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Effects of diet with different zinc levels on growth performance and N-balance of growing mink (*Neovision vision*)

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1 SUMMARY

This study was performed to evaluate the effects of diet with different zinc (Zn) levels on nutrients digestibility, growth performance, and nitrogen (N) retention of growing mink. Seventy-five healthy male minks were selected and randomly divided into five groups with different types of diet. The diet was supplemented with 0, 50, 100, 300, and 600 ppm Zinc (as $ZnSO_4H_2O$) for 75 days. The minks had no adverse reactions, the treatment codes were Z0, Z50, Z100, Z300, and Z600. From early July to middle September, the results indicated that minks fed 100 ppm added Zn had greater average daily gain (ADG) than other treatments (*P<0.05*), average daily feed intake (ADFI) increased with dietary zinc level increasing (*P<0.05*), feed to gain ratio (F/G) were similar among all treatments (*P>0.05*). Digestibility of dry matter (DM), ether extract (EE), crude protein (CP) and crude carbohydrate (CC) were not affected by different diets (*P>0.05*). N retained was greatest in Z100 group (*P>0.05*). In contrast, Fecal N of minks was lowest in Z100 group (*P<0.05*). In conclusion, when the diet supplementation with 100 ppm Zn as $ZnSO_4$ H_2O could improve the growth performance of minks during growing period, and the optimal total Zn in diet was 119 ppm.

2 INTRODUCTION

Zn is an essential element required by animals and humans for the normal functioning of numerous biological processes. Over 70 kinds of metalloenzymes are known to require Zn for normal activity. Signs of severe zinc deficiency have been reported in rats (Hurley and Mutch, 1973), but specific evidence of Zn deficiency in mink was lacking. Wood (1962) suggested levels equivalent to 66 and 59 ppm Zn on a dry matter basis for breeder and grower diets, respectively. In practice, these levels were met without supplementation in typical Finnish mink diets, which contained 57-94 ppm Zn (Kiiskinen and Mäkelä, 1977). High concentrations of inorganic Zn had been widely used in animal diets by the animal industry to enhance growth performance, but high dietary concentrations of Zn result in large quantities of Zn excreted in the faeces (Carlson *et al*, 2004; WANG *et al*, 2012). The use of high dietary concentrations of inorganic Zn has raised some environmental concerns, in addition, Zn retention rates and bioavailability of Zn may be decreased because of high dietary

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concentrations (Heddie, 1990). Dietary Zn supplementation may have beneficial effects on growth rate of mink, but information on effect of dietary Zn on growth performance of mink is lacking, and the optimum quantity of Zn in mink's diet was not confirmed. The objective of our study was to evaluate the effects of diet with different Zn levels on growth performance, nutrient digestibility, and N-balance in growing mink and found the optimal Zn level in mink diets.

3 MATERIALS AND METHODS

The experiment was carried out at the Fur Animal Farm of the Institute of Special Animals and Plant Chinese, Academy of Agricultural Science, from 8 July to 10 September in 2013.

3.1 Animals and diets: Seventy five (75) healthy male minks were selected and randomly assigned to five experimental treatments, fifteen animals each. The experiment was preceded by a 9 days adjustment period, during which the animals were accustomed to the experimental feed. The animals were fed *ad libitum* a conventional mink feed supplied by the local feeding-kitchen, at 8:00 a.m. and 14:00 p.m. every day. The animals had free access to feed and water. Five groups of minks were fed diets supplementation with 0 ppm, 50 ppm, 100 ppm, 300 ppm and 600 ppm Zn, respectively. The treatment codes were Z0, Z50, Z100, Z300 and Z600. $ZnSO_4 H_2O$ contents [g/kg DM] of the diet were 0, 0.137, 0.275, 0.826, and 1.65, respectively. Ingredients and composition of experiment diets were shown in table 1. The body weight of minks was confirmed every 15 days during the experiment, and ADG, ADFI and F/G were calculated at the end of experiment.

