Effects of Dietary Vitamin E and Selenium Supplementation on Growth Performance, Nutrient Digestibility, and Serum Biochemical Parameters in Growing Mink (Postprint)

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Abstract

This experiment aimed to investigate the effects of dietary vitamin E (VE) and selenium (Se) supplementation on growth performance, nutrient digestibility, and serum biochemical indices in growing mink. Sixty healthy male short-haired black mink at 70 days of age with an average body weight of (1 030.64±85.50) g were selected and randomly divided into 4 groups with 15 replicates per group and 1 mink per replicate, and fed a basal diet (control group), basal diet + 200 mg/kg VE (with DL- -tocopheryl acetate as the VE source at 50% concentration) (VE group), basal diet + 0.2 mg/kg Se (with glycine nano-selenium as the Se source at 1% concentration) (Se group), or basal diet + 200 mg/kg VE + 0.2 mg/kg Se (VE+Se group). The experiment lasted from July 14, 2017 to September 14, 2017. The results showed that: 1) Compared with the control group, mink in the VE and VE+Se groups exhibited significantly increased average daily gain and decreased feed-to-gain ratio ($P<0.05$). 2) The fat digestibility of mink in the VE+Se group was extremely significantly higher than that in the control group ($P<0.01$), but showed no significant difference from the VE and Se groups ($P>0.05$). 3) Serum superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) activities in mink from the VE+Se group were significantly or extremely significantly higher than those in the control group ($P<0.05$ or $P<0.01$), but showed no significant difference from the VE and Se groups ($P>0.05$); compared with the control group, dietary VE supplementation alone or combined VE and Se supplementation extremely significantly decreased serum reactive oxygen species (ROS) levels in mink ($P<0.01$). 4) Serum immunoglobulin G (IgG) levels in mink from the VE+Se group were significantly higher than those in the VE and Se groups ($P<0.05$), but showed no significant difference from the control group ($P>0.05$). Compared with the control group, simultaneous dietary supplementation of VE and Se significantly increased serum interleukin-2 (IL-2) levels in mink (P<0.05). In conclusion, under the conditions of this experiment, simultaneous dietary supplementation of 200 mg/kg VE and 0.2 mg/kg Se promoted growth, improved fat digestibility, and enhanced antioxidant capacity and immunity in growing mink.

Full Text

Effects of Dietary Vitamin E and Selenium on Growth Performance, Nutrient Digestibility, and Serum Biochemical Indices of Growing Minks

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Abstract

This experiment investigated the effects of dietary vitamin E (VE) and selenium (Se) supplementation on growth performance, nutrient digestibility, and serum biochemical indices in growing minks. Sixty healthy male standard dark minks at 70 days of age, with an average body weight of (1,030.64±85.50) g, were randomly allocated into four groups (15 replicates per group, one mink per replicate). The four dietary treatments consisted of a basal diet (control group), basal diet supplemented with 200 mg/kg VE (VE group, using DL- -tocopheryl acetate at 50% concentration), basal diet supplemented with 0.2 mg/kg Se (Se group, using glycine nano-selenium at 1% concentration), and basal diet supplemented with both 200 mg/kg VE and 0.2 mg/kg Se (VE+Se group). The trial ran from July 14, 2017, to September 14, 2017.

The results showed: (1) Compared with the control group, both the VE and VE+Se groups exhibited significantly increased average daily gain (ADG) and decreased feed-to-gain ratio (F/G) (P<0.05). (2) The VE+Se group demonstrated extremely significantly higher fat digestibility than the control group (P<0.01), though this did not differ significantly from the VE or Se groups (P>0.05). (3) Serum superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) activities in the VE+Se group were significantly or extremely significantly higher than in the control group (P<0.05 or P<0.01), but showed no significant differences compared with the VE and Se groups (P>0.05). Dietary supplementation with VE alone or combined VE and Se extremely significantly reduced serum reactive oxygen species (ROS) levels compared with the control group (P<0.01). (4) Serum immunoglobulin G (IgG) levels in the VE+Se group were significantly higher than in the VE and Se groups (P<0.05), but did not differ significantly from the control group (P>0.05). Simultaneous supplementation with VE and Se significantly increased serum interleukin-2 (IL-2) levels compared with the control group (P<0.05).

