Effects of Black Soldier Fly Larvae Meal on Growth Performance and Serum Biochemical Parameters in Growing Pigs: Postprint

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Date: 2018-12-24T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of black soldier fly larvae meal on growth performance and serum biochemical indices of growing pigs, and to explore the feasibility of replacing soybean meal with black soldier fly larvae meal reared on pig manure. Forty-eight healthy 70-day-old "Duroc × Landrace × Yorkshire" crossbred growing pigs with an initial body weight of (33.00±1.00) kg were selected and randomly divided into 2 groups, with 12 replicates per group and 2 pigs per replicate. The control group was fed a basal diet, while the experimental group was fed a test diet containing 25‰ black soldier fly larvae meal. The experimental period lasted 30 days. The results showed that, compared with the control group, the average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G) of growing pigs in the experimental group showed no significant changes ($P > 0.05$); the serum albumin (ALB) content of growing pigs in the experimental group increased extremely significantly ($P < 0.01$), the albumin/globulin ratio (A/G) increased significantly ($P < 0.05$), and the serum high-density lipoprotein cholesterol (HDL-C) content increased significantly ($P < 0.05$). In conclusion, under the conditions of this experiment, the addition of 25‰ black soldier fly larvae meal to the diet did not affect the growth performance of growing pigs and could replace part of the soybean meal in the basal diet of growing pigs.

Full Text

Effects of Black Soldier Fly Meal on Growth Performance and Serum Biochemical Parameters of Growing Pigs

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Abstract

This study investigated the effects of black soldier fly meal on growth performance and serum biochemical parameters in growing pigs to explore the feasibility of replacing soybean meal with black soldier fly larvae reared on pig manure. Forty-eight healthy 70-day-old "Duroc × Landrace × Large White" crossbred growing pigs with an initial body weight of (33.00 ± 1.00) kg were randomly allocated into two groups, each comprising 12 replicates of two pigs. The control group received a basal diet, while the experimental group received a test diet containing 25‰ black soldier fly meal. The 30-day trial period revealed no significant differences in average daily gain (ADG), average daily feed intake (ADFI), or feed-to-gain ratio (F/G) between groups ($P > 0.05$). However, the experimental group exhibited highly significant increases in serum albumin (ALB) content ($P < 0.01$), significant increases in albumin-to-globulin ratio (A/G) ($P < 0.05$), and significant increases in high-density lipoprotein cholesterol (HDL-C) content ($P < 0.05$). These findings indicate that dietary supplementation with 25‰ black soldier fly meal does not impair growth performance in growing pigs and can effectively replace a portion of the soybean meal in basal diets.

Keywords: pig manure; black soldier fly; growth performance; serum biochemical parameters

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1.1 Experimental Materials

Black soldier fly larvae were raised on pig manure from Anyou Group's Jintan pig farm. The live larvae were collected, washed, and microwave-dried to produce air-dried black soldier fly meal. A comparison of the nutritional composition of black soldier fly meal from different rearing sources is presented in Table 1 , with the nutritional values for the pig manure-reared meal determined by Anyou Group' s central laboratory.

1.2 Experimental Design and Diets

A randomized block design was employed, utilizing 48 healthy 70-day-old "Duroc × Landrace × Large White" crossbred growing pigs of the same batch with similar body weights [(33.00 ± 1.00) kg]. The pigs were randomly divided into two groups, each containing 12 replicates with two pigs per replicate. The control group received a basal diet, while the experimental group received a test diet supplemented with 25‰ black soldier fly meal (replacing soybean meal in the basal diet at a rate of 25 kg/t). The composition and nutrient levels of the experimental diets are shown in Table 2 . The trial lasted 30 days.

1.3 Husbandry Management

The experiment was conducted from August 5 to September 5, 2017, at the experimental base of Anyou Biological Technology Group Co., Ltd. in Taicang City, Jiangsu Province. Pigs had ad libitum access to feed and water, and were managed and immunized according to standard farm protocols.

1.4.1 Growth Performance Metrics

Body weight was recorded for each replicate on days 1 and 30 of the trial, along with feed consumption. Mortality and culling events were documented with body weight and days on test to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G).

1.4.2 Diarrhea Rate and Severity Scoring

Diarrhea incidence was recorded daily at 09:00 and 15:00 throughout the trial period, with severity graded according to the method of Marquardt et al. [2] on a four-point scale: 0 = firm, formed feces; 1 = soft but formed feces; 2 = loose, unformed feces without separation of fecal water; and 3 = watery feces with separation of fecal water. Diarrhea was defined as a score of 2 or higher. The diarrhea rate was calculated as: Diarrhea rate (%) = 100 × (total diarrhea episodes) / (trial days × number of pigs per group).

1.4.3 Serum Biochemical Parameters

On day 29, 10 mL blood samples were collected via jugular venipuncture from each pen. Serum was separated by centrifugation at 3,000 rpm for 10 minutes, placed on ice, and stored at -20 °C for subsequent analysis. An automatic biochemical analyzer was used to determine serum concentrations of total protein (TP), albumin (ALB), globulin (GLB), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and total cholesterol (TC) using assay kits purchased from Beijing Leadman Biochemistry Co., Ltd.

1.5 Statistical Analysis

All data were analyzed using SPSS 17.0 software via t-test and analysis of variance. Results are expressed as "mean ± standard deviation (mean ± SD)." Differences were considered significant at $P < 0.05$ and highly significant at $P < 0.01$.

