

Effects of Propolis Residue on Growth Performance, Slaughter Performance, and Meat Quality of 28- to 56-Day-Old Yellow-Feathered Broilers (Postprint)

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Date: 2017-10-23T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of propolis residue on growth performance, slaughter performance, and meat quality of yellow-feathered broiler chickens aged 28 to 56 days, thereby providing a basis for the development and utilization of propolis residue. A total of 540 Minnan yellow-feathered broiler chickens at 28 days of age were selected and randomly divided into 3 groups with 6 replicates per group and 30 birds per replicate. Group 1 was fed the basal diet, while groups 2 and 3 were fed the basal diet supplemented with 0.5% and 1.0% propolis residue, respectively, for a 28-day experimental period. The results showed that: 1) Propolis residue had no significant effect on average daily gain and feed conversion ratio of broiler chickens ($P > 0.05$). 2) Propolis residue had no significant effect on dressing percentage and semi-eviscerated yield ($P > 0.05$), but significantly increased eviscerated yield ($P < 0.05$); the leg muscle percentage and breast muscle percentage in group 3 were significantly higher than those in group 1 ($P < 0.05$). 3) Regarding meat color, propolis residue had no significant effect on lightness (L) and yellowness (b) values of leg and breast muscles ($P > 0.05$), but significantly reduced the redness (a^*) values of breast and leg muscles in group 3 ($P < 0.05$). Regarding meat quality, compared with group 1, the shear force of leg muscle and water loss rate of breast muscle in groups 2 and 3 were significantly decreased ($P < 0.05$); the drip loss of breast muscle in groups 2 and 3 was significantly lower than that in group 1 ($P < 0.05$), and the drip loss of leg muscle in group 3 was also significantly lower than that in group 1 ($P < 0.05$). It can be concluded that dietary supplementation with 1.0% propolis residue can improve the slaughter performance and meat quality of yellow-feathered broiler chickens.

Full Text

Effects of Propolis Residue on Growth Performance, Slaughter Performance, and Muscle Quality of Yellow-Feathered Broilers Aged 28 to 56 Days

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Abstract

This experiment was conducted to investigate the effects of propolis residue on growth performance, slaughter performance, and muscle quality of yellow-feathered broilers aged 28 to 56 days, thereby providing a basis for the development and utilization of propolis residue. A total of 540 Minnan yellow-feathered broilers at 28 days of age were randomly divided into three groups with six replicates per group and 30 broilers per replicate. Group I was fed a basal diet, while groups II and III were fed the basal diet supplemented with 0.5% and 1.0% propolis residue, respectively. The experimental period lasted 28 days. The results showed: (1) Propolis residue had no significant effect on average daily gain or feed-to-gain ratio of broilers ($P > 0.05$). (2) Propolis residue had no significant impact on dressing percentage or semi-eviscerated yield ($P > 0.05$), but significantly increased eviscerated yield ($P < 0.05$). The thigh and breast muscle percentages in group III were significantly higher than those in group I ($P < 0.05$). (3) Regarding meat color, propolis residue had no significant effect on lightness (L) or yellowness (b) values of thigh and breast muscle ($P > 0.05$), but significantly reduced the redness (a^*) values of breast and thigh muscle in group III ($P < 0.05$). In terms of meat quality, compared with group I, the shear force of thigh muscle in groups II and III was significantly decreased ($P < 0.05$), and the water loss rate of breast muscle was significantly decreased ($P < 0.05$). The drip loss of breast muscle in groups II and III was significantly lower than that in group I ($P < 0.05$), and the drip loss of thigh muscle in group III was also significantly lower than that in group I ($P < 0.05$). These results indicate that dietary supplementation with 1.0% propolis residue can improve the slaughter performance and meat quality of yellow-feathered broilers.