Table 1: Ingredient composition and chemical compositions of the experimental diets (as DM %)

Items	Z0	Z50	Z100	Z300	Z600
Seafish mixture	43	43	43	43	43
Jarding pork	19	19	19	19	19
Chicken offal	15	15	15	15	15
Pig Liver	10	10	10	10	10
Extrusion corn	12	12	12	12	12
premix*	1	1	1	1	1
total	100	100	100	100	100
Chemical composition					
Dry matter	33.43	34.24	34.24	33.43	33.26
In dry matter					
Ash	10.67	10.56	10.51	10.68	10.69
Crude protein	37.68	37.93	37.81	38.01	37.96
Ether extract	19.22	19.26	19.21	19.26	19.23
Carbohydrates	31.97	31.64	31.91	31.71	31.65
Zn(mg/kg)	14.93	62.93	119.28	316.38	618.25
Cu(mg/kg)	17.04	18.38	17.15	17.90	18.38
Calcium	2.70	2.69	2.75	2.64	2.70
Phosphorus	1.63	1.63	1.62	1.61	1.64
Metabolizable energy (ME)					
MJ/kg DM	17.90	17.91	18.17	18.12	17.83
% from protein	34.55	35.07	34.88	35.01	35.39
% from fat	40.09	40.47	39.90	40.20	40.52
% from carbohydrates	24.53	24.44	25.20	24.78	24.07

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*The premix provides ingredient composition for per kg diet as follows: Fe (as ferrous sulphate), 82.0 mg; Cu (as copper sulphate), 6.4 mg; I (as Potassium iodide) 0.5 mg; Se (as selenium sulphate), 0.2 mg; Mn (as manganic sulphate) 120.0 mg; Co(as Cobalt chloride) 25mg. Zn (as Zinc sulphate) from Z0-Z600 were 0mg, 50mg, 100mg, 300mg and 600mg, respectively. VA ,940 IU; VD3, 250 IU; VB1, 0.2 mg; VB2, 0.5 mg; VB6, 0.3 mg; folic acid, 0.8 mg; nicotinic acid, 2 mg; D-pantothenic acid, 1.0 mg.

N-balance experiments: N-balance experiments were carried out using 9 14 weeks old kits from each treatment groups. The faeces and urine collection period lasted for four days (7 to 9 August 2013). In principle as described by Jørgensen and Glem-Hansen (1973), the animals were kept in metabolism cages, which were constructed for separate collection of faeces and urine. To prevent ammonia evaporation from the urine, 10 ml sulphuric acid (10% solution) were put into the urine collection bottles and the urine collection trays were sprayed with citric acid (10% solution) once per day. In the process of calculating the N-balance, retained N was confirmed to be ingested N-(fecal N+ urinary N).

Chemical analyses: The chemical composition of diets, faeces and urine was analyzed by standard methods. DM, ash and CP (Kjeldahl-N, 6.25), calcium, and phosphorus contents were analyzed according to AOAC (2003) procedures. CC was calculated as the difference by subtracting ash, CP and EE from the DM content. The calculation of ME content and the proportional composition of ME were based on the digestibility coefficients achieved and the following values of ME: protein 18.8 MJ /kg, fat 39.8 MJ /kg and carbohydrate 17.6MJ /kg (Hansen *et al*, 1991). The calculation of GE content was based on the average combustion values of macronutrients: protein 23.86 MJ/kg, fat 39.76 MJ/kg and carbohydrate 17.58 MJ/kg (Mikael 2012). The concentration of Zn, copper and manganese levels were determined by Atomic Absorption Atomic absorption spectrophotometry (Analytikjena NOV AA 400). Nutrient digestibility and nitrogen retention were determined by standard methods (Dahlman *et al*., 2002). The apparent digestibility (AD) of nutrients was calculated as follows: AD=a-b/a, in which "a" is nutrient intake from feed and "b" is nutrient excretion in faeces.

Statistical analyses: All data were analyzed using the GLM procedure of SAS 9.2 of Duncan's multiple range test for a randomized complete block design (SAS Institute, Cary, NC, USA, 2002). A level of $P< 0.05$ was set as the criterion for statistical significance. Data were represented as mean ± SD.

RESULTS

Growth performance: Effects of different dietary Zn levels on growth performance of minks were shown in table 2. The initial weight of minks were similar in all groups ($P>0.05$), final weight of minks were not affected by different diets ($P>0.05$), but the highest final weight was found in Z100. Group Z100 had the greater ADG than other treatments ($P<0.05$). ADFI in group Z300 and Z600 were higher than Z0 group ($P<0.05$). F/G was not affected by dietary Zn levels ($P>0.05$), but F/G of group Z100 was the lowest one. Final weight of minks was not affected by different diets ($P>0.05$).