2.1 Effects of Black Soldier Fly Meal on Growth Performance

As shown in Table 3 , the experimental group exhibited a 0.2% increase in ADG, a 0.25% decrease in ADFI, and a 0.45% improvement in F/G compared to the control group, though none of these differences reached statistical significance

($P > 0.05$). The diarrhea rate in the experimental group was 1.68% lower than that of the control group, also without significant difference ($P > 0.05$).

2.2 Effects of Black Soldier Fly Meal on Serum Biochemical Parameters

Table 4 shows that compared to the control group, the experimental group displayed increased serum TP content ($P > 0.05$), highly significant increases in serum ALB content ($P < 0.01$), significant increases in A/G ratio ($P < 0.05$), and decreased serum GLB content ($P > 0.05$). Serum HDL-C concentration was significantly higher in the experimental group ($P < 0.05$), while TG, TC, and LDL-C levels did not differ significantly from the control group ($P > 0.05$).

3.1 Effects of Black Soldier Fly Meal on Growth Performance

Studies investigating black soldier fly meal as a protein substitute in growing pig diets, particularly meal derived from pig manure-reared larvae, remain limited in China. Makkar et al. [3] reviewed that black soldier fly meal is rich in amino acids, fats, and calcium, making it suitable for inclusion in growing pig diets. Newton et al. [4] evaluated pig manure-reared black soldier fly meal as a replacement for spray-dried plasma protein in weaned piglets at 0%, 50%, and 100% inclusion levels (with plasma protein added at 5%, 2.5%, and 0% in phases 1, 2, and 3, respectively) without additional amino acid supplementation. Their results showed improved growth performance in piglets receiving black soldier fly meal, with the 50% replacement group achieving 4% higher growth performance and 9% better feed conversion efficiency; however, the 100% replacement group exhibited 3–13% reduced performance in phase 1. These findings demonstrate that pig manure-reared black soldier fly meal can serve as a viable protein source in livestock diets, though the specific protein sources replaced (soybean meal, fish meal, plasma protein, etc.) and optimal inclusion rates require extensive animal trials to determine. In the present study, black soldier fly meal did not significantly improve growth performance, but ADG, ADFI, and F/G remained comparable to the control group. Moreover, the experimental group showed reduced diarrhea incidence, indicating that pig manure-reared black soldier fly meal can effectively replace soybean meal as a protein source in growing pig diets. Since growing pig diets contain relatively low levels of animal protein sources compared to the more diverse and higher inclusion rates used in weaned and nursery pig diets, future research should focus on evaluating black soldier fly meal in these younger age groups to better exploit the potential of insect protein ingredients.

3.2 Effects of Black Soldier Fly Meal on Serum Biochemical Parameters

Serum total protein comprises albumin and globulin, with TP levels reflecting protein absorption and metabolism. Elevated serum TP and ALB concentrations generally indicate enhanced hepatic protein synthesis capacity, which

improves metabolic function and immunity while promoting healthy growth. Serum ALB serves as a sensitive indicator of protein requirements, more responsive than TP, and functions as a crucial carrier for tissue synthesis and metabolic waste transport, facilitating nutrient generation and energy metabolism. Reduced ALB levels can impair metabolic capacity and cause edema [5-6]. In this study, the highly significant increase in serum ALB in the experimental group suggests that substituting black soldier fly meal for soybean meal enhanced nutritional metabolism and digestive efficiency, demonstrating that black soldier fly meal is a high-quality protein source that improves protein metabolism.

Serum globulin is produced by plasma cells differentiated from B lymphocytes, and its concentration increases with rising antibody levels. Beyond maintaining osmotic pressure and pH balance with albumin, GLB reflects immune status, while a decreased A/G ratio indicates enhanced GLB synthesis and improved immunity [7-8]. Although GLB elevation typically signifies improved immune function, the experimental group in this study showed reduced GLB alongside significantly increased A/G, likely attributable to enhanced growth metabolism increasing ALB demand for tissue synthesis and waste transport [9]. This suggests that while black soldier fly meal may not substantially improve immune function, it remains a promising protein feed ingredient.

Serum TC reflects lipid absorption and metabolism, while TG indicates adipose tissue development and fat deposition capacity, with reduced TG suggesting diminished fat deposition [10]. LDL-C transports hepatically synthesized cholesterol to extrahepatic tissues, whereas HDL-C returns cholesterol to the liver for conversion and excretion, maintaining cholesterol homeostasis [11]. The significant increase in serum HDL-C in the experimental group indicates that black soldier fly meal enhanced cholesterol transport to the liver for oxidation, thereby promoting lipid metabolism and reducing tissue cholesterol accumulation in growing pigs.

3.3 Homologous Pollution Concerns with Pig Manure-Reared Black Soldier Fly Meal

Regarding homologous pollution risks from animal-derived feedstuffs, the use of pig manure to rear black soldier flies, which are then processed into feed additives, theoretically interrupts the homologous contamination pathway through invertebrate transformation. The present study observed no disease outbreaks in the experimental group, and diarrhea rates were reduced compared to controls. However, whether pig manure-reared black soldier fly meal can reliably control homologous pollution requires confirmation through extensive animal feeding trials.

Conclusions

1. Dietary supplementation with 25‰ black soldier fly meal does not impair growth performance in growing pigs and can effectively replace a portion

of the soybean meal in basal diets.

2. Dietary supplementation with 25‰ black soldier fly meal significantly or highly significantly increases serum ALB and HDL-C concentrations in growing pigs.

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