Keywords: propolis residue; yellow-feathered broilers; growth performance; slaughter performance; muscle quality

Introduction

China is a major bee product producer, generating substantial quantities of propolis residue after extraction that remain underutilized, resulting in resource

waste. Utilizing propolis residue as a feed ingredient could not only prevent resource waste and environmental pollution but also yield economic benefits while promoting the development of safe, pollution-free novel feed ingredients. Han et al. [1] found that ethanol-extracted propolis residue serves as an effective preservative, significantly improving pork storage quality after eight weeks. Li et al. [2] observed that adding 0.05% and 0.10% propolis to growing pig diets significantly increased average daily gain and reduced feed-to-gain ratio. Denli et al. [3] reported that propolis significantly improved daily weight gain, feed intake, and feed conversion ratio in Japanese quail. Domestic researchers have also noted that propolis can promote livestock and poultry growth, conserve feed, and improve product quality [4-6]. Lu Yuanyuan [7] systematically investigated the extraction, composition, and antioxidant and antibacterial properties of volatile components from propolis residue, providing a theoretical basis for its reuse. However, few reports exist on the application of propolis residue in broiler production. This study aims to explore the effects of propolis residue on growth performance, slaughter performance, and muscle quality of yellow-feathered broilers to provide a reference for its application in broiler feed production.

1. Materials and Methods

1.1 Experimental Materials

Propolis residue was provided by Hangzhou Bee Language Bee Industry Co., Ltd. Its nutrient composition was: crude ash 5.02%, crude protein 23.08%, crude fat 3.91%, calcium 0.65%, phosphorus 0.48%.

1.2 Experimental Design

The experiment utilized 540 Minnan yellow-feathered broilers at 28 days of age, randomly allocated into three groups with six replicates per group and 30 broilers per replicate (equal sex ratio). Group I received a corn-soybean meal basal diet formulated as a powdered complete feed according to NRC (1994) nutrient requirements and China's "Feeding Standard of Chicken" (NY/T 33-2004). The basal diet composition and nutrient levels are shown in Table 1. Groups II and III received the basal diet supplemented with 0.5% and 1.0% propolis residue, respectively. The experimental period lasted 28 days.

1.3 Management

Broilers were raised on netting with free access to feed and water, following standard vaccination procedures. Stocking density was 10 birds/m². Lighting combined natural and artificial illumination with 24-hour light throughout the period. Temperature was maintained at 20-25°C until the experiment concluded, with ambient humidity kept at natural levels.

1.4 Measurements

1.4.1 Growth Performance Feed intake was recorded by replicate. Body weight was measured at 28 and 56 days of age (before morning feeding), and average daily feed intake, average daily gain, and feed-to-gain ratio were calculated.

1.4.2 Slaughter Performance At the end of the experiment (56 days), live weight was recorded and one bird per replicate was randomly selected for slaughter testing after 12 hours of feed withdrawal. Following bloodletting and feather removal, carcass weight was measured. Semi-eviscerated weight was determined after removing the esophagus, crop, trachea, intestines, spleen, pancreas, gallbladder, and reproductive organs. Eviscerated weight was measured after further removal of the heart, liver, gizzard, proventriculus, abdominal fat, head, and feet (including shanks). Breast and left thigh muscles were separated to determine breast and thigh muscle percentages. Dressing percentage, semi-eviscerated yield, eviscerated yield, breast muscle percentage, and thigh muscle percentage were calculated.

1.4.3 Muscle Quality The entire pectoralis major and thigh muscles were dissected (maintaining smooth inner surfaces), and conventional meat quality indices were measured according to the recommended methods in the “Technical Operating Procedures for Meat Quality Evaluation of Yellow-Feathered Broilers” [8].

Meat color: Measured using a CR400 colorimeter at three points along the muscle's longitudinal axis from thick to thin ends, recording lightness (L), redness (a), and yellowness (b^*) values and calculating averages.

pH: Measured at three points along the muscle's longitudinal axis using a pH meter, with values averaged.

Water loss rate: Meat samples were placed between two layers of medical gauze with 18 layers of filter paper above and below, compressed between iron plates on a compression instrument platform at 35 kg for 1 minute, then reweighed after pressure release.