Table 2 Effect of diet with different Zn levels on growth performance of mink

Items	Z0	Z50	Z100	Z300	Z600	p value
Initial weight (g)	824±47.73	826±58.41	823±37.48	826±57.61	826±62.76	0.9775
Final weight (kg)	1.51±0.07	1.52±0.07	1.63±0.08	1.60±0.11	1.57±0.09	0.0578
ADG (g/day DM)	10.83±1.30^{b}	10.94±1.26^{b}	12.63±1.21^{a}	12.12±1.52^{ab}	11.47±1.11^{ab}	0.0304
ADFI (g/day DM)	75.79±4.90^{b}	75.84±3.20^{b}	79.55±6.60^{ab}	85.11±3.92^{a}	84.74±3.78^{a}	0.008
F/G	6.99±0.42	6.93±0.62	6.29±0.47	7.02±0.60	7.38±0.61	0.0669

The values are the mean ± SD; for method of estimation, see text. Values within rows with different letters differ significantly ($P < 0.05$)

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Nutrition digestibility: Effects of diet with different Zn levels on nutrients digestibility in minks were shown in table 3. Apparent digestibility of DM, CP, EE, CC and GE were not affected by dietary Zn levels (P>0.05), the highest values of digestibility of DM, CP, CC and GE were found in Group Z100, the values were 81.45%, 89.20%, 81.57% and 89.76%, respectively. It was also observed that the values of digestibility of DM, CP, CC, and GE had a trend to increase early and then decrease with dietary Zn level increasing.

Table 3: Effect of diets with different Zn levels on nutrient digestibility in mink

Items	Z0	Z50	Z100	Z300	Z600	p value
Digestibility of DM (%)	79.25±6.60	79.53±2.66	81.45±3.32	80.54±3.24	79.12±3.50	0.7598
Digestibility of CP (%)	87.32±1.83	88.09±1.70	89.20±1.59	88.79±1.91	88.46±1.10	0.4449
Digestibility of EE (%)	95.76±1.17	94.58±1.13	94.87±1.24	95.04±1.73	94.42±0.93	0.3085
Digestibility of CC (%)	78.03±2.76	78.63±2.58	81.57±2.86	80.49±3.84	77.09±3.61	0.1902
Digestibility of GE (%)	89.53±2.57	88.65±1.44	89.76±0.72	89.62±1.63	88.99±2.18	0.8551

The values are the mean ± SD; for method of estimation, see text. Values within rows with different letters differ significantly (P < 0.05).

N-balance: Effects of diet with different Zn levels on N-balance of minks were shown in table 4. N intake and urinary N were significantly affected by dietary Zn supplementation (P<0.05), they were increased with dietary Zn level increasing, the highest values were in group Z600, and the lowest values were in Z0. Fecal N and N retained were not significantly affected by dietary Zn level (P>0.05), but the lowest fecal N and the highest N retained were all in group Z100, the values were 0.54g/d, and 2.39 g/d per mink, respectively.

Table 4 Effect of diet with different Zn levels on N-balance of mink

Items	Z0	Z50	Z100	Z300	Z600	p value
N intake (g/day)	4.64±0.32^{b}	4.49±0.19^{b}	4.79±0.39^{ab}	5.13±0.24^{a}	5.16±0.41^{a}	0.0112
Fecal N (g/day)	0.68±0.26	0.55±0.11	0.54±0.12	0.60±0.11	0.56±0.10	0.5465
Urinary N (g/day)	1.67±0.27^{b}	1.75±0.35^{b}	1.84±0.40^{ab}	2.26±0.35^{a}	2.31±0.36^{a}	0.0199
N retained (g/day)	2.27±0.22	2.19±0.28	2.39±0.32	2.26±0.27	2.29±0.38	0.8606

The values are the mean ± SD; for method of estimation, see text. Values within rows with different letters differ significantly (P < 0.05).

