EFFECTS OF RARE EARTH NITRATE ON INTERNAL ORGANS AND MINERAL ELEMENTS IN THE SERUM OF BROILER CHICKENS

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Summary

This paper reports the effects of rare earth nitrate (REN) on the growth of internal organs and mineral elements in serums of broiler chickens. The REN used is mixture of light RE containing mainly La, Ce, Pr and Nd 4 elements. 40 eight-week old AA broiler chickens were divided randomly into four groups that their treatments were respectively 0, 20, 200 and 2000 mg REN/kg feed and the duration of the experiment was 60 days. Responses were measured in terms of internal organic weight and tissue, contents of mineral elements in serums. There were no significant differences between the organ ratios and tissue changes of the 20, 200 mg REN/kg groups and the control group. The organs included the heart, liver, kidneys, lungs, testicles, thyroids, adrenal glands, pancreas, tonsies of caecum, stomachus glandularis, duodenum, ileum and bursa of Fabricius. The liver and thyroid indices of 2000 mg REN/kg group were significantly higher than those of the control group ($p < 0.01$, $p < 0.05$) and the adrenal gland index lower ($p < 0.05$). The pathologic changes in the heart, kidney and thyroid were more serious than that of the control group. No significant differences occured between the contents of K, Na, Mg elements in the serum of all groups, with the exception of the content of Ca, which was higher in the 2000 mg/kg group ($p < 0.05$). The contents of all trace elements including Mn, Zn and Cu, but except Fe, in the serums of all the treated groups were significantly higher than those of the control group ($p < 0.01$).

(**Key Words** :Rare Earth Nitrate, Mineral Element, Internal Organ, Broiler Chicken)

Introduction

The rare earth group includes 17 elements, namely lanthanum (La), cerium (Ce), neodymium (Nd), promethium (Pm), samarium (Sm), gadolinium (Gd), terbium (Tm), dysprosium (Dy), holmium (Ho), erbinium (Er), thulium (Tm), ytterbium (Yb), luletium (Lu), scandium (Sc), yttrium (Y), praseodymium (Pr) and europium (Eu).

A lot of researches on the effects of rare earth (RE) on animals have been reported since 1930's. Hamiltom (1948) reported that the general metabolic state of Y was lower absorption and deposition mainly in the liver and bones in the rats. Durbin (1962) determined that the primary distributional state of La in the mice varied regularly with the size of ions. Mraz (1964) reported the absorption of 91Y, 144Ce, 142Pr, 147Nd and 147Pm in the intestines and the distribution in the tissues with the White Leghorn pullets.

Since 1972, the scientists in China have done a lot of research on rare earth nitrate (REN) in agriculture (Guo, 1985). The results of those researches have demonstrated that RE can promote the growth of crops and raise the productive output. At present, RE application has been gradually popularized in the crop production.

In order to protect the safety of RE for human, in the four years 1980 through 1984 Chinese scientists completed a serier of tests, such as the acute toxicity of a mixture of REN; test for absorption, distribution and accumulation; subchronic toxicity test; study on accumulation and hygiene evaluation of natural radionuclei in soil and crops; investigation on labor hygiene of worksites and environments of RE used agriculture (Ji, 1985).

Since 1984, research on RE as feed additive in animal production have been begun in China and the results have shown that RE can promote the growth in chickens and pigs (the research group, 1988; Ceng et al., 1988; Wang, 1989; Ning,

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1988).

The purpose of the experiment is to study the effects of REN on the growth of internal organs as well as contents of mineral elements in serums of broiler chickens.

Materials and Methods

1. Rare earth type

RE is a mixture of light RE nitrate. The content of RE is 38.7% as for oxides, which includes La_2O_3 38.3%, Sm_2O_3 1.2%, Ce_2O_3 39.4%, Pr_2O_3 5.4%, Nd_2O_3 15.4% and other RE elements less than 0.3%. The REN was offered by Technological Center of Rare Earth in Agriculture (General Research Institute of Nonferrour Mental, Beijing). The amount of REN used was calculated according to oxides.

2. Feeding

The basal diet consists of 63% corn, 19% soybean cake, 8% wheat bran, 7% fish meal, 0.7% ground shells, 1.4% ground bone, 0.3% salt, 0.5% trace elements and 0.1% vitamins for poultry. It contains 3128 kcal ME/kg diet, 20.8% protein, 1.03% calcium and 0.69% phosphorus. The RE materials were mixed evenly into the basal diet. The chickens were reared indoors under temperature-controled conditions and were fed and watered *ad libitum*. They were vaccinated against Newcastle disease.

3. Experiment

A total of 40 eight-week old AA broiler chickens were divided randomly into four groups. Each group had 5 females and 5 males. The chickens of all the groups were individully in the cages. The treatments were 0, 20, 200, 2000 mg REN/kg feed and the duration of the experiment was 60 days.

