

Effects of Ginseng Polysaccharides on Growth Performance, Nutrient Digestibility, Nitrogen Metabolism, and Serum Biochemical Indices in Growing Male Mink (Postprint)

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Abstract

This experiment was conducted to investigate the effects of ginseng polysaccharides on growth performance, nutrient digestibility, nitrogen metabolism, and serum biochemical indices of growing male mink. A single-factor experimental design was adopted, in which forty healthy male mink at 70 days of age with similar body weight were randomly allocated into 4 groups, with 10 replicates per group and 1 mink per replicate. Group I (control) was fed a basal diet, while groups II, III, and IV were fed the basal diet supplemented with 10, 50, and 100 mg/kg of ginseng polysaccharides (on a dry matter basis), respectively. The experiment consisted of a 7-day preliminary period followed by a 60-day formal experimental period. The results showed that: 1) The final body weight (at 130 days of age) and average daily gain of group IV were significantly higher than those of the control group ($P < 0.05$); the feed-to-gain ratio decreased gradually with increasing ginseng polysaccharide supplementation levels across all groups, with group IV being significantly lower than the control and group II ($P < 0.05$). 2) Dry matter excretion in group IV was extremely significantly lower than that in the control group and group II ($P < 0.01$); dry matter digestibility and crude protein digestibility in groups III and IV were significantly or extremely significantly higher than those in the control group ($P < 0.05$ or $P < 0.01$), while no significant differences in crude fat digestibility were observed among all groups ($P > 0.05$). 3) No significant differences were found in nitrogen intake, fecal nitrogen, urinary nitrogen, or nitrogen retention among all groups ($P > 0.05$); net protein utilization increased gradually with increasing ginseng polysaccharide supplementation levels, with group IV being significantly higher than the control group ($P < 0.05$). 4) Serum albumin content in groups II, III, and IV was extremely significantly higher than that in the control group ($P < 0.01$); serum

total protein, globulin, and immunoglobulin M contents in group IV were significantly higher than those in the control group ($P < 0.05$), while no significant differences in serum immunoglobulin G, immunoglobulin A, total cholesterol, triglyceride, or glucose contents were observed among all groups ($P > 0.05$). In conclusion, dietary supplementation with ginseng polysaccharides can improve net protein utilization in growing male mink, thereby enhancing dry matter and crude protein digestibility, regulating serum immunoglobulin M content, boosting immunity, and improving growth performance.

Full Text

Effects of Ginseng Polysaccharide on Growth Performance, Nutrient Digestibility, Nitrogen Metabolism and Serum Biochemical Indices of Male Minks during the Growing Period

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Abstract

This experiment investigated the effects of ginseng polysaccharide on growth performance, nutrient digestibility, nitrogen metabolism, and serum biochemical indices in male minks during the growing period. Using a single-factor design, forty healthy 70-day-old male minks with similar body weight were randomly allocated into four groups, each comprising ten replicates with one mink per replicate. Group I (control) received a basal diet, while groups II, III, and IV received the basal diet supplemented with 10, 50, and 100 mg/kg ginseng polysaccharide (dry matter basis), respectively. The experiment consisted of a 7-day pre-feeding period followed by a 60-day formal feeding period. The results demonstrated: (1) Group IV exhibited significantly higher final body weight (at 130 days of age) and average daily gain compared to the control group ($P < 0.05$), with feed-to-gain ratio decreasing progressively as ginseng polysaccharide supplementation increased, and group IV showing a significantly lower ratio than both the control and group II ($P < 0.05$). (2) Dry matter output in group IV was significantly lower than in the control and group II ($P < 0.01$), while dry matter and crude protein digestibility in groups III and IV were significantly or extremely significantly higher than in the control group ($P < 0.05$ or $P < 0.01$); no significant differences were observed in crude fat digestibility among groups ($P > 0.05$). (3) No significant differences were detected among groups in nitrogen