In conclusion, under the conditions of this experiment, dietary supplementation with 200 mg/kg VE and 0.2 mg/kg Se simultaneously promoted growth, improved fat digestibility, and enhanced antioxidant capacity and immune function in growing minks.

Keywords: minks; vitamin E; selenium; growth performance; nutrient digestibility; serum biochemical indices

Introduction

Minks are carnivorous animals, and feeding high-fat diets is beneficial for improving their growth performance [1]. Fish oil, chicken fat, and soybean oil are primary sources of dietary fat for minks, but these contain high levels of unsaturated fatty acids that are prone to oxidation. Børsting et al. [2] found that feeding minks diets containing oxidized fish oil reduced feed intake and significantly decreased growth performance. Tauson et al. [3] reported that consumption of feed ingredients with oxidized fatty acids compromised fur quality in minks. Vitamin E (VE) and selenium (Se) are essential nutrients that play crucial roles in antioxidant defense, immunity, and production performance, and are commonly used antioxidants in livestock feed. Liu [4] reported that supplementing finishing pig diets with 0.3 mg/kg Se or 100 mg/kg VE improved antioxidant capacity, with the best results observed when both were added simultaneously. Tan et al. [5] demonstrated that dietary supplementation with 1.0–2.0 mg/kg Se and 83.32–166.64 IU VE not only improved laying hen performance but also substantially increased Se and VE deposition in eggs. However, research on VE and Se requirements for minks remains limited. Stowe et al. [6] indicated that 25 mg/kg dietary VE was adequate when lard was the fat source, while Treuthardt [7] recommended 200–300 mg/kg VE for mink diets rich in fish byproducts. The NRC (1982) [8] recommended 0.1 mg/kg Se supplementation for mink diets. Using chicken fat as the primary fat source, this study investigated the effects of VE and Se supplementation in dry powder diets on growth performance, nutrient digestibility, and serum biochemical indices in growing minks to provide theoretical support for enriching the nutrient requirement database for minks in China.

1. Materials and Methods

1.1 Experimental Design and Animal Management Sixty healthy male standard dark minks at 70 days of age, with an average body weight of (1,030.64±85.50) g, were randomly divided into four groups with 15 replicates per group (one mink per replicate). The dietary treatments were: basal diet (control group), basal diet + 200 mg/kg VE (using DL- -tocopheryl acetate at 50% concentration) (VE group), basal diet + 0.2 mg/kg Se (using glycine nano-selenium at 1% concentration) (Se group), and basal diet + 200 mg/kg

VE + 0.2 mg/kg Se (VE+Se group). The basal diet was formulated with extruded corn, Peruvian fish meal, meat meal, soybean meal, and poultry fat as main ingredients, supplemented with nutritional additives including minerals and vitamins. The composition and nutrient levels of the basal diet are shown in Table 1 . Poultry fat, purchased from Binzhou Aoda Feed Company in Shandong Province, served as the primary fat source (acid value 3 mg KOH/g, peroxide value 5 mmol/kg). To prevent oxidation due to hot weather, all experimental diets were stored in a cold storage facility and fed fresh daily.

The trial ran from July 14, 2017, to September 14, 2017. The entire experiment was conducted under natural outdoor lighting conditions. Animals were fed by specialized personnel twice daily (morning and evening) with ad libitum access to feed and water. Initial body weight was recorded as the fasting weight on the first day of the formal trial, and final body weight was recorded at the end of the trial to calculate individual daily gain and group average daily gain (ADG). Daily feed consumption was recorded per group to calculate average daily feed intake (ADFI). Feed-to-gain ratio (F/G) was calculated based on ADG and ADFI for each group.