Drip loss: Meat samples were weighed accurately, suspended by wire hooks from the bottom of inverted disposable plastic cups, placed in plastic bags, sealed, and stored at 4°C for 24 hours before reweighing.

Cooking loss: Meat samples were sealed in plastic bags, refrigerated at 4°C for 24 hours, equilibrated to room temperature for 30 minutes, reweighed, then heated in sealed bags in an 80°C water bath until the core temperature reached 70°C. After cooling for 24 hours, samples were reweighed.

Shear force: After cooking loss measurement, samples were trimmed a second time and cut into three pieces. Each piece was sheared twice perpendicular

to muscle fiber orientation using a shear instrument, with the average of six measurements calculated.

1.5 Statistical Analysis

Data were initially processed using Excel and analyzed using SPSS 19.0 software via one-way ANOVA, with Duncan's multiple range test for post-hoc comparisons. Results are expressed as mean \pm standard deviation, with $P < 0.05$ as the significance threshold.

2. Results

2.1 Effects of Propolis Residue on Growth Performance of Yellow-Feathered Broilers from 28 to 56 Days

As shown in Table 2, compared with group I, average daily feed intake in groups II and III increased by 1.26% and 5.97%, respectively, though differences were not significant ($P > 0.05$). Average daily gain in groups II and III showed varying degrees of improvement compared with group I, but none were significant ($P > 0.05$). Feed-to-gain ratio did not differ significantly among groups I, II, and III ($P > 0.05$).

2.2 Effects of Propolis Residue on Slaughter Performance of Yellow-Feathered Broilers from 28 to 56 Days

Table 3 shows that compared with group I, dressing percentage decreased by 1.28% in group II ($P > 0.05$) and increased by 1.76% in group III ($P > 0.05$). Semi-eviscerated yield increased by 3.04% and 3.63% in groups II and III, respectively ($P > 0.05$). Eviscerated yield increased significantly by 5.49% and 7.31% in groups II and III, respectively ($P < 0.05$). Breast muscle percentage increased to varying degrees in groups II and III, with a 17.18% increase in group II ($P > 0.05$) and a significant 36.42% increase in group III ($P < 0.05$). Thigh muscle percentage also increased in groups II and III, with a 21.41% increase in group II ($P > 0.05$) and a significant 32.52% increase in group III ($P < 0.05$).

2.3 Effects of Propolis Residue on Muscle Quality of Yellow-Feathered Broilers from 28 to 56 Days

As shown in Table 4, at 45 minutes post-slaughter: Regarding meat color, L^* and b^* values of breast and thigh muscle did not differ significantly among groups ($P > 0.05$). Compared with group I, a^* values of breast and thigh muscle decreased in group II ($P > 0.05$) but decreased significantly in group III, by 39.52% in breast muscle and 38.54% in thigh muscle ($P < 0.05$). Compared with group I, b^* values of breast and thigh muscle increased in group II and decreased in group III, but differences were not significant ($P > 0.05$). pH values of breast and thigh muscle decreased in group II and showed mixed effects in

group III, but none were significant ($P>0.05$). Cooking loss of breast and thigh muscle decreased to some extent in groups II and III, but differences were not significant ($P>0.05$). Regarding shear force, breast muscle shear force increased significantly by 83.21% and 82.62% in groups II and III, respectively ($P<0.05$), while thigh muscle shear force decreased significantly by 16.82% and 18.01% ($P<0.05$). Compared with group I, breast muscle water loss rate decreased significantly by 47.82% and 34.66% in groups II and III, respectively ($P<0.05$), while thigh muscle water loss rate increased but not significantly ($P>0.05$).

