Effects of Compound Probiotics on Growth Performance, Slaughter Performance, Immune Organ Indices and Serum Biochemical Parameters in Squabs (Postprint)

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Abstract

This experiment was conducted to investigate the effects of compound probiotics on growth performance, slaughter performance, immune organ index, and serum biochemical indices of squabs. Seventy-two pairs of breeding pigeons and 144 one-day-old squabs were selected. After measuring initial body weight, the squabs were randomly allocated into 4 groups with 6 replicates per group, each replicate comprising 3 pairs of breeding pigeons and 6 squabs. While being fed the same basal diet, the control group was supplemented with health sand, group I with health sand + compound probiotic I (Lactobacillus acidophilus + Bifidobacterium lactis), group II with health sand + compound probiotic II (Bifidobacterium lactis + Enterococcus faecalis), and group III with health sand + compound probiotic III (Lactobacillus acidophilus + Enterococcus faecalis). The experimental period was 28 days. The results showed that, compared with the control group: 1) In terms of growth performance, group II significantly increased the 28-day body weight and average daily gain of squabs ($P<0.05$). 2) In terms of slaughter performance, group II significantly increased the dressing percentage, semi-eviscerated yield percentage, and eviscerated yield percentage of squabs ($P<0.05$); groups I and III significantly decreased the abdominal fat percentage of squabs ($P<0.05$). 3) In terms of immune organ index, group II significantly increased the thymus index of squabs ($P<0.05$). 4) In terms of serum biochemical indices, groups I and III significantly decreased the contents of total protein and globulin in squab serum ($P<0.05$); groups I, II, and III all significantly decreased the creatinine content in squab serum ($P<0.05$); groups II and III significantly decreased the triglyceride content in squab serum ($P<0.05$); group II significantly increased the high-density lipoprotein content in squab serum ($P<0.05$). In conclusion, the addition of compound probiotics to health

sand improved the growth performance, slaughter performance, immune organ index, and serum biochemical indices of squabs.

Full Text

Effects of Compound Probiotics on Growth Performance, Slaughter Performance, Immune Organ Index and Serum Biochemical Parameters of Squabs

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Abstract: This experiment investigated the effects of compound probiotics on growth performance, slaughter performance, immune organ index, and serum biochemical parameters of squabs. Seventy-two pairs of breeding pigeons and 144 one-day-old squabs were selected. After measuring initial body weight, squabs were randomly divided into four groups with six replicates per group, each replicate consisting of three pairs of breeding pigeons and six squabs. While fed the same basal diet, the control group was supplemented with health care sand, while groups I, II, and III were supplemented with health care sand containing compound probiotic I (*Lactobacillus acidophilus* + *Bifidobacterium lactis*), compound probiotic II (*Bifidobacterium lactis* + *Enterococcus faecalis*), and compound probiotic III (*Lactobacillus acidophilus* + *Enterococcus faecalis*), respectively. The experimental period lasted 28 days. The results showed that, compared with the control group: (1) In terms of growth performance, group II significantly increased 28-day body weight and average daily gain of squabs ($P<0.05$). (2) In slaughter performance, group II significantly increased slaughter rate, semi-eviscerated rate, and eviscerated rate ($P<0.05$), while groups I and III significantly reduced abdominal fat rate ($P<0.05$). (3) Regarding immune organ indices, group II significantly increased thymus index ($P<0.05$). (4) For serum biochemical parameters, groups I and III significantly reduced total protein and globulin contents ($P<0.05$); groups I, II, and III all significantly reduced serum creatinine content ($P<0.05$); groups II and III significantly reduced serum triglyceride content ($P<0.05$); and group II significantly increased serum high-density lipoprotein content ($P<0.05$). In conclusion, supplementing health care sand with compound probiotics improved growth performance, slaughter performance, immune organ indices, and serum biochemical parameters of squabs.

Keywords: compound probiotics; squabs; growth performance; serum biochemical parameters

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Introduction

Probiotics are defined as live beneficial microorganisms (bacteria or yeast) that colonize the animal intestinal tract and reproductive system and produce definite health benefits [1], playing an extremely important role in animal physiology. Dietary supplementation with appropriate probiotics can improve host intestinal flora balance, enhance animal growth performance, strengthen immunity, and promote healthy animal growth. Mokhtar [2] reported that dietary supplementation with *Lactobacillus* culture significantly reduced mortality in broiler chickens. Li et al. [3] found that dietary *Lactobacillus acidophilus* supplementation significantly improved broiler growth performance. Mountzouris et al. [4] demonstrated that dietary compound probiotics significantly enhanced broiler growth performance and intestinal digestive enzyme activity. Common probiotics include *Lactobacillus*, *Bifidobacterium*, and *Enterococcus* genera, with most research focusing on broiler chickens [5], pigs [6], and cattle [7]. However, studies on squabs remain scarce. This research investigated the effects of different compound probiotics added to health care sand on squab growth performance, slaughter performance, immune organ indices, and serum biochemical parameters, providing a reference for probiotic application in squab production.