1.2 Sample Collection A digestion-metabolism trial was conducted from August 24–26, 2017. Eight minks with normal feed intake and fecal excretion were selected from each group. The total feces collection method was used to collect feces and urine for three consecutive days. Before urine collection, 10 mL of 10% sulfuric acid was added to collection buckets to fix nitrogen. Urine samples from each mink were mixed, filtered, and aliquoted into 10 mL centrifuge tubes, then stored at -20°C. Fecal samples from each mink were mixed and divided into two portions: one portion was sterilized at 80°C for 2 hours, then dried at 65–70°C to constant weight to determine initial moisture content. The dried fecal samples were ground through a 0.45 mm (40-mesh) sieve for crude fat determination. The other portion of fresh feces was treated with 10% sulfuric acid, dried at 100–105°C, ground through a 0.45 mm (40-mesh) sieve, and used for crude protein determination.

At the end of the feeding trial, eight minks from each group were selected for blood collection. Four milliliters of blood were collected via toe clipping into disposable vacuum coagulation-promoting tubes. After serum separation, samples were centrifuged at 4,500 rpm for 7 minutes at 4°C, and serum was collected and stored at -80°C.

1.3 Measurements Crude protein content was determined using an automatic Kjeldahl analyzer (FOSS Kjeltec 8400, Denmark) according to GB/T 6432–1994. Crude fat content was measured using a fat extraction apparatus (BUCHI B-81, USA) following GB/T 6433–1994. Crude ash content was determined according to GB/T 6438–92. Calcium content was measured by EDTA complexometric titration (GB/T 6436–1992). Phosphorus content was determined by ammonium vanadomolybdate colorimetry (GB/T 6437–1992). Lysine and methionine contents were analyzed using an amino acid analyzer (Hitachi L-8900, Japan) according to GB/T 5009.124–2003. VE content was measured by high-performance liquid chromatography (Agilent 1200, USA) following GB/T 9454–2000. Se content was determined by atomic fluorescence spectrometry (AFS 9130, China) according to Li [9].

Serum glutathione peroxidase (GSH-Px), superoxide dismutase (SOD) activities, malondialdehyde (MDA) content, and total antioxidant capacity (T-AOC) were measured using a UV-visible spectrophotometer (SPECORD S600, Germany) with assay kits purchased from Nanjing Jiancheng Bioengineering Institute, following the kit instructions. Serum reactive oxygen species (ROS), immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM), interleukin-2 (IL-2), interleukin-6 (IL-6), tumor necrosis factor- (TNF-), thyroxine (T4), triiodothyronine (T3), growth hormone (GH), and insulin-like growth factor-1 (IGF-1) levels were determined using a multifunctional microplate reader (Molecular Devices FilterMax F3/F5, USA) with assay kits from Shanghai Shuangying Biological Technology Co., Ltd., following the kit instructions.

1.4 Statistical Analysis Experimental data were organized using Excel 2003 and analyzed using the General Linear Model (GLM) procedure in SAS 8.0 software. Multiple comparisons were performed using Duncan's method. Differences were considered extremely significant at $P<0.01$, significant at $P<0.05$, and not significant at $P>0.05$. Results are expressed as mean ± standard deviation.

2. Results

2.1 Effects of Dietary VE and Se on Growth Performance of Growing Minks As shown in Table 2 , dietary supplementation with VE alone or combined VE and Se significantly increased ADG and significantly decreased F/G compared with the control group ($P<0.05$). No significant differences were observed in final body weight or ADFI among groups ($P>0.05$).

2.2 Effects of Dietary VE and Se on Nutrient Digestibility and Nitrogen Metabolism Table 3 shows that simultaneous supplementation with VE and Se extremely significantly improved fat digestibility compared with the control group ($P<0.01$). No significant differences were found among groups in dry matter digestibility, protein digestibility, nitrogen intake, urinary nitrogen, fecal nitrogen, or nitrogen retention ($P>0.05$).

