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A note on the effect of rare earth elements on the performance and thyroid hormone status of rearing piglets

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ABSTRACT

Rare earth elements (REE) have been used for decades in China to promote growth in plant production and farm animals. Studies are presently also being conducted under Western animal production conditions, however dose-response studies are relatively rare. In this study a total of 80 piglets were fed a diet supplemented with 0, 100, 200, 400 or 800 mg of citrate-bound rare earth elements, consisting of, %: lanthanum 30, cerium 55, praseodymium 5 and neodymium 10. The trial lasted 35 days, the initial mean body weight of the piglets was 7.2 kg. Apart from growth and feeding parameters, blood serum was analysed for T_3 and T_4 by radioimmunoassay (RIA). Feed intake decreased insignificantly with higher REE-levels. The daily weight gain of piglets amounted to 283 (control), 301 (100 mg), 254 (200 mg), 258 (400 mg) and 271 g (800 mg). Thyroid hormone levels increased with REE-supplementation. More dose-response studies will be necessary to prove the effects of REE on growth parameters and their intermediate effects.

KEY WORDS: rare earth elements, growth, thyroid hormones, piglets

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INTRODUCTION

The term rare earth elements (REE) encompasses the elements scandium, yttrium, lanthanum and the 14 chemical elements following lanthanum (order numbers 58-71) called lanthanides. REE have been used in China for decades in plant production and farm animal feeding to promote growth. Even under Western animal production conditions it has been reported that rare earth elements in the diet can improve animal growth performance significantly, as recently summarized by Redling (2006). Most of the experiments with piglets and pigs were carried out with dosages of between 100 and 300 mg REE mixtures per kg feed (Redling, 2006). Higher growth rates were mostly accompanied by decreased thyroid hormone levels (Schuller et al., 2002; Knebel, 2004). Dose-response studies with higher levels have not been described in the literature. The aim of the present study was to investigate the effect of higher REE-dosages on feed intake, daily weight gain, feed efficiency and thyroid hormone concentration in piglets.

MATERIAL AND METHODS

A total of 80 hybrid ("BHZP") piglets (40 females/40 castrated males) were bought from a commercial breeder. The piglets were weaned at the age of 21 days with an average body weight (BW) of 7.2 kg. In the Institute's stable they were divided into five groups, 4 piglets in 4 boxes, 16 piglets per group (Table 2) according their individual BW.

The animals in group 1 (control) were fed a cereal-soyabean meal based diet (Table 1). This diet was supplemented with 100, 200, 400 or 800 mg (groups 2 to 5; Table 2) of citrate-bound rare earth elements consisting of, %: lanthanum 30, cerium 55, praseodymium 5 and neodymium 10.

Table 1. Diet composition, %

Ingredients	%
Barley	36.75
Wheat	30.00
Maize, extruded	7.50
Soyabean meal	15.00
Soyabean concentrate	4.00
Soyabean oil	2.50
Premix	3.00
Amino acids	1.25
ME, MJ kg^{-1}DM, calculated	15.39
Crude protein, gkg^{-1}DM, analysed	191

[1] supplementation per kg mixed feed, IU: vit. A 12.000, vit. D_3 1.200; g: Ca 7.35, P 1.8, Na 1.65; mg: Mg 300, vit. E 36, vit. B_1 1.1, vit. B_2 3, vit. B_6 3, vit. K_3 1.6, nicotinic acid 15, phantothenate 10, choline chloride 150, Fe 120, Cu 30, Mn 60, Zn 120, I 1.5, Se 0.5, Co 0.6; µg: vit. B_{12} 22

Table 2. Experimental design

Group	1	2	3	4	5
REE-supplementation, mg/kg	-	100	200	400	800
Piglets	16	16	16	16	16
Boxes	4	4	4	4	4
Piglets per box	4	4	4	4	4

Diets were analysed for crude nutrients according to VDLUFA-guidelines (Bassler and Buchholz, 1993), and metabolizable energy content was calculated on the basis of GfE-recommendations (GfE, 2006). The use of REE-mixture premix with wheat is one of the most important problems when evaluating individual REE-effects. These naturally occurring mixtures are preferred due to their low cost compared with the pure substances.

The trial was designed as an one-period experiment with a duration of 35 days. Feed in mash form and water were offered *ad libitum*. The piglets were weighed weekly. Blood samples were taken from the *vena cava cranialis* after the first and the last trial weeks and the serum was analysed for thyroid hormones by specific radioimmunoassays. Triiodothyronine (T_3) was assayed using a commercial RIA kit (T_3 RIA, DSL-3100, Diagnostic Systems Laboratories, Webster, Texas, USA), that had been validated for porcine serum. Sensitivity of the assay was 0.06 nmol/l, intra- and inter-assay c.v. were 5.9 and 4.7%, respectively. Thyroxine (T_4) was assayed using a commercial RIA kit (T_4 RIA, DSL-3200, Diagnostic Systems Laboratories, Webster, Texas, USA), that had been validated for porcine serum. Sensitivity of the assay was 5.2 nmol/l, intra- and inter-assay c.v. were 5.1 and 7.1%, respectively.