Materials and Methods

1.1 Experimental Materials

Lactobacillus acidophilus and *Enterococcus faecalis* were purchased from Beijing Qiankezhu Biotechnology Co., Ltd., while *Bifidobacterium lactis* was obtained from Shandong Zhongke Jiayi Biological Engineering Co., Ltd. The viable bacterial counts were measured at 1×10^{10} CFU/g for *L. acidophilus*, 1.3×10^{11} CFU/g for *E. faecalis*, and 1.5×10^{10} CFU/g for *B. lactis*. Experimental breeding pigeons and squabs were provided by Jiangsu Cuigu Pigeon Industry Co., Ltd., using white king pigeons.

1.2 Experimental Design

The experiment selected 72 pairs of breeding pigeons from the same reproductive cycle and 144 squabs hatched on the same day, with each pair raising two squabs. After measuring initial body weight, squabs were randomly divided into four groups with six replicates each, each replicate containing three pairs of breeding pigeons and six squabs. The experimental period was 28 days. While all groups received the same basal diet, the control group was supplemented with health care sand only, whereas groups I, II, and III received health care sand supplemented with compound probiotic I (*L. acidophilus* 6×10^{7} CFU/g + *B. lactis* 6×10^{7} CFU/g), compound probiotic II (*B. lactis* 6×10^{7} CFU/g + *E. faecalis* 6×10^{7} CFU/g), and compound probiotic III (*L. acidophilus* 6×10^{7} CFU/g + *E. faecalis* 6×10^{7} CFU/g), respectively. Pigeons consumed health care sand at approximately 5% of total dietary intake daily. The composition and nutrient levels of the basal diet are shown in Table

1 , and those of the health care sand in Table 2 .

1.3 Management

The feeding trial was conducted at Jiangsu Cuigu Pigeon Industry Co., Ltd. using single-cage housing, with each pair of breeding pigeons raising two squabs. Birds had free access to feed, water, and health care sand under natural lighting conditions. The pigeon house was inspected and cleaned daily.

1.4 Measurements

1.4.1 Growth Performance

Squabs were weighed on days 1 and 28 of the experiment, and average daily gain (ADG) was calculated for each replicate.

1.4.2 Slaughter Performance

On day 28, squab live weight, carcass weight, semi-eviscerated weight, eviscerated weight, breast muscle weight, leg muscle weight, and abdominal fat weight were measured to calculate slaughter rate, semi-eviscerated rate, eviscerated rate, breast muscle rate, leg muscle rate, and abdominal fat rate [8].

1.4.3 Immune Organ Indices

On day 28, one squab per replicate with body weight close to the replicate average was selected for slaughter. The spleen, bursa of Fabricius, and thymus were excised and weighed to calculate immune organ indices using the formula: Immune organ index (%) = [immune organ weight (g) / live weight (g)] × 100.

1.4.4 Serum Biochemical Parameters

Serum total protein (TP), globulin (GLO), creatinine (CREA), urea nitrogen (UN), glucose (GLU), total cholesterol (TCHO), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were determined using a UniCel DxC800 automatic biochemical analyzer.

1.5 Statistical Analysis

Raw data were processed using Excel 2007 and analyzed by one-way ANOVA using SPSS 20.0 software. Multiple comparisons were performed using the LSD method. Results are expressed as "mean ± standard deviation," with $P<0.05$ considered statistically significant.

Results

2.1 Effects of Compound Probiotics on Growth Performance

As shown in Table 3 , no significant differences were observed in 1-day body weight among groups ($P>0.05$). Compared with the control group, group II significantly increased 28-day body weight and ADG ($P<0.05$), while groups I and III showed no significant differences in these parameters ($P>0.05$).

2.2 Effects of Compound Probiotics on Slaughter Performance

Table 4 shows that group II significantly increased slaughter rate, semi-eviscerated rate, and eviscerated rate compared with the control group ($P<0.05$), while groups I and III significantly reduced abdominal fat rate ($P<0.05$). Additionally, group II had significantly higher semi-eviscerated and eviscerated rates than group I ($P<0.05$). These results indicate that supplementing health care sand with compound probiotics improved squab slaughter performance.

2.3 Effects of Compound Probiotics on Immune Organ Indices

Table 5 demonstrates that group II significantly increased thymus index compared with both the control group and group III ($P<0.05$). These findings suggest that compound probiotic II significantly stimulated thymus development and enhanced immune function.

