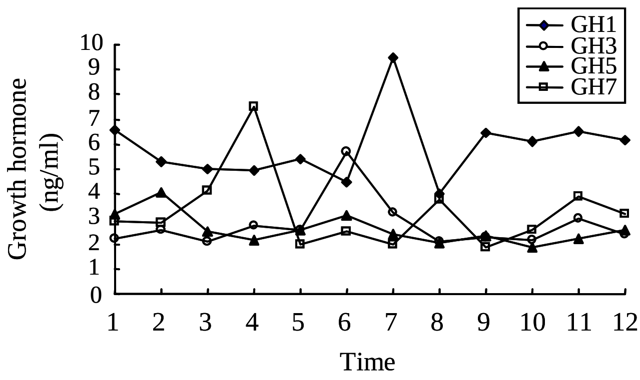

Figure 2. GH secretion pattern of REE-La treated group; 2 4, 6, 8 are pig number. Pigs were bled at 15 minintervals for 3 h. Growth hormones in serum were determined with the RIA kit.

Statistical analysis

A completely randomized design with two treatments was used. Data were analyzed by analysis of variance (ANOVA) using the general liner model procedures of PC SAS (SAS, 1989). For all data, the model included treatment as main effect. Comparisons were considered significantly different if $p<0.05$.

RESULTS

Growth performance

Growth performance of pigs fed REE-La as compared to the control is presented in Table 2. Pigs treated with

REE-La had a significant improvement of 12.95 ($p<0.05$) in ADG, 5.43% ($p<0.05$) in feed intake, and 6.78% ($p<0.05$) in FCR as compared to the control group.

Growth hormone secretion

The results obtained showed that serum GH peak amplitude, base-line levels and mean levels were increased by 80.42% ($p<0.05$), 70.99% ($p<0.05$) and 64.91% ($p<0.05$) respectively with the addition of REE-La (Figures 1, 2 and Table 3).

REE-La content in selected organs

Addition of REE-La in the diet reflected in the appearance of various La residues in selected organs. However no significant differences were found between the control and experimental group (Table 4).

Table 4. La residues in pooled samples selected

	REE-La (mg/kg)		S.E.M[2]
	0	100	
Longissimus muscle (mg/kg)	0.15±0.01	0.29±0.09	0.01
Liver (mg/kg)	0.33±0.07	0.38±0.03	0.02
Kidney (mg/kg)	0.13±0.03	0.16±0.04	0.01
Spleen (mg/kg)	0.17±0.05	0.15±0.05	0.01
Pancreas (mg/kg)	0.16±0.03	0.18±0.06	0.01

[1] Values are presented as means; n=10 per treatment. Means in a row with different letters differ significantly.
[2] Standard error of the mean.

DISCUSSION

Both the ADG feed intake and FCR of pigs were improved after feeding Ree-La containing diets. The results are similar to those described previously (Shen et al., 1991; Li et al., 1992; Cheng et al., 1994; Zhu et al., 1994; He and Xia, 1998). It is evident that La may be the important component causing performance enhancing effects as shown in this study. Based on the former literature, only a distinct concentration of REE in the diet can improve ADG and FCR, as a very high content of REE in diets may have little or even no effects at all. Apparently, further studies are required to find the optimum content of REE-La in feed on dose response trials.

The growth hormone secretion pattern was studied through blood samples taken via auriculares. The results obtained showed that serum GH peak amplitude, base-line levels and mean levels were increased significantly. One suggested reason for striking effect of REE on animal growth is that the REE can improve digestibility and utilization of nutrients in the diets as reported in other studies (Li et al., 1992; Cheng et al., 1994; Lu and Yang, 1996). This may be achieved through influencing the development of selected bacterial groups in the intestinal tract, or through stimulating activities of the hormones such as GH and triiodothyronine (T_3) (Xie et al., 1991). This suggestion was supported by our present study. As there is a relationship between REE and calcium in both animal and plant cells, the structure and character of lanthanum are similar to calcium, it is also suggested that REE may affect activities of the hormones or enzymes by inhibiting or replacing calcium (Nayler, 1975; Hanioka, 1994; Takada et al., 1999). Further studies should be conducted to confirm the effect of REE on GH secretion and to determine the effect on nutrient digestibility.

No significant difference of La residues was found in selected organs between the control and La-treated group. In general, the contents of La in these organs were very low. These results are consistent with those findings in rats and in broilers (Nakamura et al., 1991; Xie et al., 1991), the health of the animals and the safety of animal products were not influenced by REE-La. It was suggested that a daily dose of 20 to 200 mg/kg of REE nitrates can be defined as the no-effect dose range on safety, resulting in a safety factor of about 100 (Ji, 1985). The acceptable daily intake for a person would be 0.2 to 2 mg/kg BW. Recently it was found that La even may have anti-tumor effects (Xiao et al., 1997).

CONCLUSION

In conclusion, 100 mg/kg REE-La had significant effect on ADG FI and FCR of pigs. Serum GH peak amplitude, base-line levels and mean levels were dramatically increased, which maybe be the explanations for the striking effect of REE on animal growth. The contents of La residues in selected organs were very low and safe for human consumption.

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