intake, fecal nitrogen, urinary nitrogen, or nitrogen retention ($P>0.05$); however, net protein utilization increased progressively with ginseng polysaccharide supplementation, with group IV showing significantly higher values than the control group ($P<0.05$). (4) Serum albumin content in groups II, III, and IV was extremely significantly higher than in the control group ($P<0.01$), while serum total protein, globulin, and immunoglobulin M contents in group IV were significantly higher than in the control group ($P<0.05$); no significant differences were observed among groups in serum immunoglobulin G, immunoglobulin A, total cholesterol, triglycerides, or glucose contents ($P>0.05$). In conclusion, dietary supplementation with ginseng polysaccharide can enhance net protein utilization in growing male minks, thereby improving dry matter and crude protein digestibility, modulating serum immunoglobulin M levels, boosting immunity, and ultimately enhancing growth performance.

Keywords: ginseng polysaccharide; minks; growth performance; nutrient digestibility; serum biochemical indices

Introduction

Minks (*Mustela vison*) belong to the family Mustelidae, order Carnivora, class Mammalia, and are valued primarily for their fur. As carnivorous animals with relatively short intestinal tracts, minks have rapid food transit times and short gut emptying cycles. Their diet consists predominantly of animal-based feed ingredients (approximately 70%), with cereal ingredients accounting for less than 30% [1]. The digestive enzymes in the mink gastrointestinal tract are primarily proteases and lipases, with limited quantities of other digestive enzymes. The gut harbors a substantial microbial community, predominantly bacteria, along with archaea and parasites, that participates in auxiliary digestion, particularly in the large intestine [2]. Since mink size directly influences pelt dimensions and thus economic returns, improving body weight and feed digestibility represents a critical research priority. Polysaccharides exhibit prebiotic effects, and identifying substances that can modulate nutrient digestibility and promote growth would significantly enhance the economic viability of mink farming. Previous studies have demonstrated that polysaccharides and oligosaccharides such as xylan, fructooligosaccharides (FOS), and astragalus polysaccharide possess prebiotic properties, making them promising feed additive candidates [3]. Wang et al. [4] reported that dietary supplementation with 0.9% FOS in growing minks could replace 150 mg/kg oxytetracycline. Ginseng polysaccharide (GPS), a primary bioactive component of ginseng, exhibits immunoenhancing, antitumor, anti-aging, and anti-radiation effects [5]. Compared to other common polysaccharides (e.g., ganoderma, astragalus, and lentinan polysaccharides), GPS is characterized by high starch content and complex pectin structures [6]. GPS has been shown to modulate immune activity, with GPS complexes enhancing superoxide dismutase (SOD) activity in the hepatopancreas of *Litopenaeus vannamei* and boosting immunity [7]. This study aimed to evaluate the effects of

GPS supplementation in mink diets on growth performance, nutrient digestibility, nitrogen metabolism, and serum biochemical indices, thereby providing theoretical support for the application of GPS as a functional feed additive in fur-bearing animals.

Materials and Methods

1.1 Experimental Material

Ginseng polysaccharide was provided by the Medicinal Plant Resources Innovation Team at the Institute of Special Animal and Plant Sciences, Chinese Academy of Agricultural Sciences. The polysaccharide was extracted from dried ginseng roots through soaking, hot water extraction, and two rounds of ethanol precipitation, yielding a 10% extraction rate. Using glucose as the standard, the total carbohydrate content of GPS was determined to be 90% by the phenol-sulfuric acid method [8].

1.2 Experimental Design and Management

Forty healthy 70-day-old male short-haired black minks with an average body weight of (1.05 ± 0.09) kg were randomly divided into four groups, each consisting of ten replicates with one mink per replicate. Initial body weights did not differ significantly among groups ($P > 0.05$). The experiment employed a single-factor design: group I (control) received the basal diet, while groups II, III, and IV received the basal diet supplemented with 10, 50, and 100 mg/kg GPS (dry matter basis), respectively. The basal diet was formulated according to NRC (1982) recommendations combined with domestic feeding experience, using common fresh animal-based ingredients including fish, chicken liver, and chicken skeleton. The composition and nutrient levels of the basal diet are presented in . The experiment included a 7-day pre-feeding period followed by a 60-day formal feeding period. Body weights were measured at 07:00 every two weeks throughout the trial. Animals were housed individually in cages and managed by dedicated personnel, receiving feed twice daily at 08:00 and 15:00 with ad libitum access to feed and water.