4. Measurement

(1) The changes of weight, respiration, heart beat and temperature.

(2) The ratios of the organ to carcass weight: The ratios of heart, liver, spleen, kidney, lung, testicle, thyroid, adrenal gland, bursa of Fabricius to carcass weight were measured at the end of the feeding test. The formula of calculating the organs to the carcass weight is as follows: Organ weight/carcass weight × 1000.

(3) The contents of K, Na, Ca, Mg, Zn, Fe and Cu in the serum were examinated by atomic absorption spectroscopy (PE-4000).

(4) After organ ratios above were measured, the heart, liver, spleen, kidney, lung, testicle, thyroid, adrenal gland, bursa of Fabricius, pancreas, ileum, duodenum, tonsil of caecum and stomachus glandularis were examinated in all the groups. The organs were fixed in 10% Formalin, buried in the wax, stained in HE and examimed under the light microscope.

(5) Statistical analyses: The analyses of variance, test of significance and differences between means.

Results

1. The weight, respiratory, heart beat and temperature

There were no differences between the treated and the control groups in respiratory, heart beat and temperature (table 1). The appetite of the chickens in 2000 mg/kg group was affected a little. Other abnormal behaviors were not detected in all the groups.

2. The ratios of the organ to carcass weight (table 2).

The diet containing the 2000 mg/kg had a great effect on the liver. There was a significant difference between the liver ratios of the control and the 2000 mg/kg groups ($p < 0.01$). The ratios of the adrenal gland and thyroid were respectively 31% lower and 28% higher than that of the control group, between those the significant difference was found ($p < 0.05$).

The special pathologic changes were not found on the shape, colour and quality of chicken bodies and organs in the anatomic observation, but some of chickens in the 2000 mg/kg group had the serious pericarditis.

3. The content of mineral elements in the serum

There was a significant difference between the content of Ca in the serum of the 2000 mg/kg and the control groups ($p < 0.05$) (table 3). The contents of Mn in the serum of all the treated groups are higher than that of the control group ($p < 0.01$). The contents of Zn in the serum of the 200 mg/kg group were about 40% higher than that of the control ($p < 0.05$). The contents of

TABLE 1. EFFECTS OF REN ON WEIGHT, RESPIRATORY, HEART BEAT AND TEMPERATURE OF CHICKENS

	Number	Sex	Initial weight (g)	Final weight (g)	Weight gain (g)	Respiratory (/min)	Heart beat (/min)	Temperature (℃)
Control	3	M	1958	3488	1530	21	199	41.0
	3	F	1824	3200	1376	23	198	41.1
20 mg REN/kg	3	M	1882	3380	1498	21	178	41.7
	3	F	1756	3032	1276	25	194	41.2
200 mg REN/kg	3	M	1932	3500	1568	25	188	41.5
	3	F	1964	2997	1233	24	198	41.0
2000 mg REN/kg	3	M	1836	3267	1431	21	182	41.0
	3	F	1636	3100	1464	18	192	40.5

TABLE 2. RATIOS OF INTERNAL ORGANS' OF CHICKENS (%)

	Control	20 mg REN/kg	200 mg REN/kg	2000 mg REN/kg
Carcass weight (kg)	2.30	2.25	2.25	2.10
Heart	6.68	6.02	6.18	8.21
Liver	18.71	20.45	19.83	25.96**
Spleen	2.18	2.29	2.02	2.74
Lung	7.69	8.95	9.95	8.89
Testicle	6.65	5.15	3.90	4.71
Adrenal gland	0.059	0.050	0.051	0.041*
Thyroid	0.109	0.128	0.111	0.139*
Kidney	9.25	9.56	8.81	10.48
Bursa of Fabricius	0.59	0.66	0.41	0.52

' Means of six animals/treatment. Was measure as organ weight/carcass weight × 1000.
* $p < 0.05$, ** $p < 0.01$.

TABLE 3. CONTENTS OF MINERAL ELEMENTS IN SERUMS OF CHICKENS (mg / kg)

	Number	K	Na	Ca	Mg	Mn (μg/kg)	Zn	Fe	Cu
Control	6	81.6	182.5	24.1	7.1	26	1.65	2.97	0.176
20 mg REN/kg	6	74.8	188.5	24.7	7.3	42**	1.95	2.79	0.194
200 mg REN/kg	6	77.1	189.6	28.5	7.5	70**	2.76*	3.75	0.226*
2000 mg REN/kg	6	62.9	174.8	33.5*	7.6	113**	2.75	4.09	0.263*

* $p < 0.05$, ** $p < 0.01$.

Cu in the serum of the 200 and 2000 mg/kg groups were significantly higher than that of the control ($p < 0.05$).

4. The examination of organ tissue slices

In the test, slices of thirteen organs were examined. There were light fatty hearts in a part of chickens of the control group.