At 24 hours post-slaughter: Regarding meat color, compared with group I, L^* values of breast muscle decreased in groups II and III, while L^* values of thigh muscle increased, but differences were not significant ($P>0.05$). a^* values of breast and thigh muscle decreased in group II ($P>0.05$), while group III showed significant decreases of 31.23% in breast muscle and 19.24% in thigh muscle ($P<0.05$). b^* values of breast muscle did not differ significantly among groups ($P>0.05$), while b^* values of thigh muscle decreased in groups II and III but not significantly ($P>0.05$). pH values did not differ significantly among groups ($P>0.05$). Compared with group I, breast muscle cooking loss decreased in groups II and III ($P>0.05$), while thigh muscle cooking loss increased in group II and decreased in group III, but differences were not significant ($P>0.05$). Regarding shear force, breast muscle shear force increased significantly by 74.14% in group II and 52.29% in group III ($P<0.05$), while thigh muscle shear force decreased significantly by 20.53% in group II and 19.62% in group III ($P<0.05$). Compared with group I, breast muscle water loss rate decreased significantly by 45.60% and 35.35% in groups II and III, respectively ($P<0.05$), while thigh muscle water loss rate increased but not significantly ($P>0.05$).

Results showed that at 24 hours post-slaughter, breast muscle drip loss decreased significantly by 35.41% and 40.07% in groups II and III, respectively ($P<0.05$), while thigh muscle drip loss decreased slightly in group II ($P>0.05$) and significantly by 12.80% in group III ($P<0.05$). At 48 hours post-slaughter, breast muscle drip loss decreased significantly by 20.30% and 27.36% in groups II and III, respectively ($P<0.05$), while thigh muscle drip loss decreased slightly in group II ($P>0.05$) and significantly by 20.48% in group III ($P<0.05$).

3. Discussion

3.1 Effects of Propolis Residue on Growth Performance of Yellow-Feathered Broilers from 28 to 56 Days

Measuring daily weight gain and feed-to-gain ratio over a defined period represents the simplest and most effective method for assessing broiler growth performance. The current results indicate that dietary propolis residue supplementation had no significant effect on growth performance. Similar conclusions were reached by Duarte et al. [9] in their study on propolis effects on broiler intestinal morphology and digestive enzymes, where 1,020 male broilers

divided into six treatments with varying propolis levels (0-500 mg/kg) showed no significant differences in growth performance among treatments. However, Li Zhongli et al. [10] and Xiao Benxian et al. [11] found that propolis and propolis extracts significantly improved broiler growth performance, possibly because growth-promoting components were reduced in ethanol-extracted propolis residue. Propolis composition is highly complex, with identified chemical constituents including flavonoids, terpenoids, phenolic acids, various amino acids, enzymes, vitamins, polysaccharides, and trace elements [7]. Compared with propolis utilization in livestock production, few reports exist on propolis residue applications. The differences in active components before and after industrial ethanol extraction of propolis require further investigation.

3.2 Effects of Propolis Residue on Slaughter Performance of Yellow-Feathered Broilers from 28 to 56 Days

Slaughter performance represents the most direct and effective measure of broiler meat production efficiency and constitutes one of the most important indicators of growth performance, with breast and thigh muscle percentages serving as crucial indices of carcass quality. Analysis of conventional slaughter performance indicators in this study revealed that propolis residue supplementation had no significant effect on dressing percentage or semi-eviscerated yield but significantly increased eviscerated yield, with the 1.0% supplementation level significantly increasing both breast and thigh muscle percentages. These findings align with Seven et al. [12], who reported that dietary propolis supplementation at 500 and 1,000 mg/kg improved carcass yield in heat-stressed broilers. Zeng Zhijiang et al. [13] also found that propolis significantly increased broiler thigh and breast muscle percentages, with similar conclusions reported by Zhang Min et al. [14]. Tao Shunmei et al. [15] confirmed that dietary propolis powder supplementation at 400 and 800 mg/kg increased broiler dressing percentage, semi-eviscerated yield, eviscerated yield, breast muscle percentage, and thigh muscle percentage, with only breast and thigh muscle percentages reaching significance. Thus, propolis and its residue as feed ingredients can increase breast and thigh muscle percentages, though the underlying mechanisms require further research.