1.3 Sample Collection

Fecal and Urine Samples: A digestion and metabolism trial was conducted during the rapid growth phase, 30 days after the formal period began. Six healthy minks with similar body weight and normal feed intake were selected from each group. Management procedures during the metabolism trial were identical to routine practices. Total fecal collection was performed over four days, with 10 mL of 10% sulfuric acid added to urine collection containers to preserve nitrogen. Following the metabolism trial, urine was filtered, collected in 10 mL centrifuge tubes, and stored at -20°C . Fecal samples were thoroughly mixed, and 200-300 g subsamples were treated with 10% sulfuric acid, dried at 65°C , ground, and passed through a 40-mesh sieve for storage.

Serum Samples: At the conclusion of the feeding trial, six minks per group were selected for blood collection via toenail clipping. Five milliliters of blood were collected into procoagulant tubes, allowed to clot, and then centrifuged at 3,500 rpm for 10 minutes at 4°C. The separated serum was aliquoted into 1.5 mL Eppendorf tubes and stored at -80°C for subsequent analysis.

1.4.1 Nutrient Digestibility and Nitrogen Metabolism

Determinations of dry matter, crude protein, crude fat, and crude ash in diets and feces, as well as crude protein in urine, followed the methods described by Zhang Liying [7]. Calculations for nutrient digestibility and nitrogen metabolism were performed using the following formulas:

Dry matter digestibility (%) = [(Dry matter intake - Dry matter output) / Dry matter intake] × 100

Crude protein digestibility (%) = [(Protein intake - Protein output) / Protein intake] × 100

Crude fat digestibility (%) = [(Fat intake - Fat output) / Fat intake] × 100

Nitrogen retention (g/d) = Nitrogen intake - Fecal nitrogen - Urinary nitrogen

Net protein utilization (%) = (Retained nitrogen / Nitrogen intake) × 100

Biological value of protein (%) = [Nitrogen retention / (Nitrogen intake - Fecal nitrogen)] × 100

1.4.2 Growth Performance

Body weight was measured at 07:00 every two weeks after an overnight fast. Average daily gain, average daily feed intake, and feed-to-gain ratio were calculated for the entire experimental period.

1.4.3 Serum Biochemical Indices

Serum albumin (ALB), total protein (TP), globulin (GLO), total cholesterol (CHO), triglycerides (TG), and glucose (GLU) were measured using an automatic biochemical analyzer (Selectra E, Netherlands) with assay kits from Zhongsheng Beikong Biotechnology Co., Ltd., following the manufacturer's instructions. Immunoglobulin G (IgG), immunoglobulin A (IgA), and immunoglobulin M (IgM) concentrations were determined using enzyme-linked immunosorbent assay (ELISA) kits purchased from Nanjing Jiancheng Bioengineering Institute.

1.5 Statistical Analysis

Data were analyzed using SAS V8 software. One-way analysis of variance (ANOVA) was performed using the General Linear Model (GLM) procedure. Duncan's multiple range test was used for post-hoc comparisons when significant differences were detected. Results are expressed as means ± standard

deviation, with $P < 0.05$ considered statistically significant and $P < 0.01$ considered extremely significant.

Results

2.1 Effects of Ginseng Polysaccharide on Growth Performance of Growing Minks

As shown in , initial body weight (at 70 days of age) did not differ significantly among groups ($P > 0.05$). Compared with the control group, body weights at 85 and 100 days of age in groups II, III, and IV showed no significant differences ($P > 0.05$). However, body weights at 115 and 130 days of age in group IV were significantly higher than in the control group ($P < 0.05$). Average daily gain in group IV was significantly greater than in the control group ($P < 0.05$). No significant differences were observed in average daily feed intake among groups ($P > 0.05$). Feed-to-gain ratio decreased progressively with increasing GPS supplementation, with group IV exhibiting a significantly lower ratio than both the control group and group II ($P < 0.05$), though not significantly different from group III ($P > 0.05$).