It was discovered that a few chickens from the 20 and 200 mg/kg groups were afflicted with the light pericarditis, carditis and light interstitial inflammation of liver. These pathologic changes

belong to the natural disease. There are no significant difference between the pathologic changes of the control and 20, 200 mg/kg groups.

Serious pathologic changes of internal organs were found in a part of 2000 mg/kg group. Some hearts were afflicted seriously with pericarditis and carditis. As for kidneys, the necrosis of epithelium cells on the nephric tubule was discovered. There were cell necrosis or dissolution in the thyroids. At the same time, small acinus were increased in thyroids. The liver showed the change of the fatty liver. There are significant differences between the changes of heart, kidney and thyroid of the 2000 mg/kg group and the control group (table 4).

TABLE 4. RIDIT ANALYSES OF SLICE EXAMINATION OF PATHOLOGIC TISSUES[1]

	Number	Control	1	2	3	Significance
Heart	24	0.281[2]	0.472	0.479	0.768*	$p < 0.05$
Liver	24	0.257	0.518	0.580	0.646	NS[3]
Lung	24	0.541	0.541	0.458	0.458	NS
Kidney	24	0.292	0.417	0.458	0.833**	$p < 0.01$
Pancreas	24	0.417	0.417	0.576	0.590	NS
Stomachus glandularis	24	0.500	0.500	0.500	0.500	NS
Duodenum	24	0.479	0.479	0.419	0.562	NS
Ileum	24	0.500	0.500	0.500	0.500	NS
Tonsil of caecum	24	0.542	0.458	0.375	0.625	NS
Testicle	11	0.546	0.318	0.318	0.834	NS
Thyroid	21	0.262	0.443	0.488	0.809*	$p < 0.05$
Adrenal gland	23	0.460	0.356	0.457	0.722	NS
Bursa of Fabricius	20	0.456	0.350	0.465	0.683	NS

[1] Group 1,2,3 is respectively 20, 200, 2000 mg REN/kg group.
[2] Mean ridit value of group.
[3] NS-Nonsignificant ($p > 0.05$).

Discussion

1. Effects of REN on livers

The pathologic changes of the fatty liver were found in a part of chickens of the 2000 mg/kg group in the test, and the liver ratios in the 2000 mg/kg was higher than those of the control.

It was reported that the toxicity funtion of RE occurred mainly in the liver (Chen et al., 1989). The fatty liver is the main pathologic change effected by RE. Its causes are probablely as follows: A. The intensification of the esterolysis of glucerol 3-phosphate might result in an increase of the synthesis of the free fatty acid of glycerol 3-phosphate; B. The fat might be transfered immediately from the storage; C. The fat oxidated might be inhibited in the chondriosome.

2. Effects of RE on other organs

The special changes of all the organs were not found in the chickens receiving the diet of 20 and 200 mg/kg in the test. When the chickens were fed with the diet containing 2000 mg/kg, pathologic changes were found in kideys, thyroids and hearts.

In the subchronic toxicity experiment of rats receiving the diet of 2000 mg/kg, Yang et al. (1985) did not find those pathologic changes of the given organs with light and electric microscope.

In the subchronic toxicity test, Dong et al. (1985) found that the kidney ratios of the male rats in 2000 mg/kg group were significantly higher than that of the control group. But the obvious pathologic changes of the kidneys were not found in the examination of the tissues. It was probably thought that after a certain amount of REN was intaken, the animal body needed to discharge continually RE through the kidney. The burden of kidneys was so heavy that kidneys had to develop for a compensative expansion.

The different effects of REN on the chickens

and rats is probablely caused by the different species they belong to, and thus the difference of their sensitivity to RE.

3. Effects of REN on the content of mineral elements in serum

The analyses Ca in the serum of the 2000 mg/kg group was higher than that of the control ($p < 0.05$). Wu reported (1984) that *in vitro* La inhibitated the adenosine triphosphatase which related with Ca through competing the actor of the enzyme.

The results of the test have shown that RE had some effects on the contents of trace elements in serums. But the cause of the change of trace elements is not clear now.

The contents of trace elements in REN were analyzed. The Zn, Cu, Fe and Mn were respectively 29.44, 2.15, 12.03 and 5.8 mg/kg in REN. If 200 mg/kg is added, the amount of Zn, Cu, Fe and Mn will increase respectively 0.0059, 0.0004, 0.0024 and 0.0012 mg/kg in the diet. Campared with the amount of trace elements in the diet, the amount added by REN is very little. So perhaps trace elements in REN used can not cause the increase of trace elements in the serum.

4. Effects of REN on the different sex

According to the literatures, the experiments have showed that there are not similar reactions between different sex animals to the RE. In the early stage research (Ji et al., 1985), some scientists found that male rats were not so obviously afflicted with fatty liver as female rats under the same treatment. When the tissues of all the treated groups were examinated in our experiment, fatty livers were found in the female chickens. The result coincides with above reports.

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