3.3 Effects of Propolis Residue on Muscle Quality of Yellow-Feathered Broilers from 28 to 56 Days

Meat color is a crucial indicator of muscle appearance that directly determines consumer acceptance. Muscle pH reflects acidity levels and represents an important meat quality parameter. Water-holding capacity, which affects meat tenderness, color, and juiciness while influencing processed meat yield, structure, and color, is primarily evaluated through water loss rate, drip loss, and cooking loss. Meat tenderness, the most important sensory indicator, depends on muscle tissue components and biochemical changes altering these components. The shear force method, which comprehensively reflects the effects of muscle

fiber structure and collagen content on tenderness while showing high correlation with sensory evaluation and excellent resolution, has become an effective method for assessing chicken tenderness [8].

In this experiment, propolis residue effects on meat color aligned with Wu Hongxiang et al. [16], who reported that compound propolis-bee pollen supplementation improved meat color in Lingnan yellow-feathered broilers, suggesting propolis residue beneficially influences color. Dietary propolis residue significantly reduced breast muscle water loss rate and drip loss, with the 1.0% level also significantly reducing thigh muscle drip loss, indicating improved water-holding capacity. This agrees with Peng Helu et al. [17], who concluded that propolis and bee pollen significantly improved pork water-holding capacity. Wang Qifa et al. [18] also confirmed that 5% bee pollen supplementation significantly reduced pork drip loss. Regarding tenderness, the experimental groups showed significantly lower thigh muscle shear force than the control group, consistent with Wu Hongxiang et al. [16], who found that 1% propolis alone optimized tenderness in Lingnan yellow-feathered broilers. This may result from active substances in propolis residue promoting endogenous muscle proteases that facilitate muscle tenderization. Zhang Min et al. [14] and Tang Kaijie [19] both confirmed that bee pollen or propolis supplementation significantly affected protein content in yellow-feathered broiler muscle. Research has reported that feeding 14-day-old chicks a diet containing propolis extract at 15 mg/d for 30 days resulted in higher myofibrillar protein organization and chicken protein content than the control group [20]. However, this experiment showed opposite effects on breast muscle shear force, requiring further investigation. Li Tongshu et al. [21] noted that the shear method can distinguish tenderness differences among chicken breeds and that breast and thigh muscle tenderness differs considerably, with thigh muscle generally being more tender than breast muscle in most breeds.

These results demonstrate that propolis residue can improve yellow-feathered broiler muscle quality to some extent. Tu Lijun et al. [22] fed 0.1% propolis to Arbor Acre broilers and evaluated 29 indicators including carcass, meat physical, chemical, and histological properties, concluding through comprehensive analysis that propolis supplementation significantly improved meat quality, with experimental group breast and thigh meat quality surpassing the control group. Zheng Yunlin et al. [23] also concluded that propolis-bee pollen complexes improved pork quality and flavor. This suggests that beneficial components for meat quality improvement remain in propolis residue after utilization. Lu Yuanyuan [7] analyzed volatile components in Brazilian propolis residue and raw propolis using GC-MS, identifying 42 volatile components in propolis residue (79.283% of total volatile content) and 28 in raw propolis (86.073% of total). Both shared 21 components including acetophenone, linalool, methyl phenylpropionate, phenylpropionic acid, caryophyllene, and aromadendrene, with 17 being terpenoid compounds. Propolis residue retains substantial volatile components with antioxidant and antibacterial activities worthy of further research and development. Reports on propolis residue application in livestock produc-

tion are scarce, and this study provides a theoretical basis for propolis residue reuse.

Conclusion

1. Dietary propolis residue supplementation had no significant effect on growth performance of yellow-feathered broilers aged 28 to 56 days.
 2. Dietary propolis residue supplementation significantly increased eviscerated yield in yellow-feathered broilers aged 28 to 56 days, with the 1.0% supplementation level significantly increasing both breast and thigh muscle percentages.
 3. Dietary propolis residue supplementation improved meat color, water-holding capacity, and tenderness in yellow-feathered broilers aged 28 to 56 days, with the 1.0% supplementation level showing superior effects.
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