DISCUSSIONS

Growth performance: Zn is considered critically important in maintaining the structure of metalloproteins such as insulin and growth hormone. Zinc deficiency primarily affects protein metabolism in fast-growing animals (Swinkels *et al.*, 1994). Especially, the influence of supplementation of Zn ($ZnSO_4H_2O$) and 100ppm Zn on protein metabolism was higher than other relative groups. Hahn and Baker (1993) reported the similar findings that ADG and ADFI were increased 17% and 14% respectively in pigs supplemented with 3,000 ppm Zn, which also occurred in other non-ruminant

animals. Earlier studies demonstrated that ADG and ADFI both were increased by ZnO in weanling (Shelton *et al*., 2008) and nursery pigs (Case *et al*., 2002). Wood (1962) suggested that the zinc on a dry matter basis for breeder and grower diets in mink should be equivalent to 66 and 59 ppm, but this study results showed that ADG in Z100 was significantly higher than that in Z50. The results were consistent with the published report by Walk (2013), in their experiments, the influence of zinc on ADFI had a larger scale than ADG. The results of F/G indicated that Z100 was significantly greater than other groups, feed consumption appeared to be less than the effect on growth rate and was reflected in a large decrease in feed efficiency. This effect had also been observed in other species (Brink *et al*., 1959; Ott *et al*., 1966). As other trials reported, supplementing diet with zinc may enhance the growth performance of animals (Chaudhar *et al*., 2009; El-Nour *et al*., 2010; Lai *et al*., 2010; Mohanna and Nys, 1999). Results from this study indicated that supplementation of 100 ppm Zn was sufficient to get an optimal growth performance in minks.

Nutrition digestibility: Zinc is considered to be an antioxidant, which has a protective role on pancreatic tissues against oxidative damage (Pond, 1995; Muhittin, 2003). They can enhance the function of pancreas, such as secretions of digestive enzymes, therefore improving the digestibility of nutrients. In this study, the apparent digestibility of DM and CP were not dependent on the Zn level of the diets. Similar results were obtained on the study of cashmere goat by Wen *et al.*(2008), on pigs by Han *et al* (2009), and the similar findings had also been reported in Holstein calves (Ivan *et al*, 1975) and male buffalo calves (Jadhav, 2005), supplemental Zn had no effects on the digestibility of nutrients in these animals. It was also been reported that there was no difference in the digestibility of nutrients in broiler chickens supplemented with 100 ppm Zn as Zn-methionine (Zn-Met) chelate (Hong *et al*., 2002). Digestibility of EE was not dependent on dietary zinc level, which was unexpected. The research by Chen *et al* (1996) and Kennedy *et al*. (1987) pointed out that dietary zinc could improve the utilization of animal fat, however, our results showed there were no significantly differences between each group, and the highest one was group Z100.

N-balance: In this experiment, the CP, EE, CC and GE were similar among all groups. The ADFI and N intake were mainly affected by Zn levels of diets. In the meantime, this experiment observed that Urinary N went up with the dietary zinc increasing, which was identical with the tendency of N intake, and in according with Pfeiffer (1995) and Kerr (1995), research results that there was a correlation between protein intake and urinary N. In this experiment, the amount of urinary N was close to 36%-44% of N intake; the result was different from Newell (1999) research of 80%, which may be caused by different feed composition and animal rearing environment. This study results indicated that the dietary Zn levels had no significant effects on N retention. The values of N retention were from 2.19 to 2.39 g/d where the highest one was in group Z100, and the lowest one s appeared in group Z50. This indicated that low levels of dietary Zn had lesser advantage in N retention. Similar results were obtained in early study by B. Rodriguez *et al* (1995). Wen *et al* (2008) also reported that low level zinc in the diets had no beneficial effects on N retention. The responses of minks in both N retention and growth performance to zinc showed that the quantity of 119.28mg/ kg (DM) in diet was enough for mink during the growing period.

CONCLUSION

Our results indicated that dietary Zn levels did not significantly affect the nutrients apparent digestibility of mink. N intake and urinary N were increased with dietary Zn level increasing; the lowest faeces N and the highest N retention were all in group Z100. Overall, in fur farm, the diet supplementation with 100 ppm Zn was optimal to the mink growth during the growing period, with the dietary total Zn being 119.28mg/kg. Furthermore, the faeces N could be decreased emission to the environment.

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