2.2 Effects of Ginseng Polysaccharide on Nutrient Digestibility of Growing Minks

As presented in , dry matter output decreased gradually with increasing GPS supplementation, with group IV showing extremely significantly lower values than the control and group II ($P < 0.01$), while no significant difference was observed between groups IV and III ($P > 0.05$). Dry matter digestibility increased with GPS supplementation levels, with group IV being extremely significantly higher than the control group ($P < 0.01$) and group III being significantly higher than the control group ($P < 0.05$). Similarly, crude protein digestibility increased with GPS supplementation, with group IV being extremely significantly higher than the control group ($P < 0.01$) and group III being significantly higher than the control group ($P < 0.05$). No significant differences were found in crude fat digestibility among all groups ($P > 0.05$).

2.3 Effects of Ginseng Polysaccharide on Nitrogen Metabolism of Growing Minks

As shown in , no significant differences were detected among groups in nitrogen intake, fecal nitrogen, urinary nitrogen, or nitrogen retention ($P > 0.05$). However, net protein utilization increased progressively with GPS supplementation, with group IV showing significantly higher values than the control group ($P < 0.05$). Although protein biological value increased gradually with GPS supplementation, no significant differences were observed among groups ($P > 0.05$).

2.4 Effects of Ginseng Polysaccharide on Serum Biochemical Indices of Growing Minks

As presented in , serum TP content in group IV was significantly higher than in the control group ($P < 0.05$). Serum ALB content in groups II, III, and IV was extremely significantly higher than in the control group ($P < 0.01$), with no significant differences among these three groups ($P > 0.05$). Serum GLO and IgM contents in group IV were significantly higher than in the control group ($P < 0.05$). No significant differences were observed among groups in serum IgG, IgA, CHO, TG, or GLU contents ($P > 0.05$).

Discussion

3.1 Effects of Ginseng Polysaccharide on Growth Performance and Nutrient Digestibility

The results indicate that dietary GPS supplementation significantly increased body weight at 115 and 130 days of age in group IV compared to the control group, with group IV also showing significantly higher average daily gain. No significant differences were observed in average daily feed intake among groups. Feed-to-gain ratio, a critical indicator of feed conversion efficiency, decreased progressively with increasing GPS levels, with group IV exhibiting significantly lower values than the control and group II, though not significantly different from group III. Polysaccharides are complex macromolecules that constitute one of the four fundamental biological substances and possess immunomodulatory properties. Ginseng polysaccharide is a bioactive polysaccharide mixture extracted from ginseng [8-9]. In aquaculture, Chen et al. [10] reported that GPS enhanced digestive enzyme secretion and promoted beneficial intestinal microflora proliferation, thereby improving digestive function in gibel carp. Xi et al. [7] found that GPS complexes did not significantly affect weight gain in *Litopenaeus vannamei*. Lu [11] demonstrated that dietary supplementation with 0.2 and 0.4 g/kg pine nut shell polysaccharide significantly improved weight gain in Nile tilapia within a certain effective timeframe. In the present study, GPS exhibited growth-promoting effects and improved serum biochemical indices and protein digestibility in minks. Relative to body length, minks have shorter intestinal tracts than other mammals, resulting in shorter digestion and emptying cycles. Research indicates that functional oligosaccharides utilized by beneficial gastrointestinal microorganisms, particularly *Bifidobacterium*, promote healthy microecology formation and maintenance, enhance immune function, reduce diarrhea incidence, increase metabolic activity and feed intake, and facilitate feed ingredient degradation and utilization, thereby promoting nutrient absorption and animal growth [12]. The current findings demonstrate that dietary GPS supplementation reduced dry matter output and increased crude protein digestibility with increasing supplementation levels, with group IV showing extremely significant improvements over the control group and group III showing significant improvements. Studies on polysaccharide mechanisms suggest that selective proliferation of intestinal microorganisms synthesizes various volatile

fatty acids and amino acids, thereby influencing nitrogen metabolism [13]. The specific mechanisms through which GPS enhances nitrogen metabolism warrant further investigation.