2.3 Effects of Dietary VE and Se on Serum Antioxidant Indices As presented in Table 4 , serum SOD and GSH-Px activities in the VE+Se group were significantly or extremely significantly higher than in the control group ($P<0.05$ or $P<0.01$), but did not differ significantly from the VE or Se groups ($P>0.05$). Dietary supplementation with VE alone or combined VE and Se extremely significantly reduced serum ROS levels compared with the control group (P<0.01). No significant differences were observed among groups in serum MDA content or T-AOC (P>0.05).

2.4 Effects of Dietary VE and Se on Serum Immune Indices Table 5 indicates that serum IgG levels in the VE+Se group were significantly higher than in the VE and Se groups (P<0.05), but showed no significant difference from the control group (P>0.05). Combined VE and Se supplementation significantly increased serum IL-2 levels compared with the control group (P<0.05). No significant differences were detected among groups in serum IgA, IgM, IL-6, or TNF- levels (P>0.05).

2.5 Effects of Dietary VE and Se on Serum Hormone Levels As shown in Table 6 , no significant differences were observed among groups in serum T3, T4, GH, or IGF-1 levels (P>0.05).

3. Discussion

3.1 Effects of Dietary VE and Se on Growth Performance of Growing Minks VE is an essential component of the antioxidant defense system and plays an important role in animal growth by participating in key enzymatic reactions [10]. Ebeid et al. [11] reported that dietary VE supplementation significantly improved final weight and feed conversion ratio in young rabbits. Guo et al. [12] found that adding 100 mg/kg VE to diets significantly increased body weight and feed conversion ratio in broiler chickens aged 1–21 days. Liu [4] observed that VE supplementation improved production performance in finishing pigs during both 60–80 kg and 80–110 kg phases. In the present study, dietary VE supplementation also significantly improved growth performance in growing minks, possibly because the complex intestinal environment in minks exposes enterocytes to dietary peroxides and endogenous ROS, which can cause oxidative damage to intestinal cell membranes and impair their function. Particularly during the post-weaning period, minks show reduced mucus-staining areas in the intestine, making them susceptible to pathogen infection and oxidative stress damage [13]. As an antioxidant, VE can directly donate electrons to block free radical chain reactions, protecting intestinal mucosa from oxidative damage and pathogen infection, thereby improving nutrient digestion and utilization [14,15]. Se is an essential trace element for animals, and its growth-promoting effects have been extensively studied in livestock with inconsistent results. Feng [16] reported that dietary Se supplementation at 0.08–0.16 mg/kg improved growth performance in growing ducks. Ma [17] found that dietary Se level had no significant effect on growth performance in cashmere goat kids. Under the conditions of this experiment, supplementation with 0.2 mg/kg Se did not significantly affect growth performance in growing minks, suggesting that the basal dietary Se level (0.48 mg/kg) may have met the basic growth requirements for this species.

3.2 Effects of Dietary VE and Se on Nutrient Digestibility and Nitrogen Metabolism Limited research has been reported on the effects of VE and Se on nutrient digestibility and nitrogen metabolism in livestock, with inconsistent conclusions. Zhang et al. [18] found that dietary supplementation with 0.3 mg/kg Se and 30 IU/kg VE improved dry matter and protein apparent digestibility and nitrogen retention in beef cattle. Liu [4] reported that dietary VE and Se supplementation had no significant effect on nutrient digestibility in finishing pigs. In this experiment, simultaneous supplementation with VE and Se significantly improved fat digestibility in growing minks, which may be related to VE' s regulation of genes involved in fat metabolism. González-Calvo et al. [19] found that VE supplementation significantly increased peroxisome proliferator-activated receptor- gene expression in subcutaneous adipose tissue of lambs. Additionally, VE and Se may protect intestinal mucosa from attack by free radicals and pathogens through their antioxidant properties, thereby maintaining intestinal digestive and absorptive functions.