Mean comparisons were conducted by multiple Student's t-test with the SAS (2002) univariate procedure.

RESULTS AND DISCUSSION

Growth performance. No disturbances in animal health were observed throughout the course of the experiment. The piglets in group 2 (100 mg REE kg^{-1}) consumed insignificantly more feed than the animals of all other groups ($P>0.05$; Table 3) and showed the highest daily weight gain (Table 3). The daily weight gain of piglets in group 2 (100 mg REE kg^{-1}) was significantly higher ($P<0.05$) than those of group 3 (200 mg REE kg^{-1}), but did not show significant differences with any of the other treatments ($P>0.05$; Table 3). The animals in group 3 (200 mg REE kg^{-1}) needed significantly more feed per kg weight gain than the piglets in all other groups ($P<0.05$; Table 3).

Table 3. Animal performance in relation to REE-supplementation

Groups	1	2	3	4	5
REE mg kg^{-1}	-	100	200	400	800
Initial body weight, kg	7.2 ± 1.0	7.2 ± 0.9	7.2 ± 0.9	7.1 ± 0.9	7.1 ± 0.8
Final body weight, kg	17.1^{ab} ± 2.2	17.7^{a} ± 3.1	15.6^{b} ± 3.9	16.2^{ab} ± 1.5	16.4^{ab} ± 2.9
Feed intake, g day^{-1}	467 ± 39	494 ± 61	461 ± 52	447 ± 33	433 ± 44
Daily weight gain, g	283^{ab} ± 47	301^{ab} ± 65	243^{b} ± 101	258^{ab} ± 34	265^{ab} ± 71
Feed conversion ratio, kg kg^{-1}	1.67^{b} ± 0.09	1.64^{b} ± 0.15	1.93^{a} ± 0.13	1.74^{b} ± 0.10	1.64^{b} ± 0.04

^{a,b} different letters in one line show significant differences (P<0.05)

Similarly to the Chinese experiments (see Redling, 2006) the effects of low doses of REE (up to 300 mg/kg) on weight gain of piglets have been described in the literature (Rambeck et al., 1999; He et al., 2001; Borger, 2003; Knebel, 2004). In some cases, DWG increased by up to 22.5% (He et al., 2001; Knebel, 2004) and feed conversion improved by up to 11%. In agreement with a recent study by Kratz et al. (2006) the present study did not show such significant effects. Supplementation of 200 mg REE or more decreased feed intake and showed lower DWG than control animals or piglets supplemented with 100 mg REE per kg (Table 3). Reasons for such large differences between various authors could not be explained and need further clarification.

Thyroid hormones. Thyroid hormone concentrations in blood serum decreased after five weeks of experimentation in comparison with one week in all groups (Table 4). Apart from the T_3-concentration after one week, thyroid

Table 4. Influence of REE-supplementation on thyroid hormones in serum of piglets, nmol·l^{-1} (n=4)

Experiment of week	1st		5th	
Group, dosage, mg kg^{-1}	T_4	T_3	T_4	T_3
1 (0)	57.6 ± 5.9	1.27^{bc} ± 0.53	35.7 ± 3.4	0.73 ± 0.14
2 (100)	56.0 ± 9.4	0.85^{c} ± 0.16	42.2 ± 3.8	1.20 ± 0.21
3 (200)	60.9 ± 5.5	1.49^{b} ± 0.21	42.8 ± 6.2	1.16 ± 0.64
4 (400)	57.0 ± 7.4	1.00^{bc} ± 0.24	42.2 ± 2.8	1.20 ± 0.25
5 (800)	52.2 ± 13.3	2.09^{a} ± 0.35	41.2 ± 7.3	1.31 ± 0.53

^{a,b} different letters in one column show significant differences (P<0.05)

hormones did not show significant differences (P>0.05) between treatments. The combination of low sample numbers (n=4) and the high variability within groups precludes an interpretation of these data (Table 4). Lower T3- and T4-concentrations in older piglets were also observed by Carroll et al. (1998) and Tarn et al. (1998).

At present, the effects of REE-supplementation on thyroid hormone concentration are not clear. Contrary to the present study, thyroid hormone concentrations have been shown to decrease with higher animal performances in some cases (He et al.,

2001; Schuller et al., 2002; Eisele, 2003). It has to be considered that these studies can only be compared to a limited extent. The concentrations of thyroid hormones may be influenced by a variety of factors, such as the age of the animals, feeding procedures, REE-concentrations and the relationship between feeding time and the time of blood collection.

In conclusion, further studies are necessary to understand the mode of action of supplemented rare earth elements.

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