3.2 Effects of Ginseng Polysaccharide on Serum Biochemical Indices

Polysaccharides are important components of traditional Chinese medicine that play crucial roles in therapeutic effects. Research has shown that polysaccharides and polysaccharide complexes participate in and mediate various cellular functions by stimulating immune cells, promoting synthesis of cytokines such as interleukins, tumor necrosis factor, and interferons, and modulating antibodies and complement to regulate the immune system [14]. Following dietary polysaccharide complex supplementation, miRNAs may participate in regulating immune-related genes or immunomodulatory proteins such as C-type lectins and hemocyanin to enhance immunity in *Litopenaeus vannamei* [15]. Ginseng polysaccharide and polyporus polysaccharide regulate intestinal mucosal lymphocyte function in rats by increasing tumor necrosis factor levels in peripheral blood mononuclear cell (PBMC) and Peyer's patch lymphocyte (PPL) culture supernatants [16], and GPS promotes growth and affects non-specific immune function in black porgy [17]. Collectively, these studies suggest that GPS enhances immunity primarily by modulating immune-related gene expression, stimulating immune factor secretion, or increasing antimicrobial enzyme activity.

Serum biochemical indices reflect nutritional metabolic status, organ function, and indirectly indicate growth performance. Generally, elevated serum TP and ALB contents indicate enhanced hepatic protein synthesis capacity, while increased serum globulin content reflects improved immunity [18]. Liu et al. [19] found that probiotics positively affected hepatic protein synthesis and immunity by increasing serum TP and globulin contents. Immunoglobulins are primary mediators of humoral immunity and important indicators of immune function, with elevated serum IgG, IgM, and IgA contents indicating enhanced immunity. In the present study, serum biochemical indices related to nitrogen metabolism showed trends consistent with digestibility changes, with groups II, III, and IV exhibiting higher TP and ALB contents than the control group, with ALB reaching extremely significant levels, though no significant differences were observed among the three supplemented groups. Serum GLO and IgM contents in group IV were significantly higher than in the control group, while groups II and III did not differ significantly from the control. No significant differences were detected among groups in serum CHO, TG, or GLU contents.

Research indicates that yeast cell wall components (e.g., mannan oligosaccharides, glucans) can enhance immunity by triggering intestinal epithelial cell or gut-associated lymphoid tissue lymphocyte (Th1) responses through activated macrophages [20-21]. The intestinal mucosal immune system is a critical site for immune tolerance induction, and activating intestinal mucosal immunity to achieve immune tolerance or suppression represents a potential therapeutic ap-

proach for autoimmune diseases. Future research should focus on evaluating GPS effects on mink diarrhea rates compared to antibiotics, elucidating mechanisms for effective immunity enhancement, and identifying specific genes or factors modulated by GPS.

Conclusion

Dietary supplementation with ginseng polysaccharide improved growth performance, crude protein digestibility, and net protein utilization in growing male minks. In this experiment, supplementation levels of 50-100 mg/kg GPS in diets for growing male minks effectively enhanced immune capacity.