2.4 Effects of Compound Probiotics on Serum Biochemical Parameters

As presented in Table 6 , groups I and III significantly reduced serum TP and GLO contents compared with the control group ($P<0.05$). Groups I, II, and III all significantly decreased serum CREA content ($P<0.05$). Groups II and III significantly reduced serum TG content ($P<0.05$), while group II significantly increased serum HDL content ($P<0.05$). Furthermore, group II had significantly higher HDL content than group I ($P<0.05$). These results indicate that compound probiotic supplementation improved serum biochemical parameters in squabs.

Discussion

3.1 Effects on Growth Performance

Probiotics can colonize the intestinal tract and produce abundant nutrients that participate in growth and metabolism, thereby improving nutrient digestion and absorption and promoting poultry development. During early growth, the digestive tract microbiota is not fully established and remains dynamically variable; thus, early probiotic administration can facilitate the establishment of a more favorable intestinal flora that promotes healthy animal growth [9]. After entering the intestine, probiotics produce short-chain fatty acids and vitamins through substrate fermentation that participate in poultry nutritional metabolism [10-11]. Additionally, probiotics significantly affect digestive enzyme activities. Xi et al. [12] reported that probiotic and organic acid compound supplementation in partridge-shank chickens enhanced digestive enzyme activity. Wang et al. [13] found that dietary probiotics significantly increased pancreatic amylase and trypsin activities in broiler chickens. These factors may explain why probiotics promote poultry growth. The present results show that supplementing health care sand with compound probiotics significantly improved 28-day body weight and ADG in squabs, consistent with findings by Lu et al. [14].

3.2 Effects on Slaughter Performance

Slaughter performance is a crucial indicator for evaluating meat animal growth performance, reflecting differences in nutrient deposition among tissues and within the same tissue [15]. This study showed that health care sand containing the *B. lactis* and *E. faecalis* compound probiotic significantly increased slaughter rate, semi-eviscerated rate, and eviscerated rate in squabs. This may be because probiotics in health care sand produced nutrients and digestive enzymes through fermentation that enhanced squab digestion and absorption, thereby improving these slaughter parameters. Huang et al. [16] investigated compound probiotic effects on broiler slaughter performance and found significant improvements in semi-eviscerated and eviscerated rates, similar to our results. The compound probiotics containing *L. acidophilus* + *B. lactis* and *L. acidophilus* + *E. faecalis* significantly reduced abdominal fat rate, possibly by altering intestinal microbial flora to decrease abdominal fat deposition, though the specific mechanism requires further investigation.

3.3 Effects on Immune Organ Indices

The spleen, bursa of Fabricius, and thymus are primary avian immune organs involved in cellular and humoral immunity. The spleen is the largest peripheral immune organ, participating in non-specific and specific immunity. The bursa of Fabricius is unique to birds, producing B lymphocytes for specific immune responses. The thymus is where T lymphocytes differentiate and mature, serving as the central organ for cellular immunity. Research indicates that greater weight and relative weight of these organs signify higher immune function [17]. Chen et al. [18] reported that *Lactobacillus* administration via syringe significantly increased thymus and bursal indices in squabs. Li et al. [19] found that dietary probiotics significantly increased spleen and bursal indices in broiler chickens. Our results show that compound probiotic supplementation in health care sand increased thymus index in squabs, possibly because probiotics interact with host epithelium to recruit immune cells to infection sites, inducing production of specific immune markers that promote immune organ development and enhance immunity. The specific reasons for this probiotic effect on immune organs require further exploration.

3.4 Effects on Serum Biochemical Parameters

Changes in serum biochemical parameters reflect alterations in organism metabolism. Serum total protein content reflects protein absorption and metabolism capacity, while globulin content is closely related to immunity. Yu et al. [20] reported that dietary *Lactobacillus plantarum* significantly reduced serum TP content in laying hens. Our results also showed that compound probiotic supplementation in health care sand significantly reduced serum TP content in squabs, possibly because probiotics regulated the endocrine system to promote growth hormone secretion, thereby accelerating protein deposition. The reduced serum GLO content observed may be related to the squabs' ability to eliminate foreign invaders, though specific mechanisms need further study. Creatinine is a final product of protein metabolism in birds, and serum CREA content indirectly reflects protein and amino acid utilization capacity. Our results demonstrate that compound probiotics significantly reduced serum CREA content, indicating improved protein and amino acid utilization. Serum TG and HDL contents reflect lipid metabolism status; elevated TG can trigger disease, while increased HDL helps clear excess cholesterol from blood vessels, benefiting cardiovascular health. Song et al. [21] found that dietary *E. faecalis* significantly reduced serum TG and increased HDL in broiler chickens. Our results similarly show that compound probiotic supplementation reduced serum TG content in squabs.

In conclusion, supplementing health care sand with compound probiotics improved growth performance, slaughter performance, immune organ indices, and serum biochemical parameters in squabs.

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