3.3 Effects of Dietary VE and Se on Serum Antioxidant Indices As antioxidants, VE and Se regulate antioxidant capacity through related enzymes. SOD and GSH-Px are important free radical-scavenging enzymes, and their activities objectively reflect the antioxidant capacity of the organism. Chen et al. [20] reported that dietary Se supplementation significantly increased serum SOD activity in 21-day-old piglets. Ebeid et al. [11] found that combined dietary VE and Se supplementation significantly increased serum GSH-Px activity in meat rabbits. Yuan [21] reported that high-level VE and appropriate Se supplementation significantly increased serum SOD and GSH-Px activities in laying ducks. The present results are consistent with these findings, showing that combined VE and Se supplementation significantly increased serum SOD and GSH-Px activities in growing minks. ROS refers to oxygen-containing molecules with high chemical reactivity. Under physiological conditions, a balance exists between ROS formation and endogenous antioxidant clearance. Various stimuli can cause ROS production to exceed clearance capacity, resulting in oxidative damage such as lipid peroxidation, altered biological membrane structure and function, and DNA damage. In this experiment, dietary VE supplementation alone or combined with Se reduced serum ROS levels in minks, consistent with findings in ruminants by Baldi et al. [22] and Colitti et al. [23].

3.4 Effects of Dietary VE and Se on Serum Immune Indices VE and Se are crucial for immune function and have immune-enhancing effects in the diets of various animals, including humans. As antioxidants, their effects on immune response may be mediated by protecting immune cells and surrounding tissues from oxidative stress damage, thereby maintaining the integrity and normal physiological function of immune cells and tissues [24]. In humoral immunity, VE and Se stimulate specific humoral immune responses, promoting immunoglobulin synthesis such as IgG and IgM. In cellular immunity, they stimulate the production of high-affinity T cell IL-2 receptors, thereby increasing IL-2 secretion [25,26]. Zhang [27] investigated the effects of VE and Se on immune function in Gushi chickens under immune stress, reporting that supplementation at 0.6 mg/kg Se and 100-200 mg/kg VE effectively reduced inflammatory factor levels and improved immune function. The present results showed that combined VE and Se supplementation significantly increased serum IL-2 levels in growing minks, and serum IgG levels in the VE+Se group were significantly higher than in the Se and VE groups alone, demonstrating a synergistic effect of VE and Se in improving immune function in growing minks.

3.5 Effects of Dietary VE and Se on Serum Hormone Levels Se is a component of iodothyronine deiodinase enzymes and plays an important role in T4 metabolism. T4 participates widely in nutrient metabolism, promoting growth and tissue development. T3 is one of the factors regulating pentose phosphate cycle enzymes and promotes fatty acid synthesis and transcription of key enzymes. T3 increases insulin RNA content and insulin levels, promoting muscle protein synthesis and turnover, and controls GH gene expression and synthesis. Se deficiency can decrease type I deiodinase activity, reducing the conversion rate of T4 to T3 and causing increased blood T4 and decreased T3 levels [28]. Hezarjaribi et al. [29] reported that intramuscular injection of 0.3 mg/kg BW VE in broilers significantly increased serum T3 levels. Liu et al. [30] also found that Se deficiency in chickens decreased blood T3 and increased T4 levels, with T3 levels tending to increase as Se levels rose. However, the present study found no significant effects of dietary VE and Se supplementation on serum T3, T4, GH, or IGF-1 levels in growing minks, suggesting that the specific mechanisms require further investigation.

4. Conclusion

Under the conditions of this experiment, dietary supplementation with 200 mg/kg VE and 0.2 mg/kg Se simultaneously promoted growth, improved fat digestibility, and enhanced antioxidant capacity and immune function in growing minks.

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Note: Figure translations are in progress. See original paper for figures.