References

- [1] LI Guangyu, YANG Fuhe. New breeding techniques for foxes, raccoon dogs, and minks [M]. Beijing: China Agricultural Science and Technology Press, 2006.
- [2] FAN Zhongyuan. Analysis of intestinal microbial diversity in farmed minks [D]. PhD thesis. Beijing: Chinese Academy of Agricultural Sciences, 2015.
- [3] CHEN Qun, LIU Jiachang. Research progress on ginseng polysaccharide, astragalus polysaccharide, and lycium barbarum polysaccharide [J]. Journal of Huainan Normal University, 2001, 3(2): 39-41.
- [4] WANG Zhuo, SUN Weili, FAN Yanyan, et al. Effects of fructooligosaccharide on growth performance, nutrient digestibility, nitrogen metabolism, and serum biochemical indices of growing minks [J]. Chinese Journal of Animal Nutrition, 2015, 27(11): 3613-3619.
- [5] ZHANG Bin, LIN Ruichao, FENG Fang. Research overview of ginseng polysaccharide [J]. Chinese Pharmaceutical Affairs, 2004, 18(9): 566-569.
- [6] LI Shanshan, JIN Yingping, YAO Chunlin, et al. Research progress on structure and activity of ginseng polysaccharide [J]. China Journal of Chinese Materia Medica, 2014, 39(24): 4709-4715.
- [7] XI Qianyun, LIU Xiaolong, FANG Shuxian, et al. Study on immune enhancement effects of ginseng polysaccharide complex in *Litopenaeus vannamei* [J]. Feed Industry, 2009, 30(6): 15-17.
- [8] SONG Lihua, WANG Hongmei, XIAO Wei. Fractionation and preliminary immunological activity of ginseng polysaccharide [J]. Chinese Journal of Experimental Traditional Medical Formulae, 2012, 18(14): 162-166.
- [9] NI Weihua. Immunological activity and anti-tumor effects of ginseng polysaccharide [D]. PhD thesis. Changchun: Northeast Normal University, 2010.
- [10] CHEN Yong, ZHOU Hongqi. Effects of three polysaccharides on intestinal and hepatopancreatic protease and amylase activities in gibel carp [J]. Journal of Shanghai Fisheries University, 2005, 14(4): 468-471.
- [11] LU Ke. Study on immunomodulatory effects of pine nut shell polysaccharide on Nile tilapia [D]. Master's thesis. Changchun: Jilin University, 2007.
- [12] TOKUNAGA T, OKU T, HOSOYA N. Utilization and excretion of a

new sweetener, fructooligosaccharide (Neosugar), in rats [J]. *The Journal of Nutrition*, 1989, 119(4): 553-559.

[13] LIN Yingting. Factors affecting the efficacy of oligosaccharide feed additives [J]. *Animal Husbandry and Veterinary Medicine*, 2001, 33(6): 15-16.

[14] OOI V E C, LIU F. Immunomodulation and anti-cancer activity of polysaccharide-protein complexes [J]. *Current Medicinal Chemistry*, 2000, 7(7): 715-729.

[15] WANG Yuanmei, XIONG Jiehua, YE Ruisong, et al. Effects of dietary ginseng polysaccharide on miRNAs in *Litopenaeus vannamei* [J]. *Animal Husbandry and Veterinary Medicine*, 2012(S1): 370.

[16] ZHANG Wandong, LÜ Cheng, LIU Zhenli, et al. Effects of ginseng polysaccharide and polyporus polysaccharide on rat intestinal mucosal lymphocyte function [J]. *Chinese Traditional and Herbal Drugs*, 2007, 38(2): 221-223.

[17] LI Chunzhen, HU Kun, TANG Xuelian, et al. Effects of ginseng polysaccharide on growth performance and antioxidant enzyme mRNA expression in black porgy [J]. *Journal of Huazhong Agricultural University*, 2015, 34(6): 94-100.

[18] DONG Xiaoli, ZHANG Naifeng, ZHOU Meng, et al. Effects of compound bacterial preparation on growth performance, fecal microorganisms, and serum indices of weaned piglets [J]. *Chinese Journal of Animal Nutrition*, 2013, 25(6): 1285-1292.

[19] LIU Hui, JI Haifeng, WANG Sixin, et al. Effects of probiotics on growth performance, fecal microbial count, nutrient digestibility, and serum immune indices in growing pigs [J]. *Chinese Journal of Animal Nutrition*, 2015, 27(3): 829-837.

[20] INDEGREW W M. Yeast: could you have a business on this bug [C]//*Biotechnology in the feed industry*. Loughborough, Leics: Nottingham University Press, 1999: 27-50.

[21] SHEN Y B, PIAO X S, KIM S W, et al. Effects of yeast culture supplementation on growth performance, intestinal health, and immune response of nursery pigs [J]. *Journal of Animal Science*, 2009, 87(8): 2614-2624.

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