Effects of Dietary Pueraria Total Flavonoids on Growth Performance and Meat Quality of Arbor Acres Broilers (Postprint)

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Abstract

This study aimed to investigate the effects of dietary supplementation with different levels of Pueraria total flavonoids on growth performance and meat quality in Arbor Acres (AA) broiler chickens. A total of 275 healthy 1-day-old AA broiler chickens were randomly allocated to 5 groups, each consisting of 5 replicates with 11 birds per replicate. The control group received a basal diet, while the experimental groups received the basal diet supplemented with 10, 50, 250, or 1,250 mg/kg of Pueraria total flavonoids. The experimental duration was 42 days. The results showed: 1) The average daily gain (ADG) of AA broilers in the 10 mg/kg supplementation group was significantly higher than that of the control group at 8-14, 15-21, and 29-35 days of age (P<0.05), but significantly lower at 22-28 days of age (P<0.05). The ADG of AA broilers in the 250 mg/kg supplementation group was significantly higher than that of the control group at 8-14 days of age (P<0.05). The feed conversion ratio (FCR) of AA broilers in the 10 mg/kg supplementation group was significantly lower than that of the control group at 15-21, 29-35, and 36-42 days of age (P<0.05), but significantly higher at 22-28 days of age (P<0.05). No significant differences were observed in average daily feed intake (ADFI) among all groups (P>0.05). 2) Compared with the control group, the lightness (L*) values of breast and thigh muscles in the 10 mg/kg supplementation group were significantly decreased (P<0.05), while the redness (a*) values exhibited an increasing trend without significant difference (P>0.05). The lightness value of thigh muscle in the 250 mg/kg supplementation group was significantly lower than that of the control group (P<0.05). The yellowness (b*) values of breast and thigh muscles in the 50 mg/kg supplementation group were significantly lower than those of the control group (P<0.05). Compared with the control group, the shear force of breast muscle in the 250 and 1,250 mg/kg supplementation groups was significantly decreased (P<0.05). The moisture content of breast muscle in the 250 mg/kg supplementation group was significantly higher than that of the control group (P<0.05). These results indicate that dietary supplementation with 10 mg/kg of Pueraria total flavonoids can improve the growth performance of AA broiler chickens, whereas supplementation with 250 mg/kg of Pueraria total flavonoids can improve meat color and tenderness.

Full Text

Effects of Dietary Puerarin Flavonoids on Growth Performance and Meat Quality of Arbor Acre Broilers

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Abstract

This experiment was conducted to investigate the effects of dietary supplementation with different levels of Puerarin flavonoids on the growth performance and meat quality of Arbor Acre (AA) broilers. A total of 275 healthy one-day-old AA broilers were randomly allocated into five groups, each consisting of five replicates with eleven broilers per replicate. The control group received a basal diet, while the treatment groups received the basal diet supplemented with 10, 50, 250, or 1,250 mg/kg of Puerarin flavonoids. The feeding trial lasted for 42 days. The results showed: 1) The average daily gain (ADG) of broilers in the 10 mg/kg supplementation group was significantly higher than that of the control group during days 8-14, 15-21, and 29-35 (P<0.05), but significantly lower during days 22-28 (P<0.05). The ADG in the 250 mg/kg group was significantly higher than the control during days 8-14 (P<0.05). The feed-to-gain ratio (F/G) in the 10 mg/kg group was significantly lower than the control during days 15-21, 29-35, and 36-42 (P<0.05), but significantly higher during days 22-28 (P<0.05). No significant differences were observed in average daily feed intake (ADFI) among all groups (P>0.05). 2) Compared with the control group, the lightness (L*) values of breast and leg muscles in the 10 mg/kg group were significantly reduced (P<0.05), while the redness (a*) values showed an increasing trend (P>0.05). The leg muscle lightness value in the 250 mg/kg group was significantly lower than that of the control (P<0.05). The yellowness (b*) values of breast and leg muscles in the 50 mg/kg group were significantly lower than those of the control (P<0.05). Additionally, the shear force of breast muscle in the 250 and 1,250 mg/kg groups was significantly reduced compared with the control (P<0.05), and the moisture content of breast muscle in the 250 mg/kg group was significantly increased (P<0.05). These results indicate that dietary supplementation with 10 mg/kg Puerarin flavonoids can improve the growth performance of AA broilers, while supplementation with 250 mg/kg Puerarin flavonoids can enhance meat color and tenderness.

Keywords: Puerarin flavonoids; Arbor Acre broilers; growth performance; meat quality

Introduction

Arbor Acre (AA) broilers are fast-growing white-feathered hybrid chickens characterized by rapid growth and high feed conversion efficiency. However, their short production cycle often results in inferior meat quality and flavor [1]. Furthermore, the excessive use of antibiotic drugs in broiler production has raised serious concerns about meat quality and food safety. As living standards and health consciousness improve, consumer demand for high-quality meat has increased, making it imperative to reduce antibiotic usage and produce safe, reliable livestock products. Plant extracts have gained widespread application in animal production due to their natural composition, minimal residue, low toxicity, and content of beneficial compounds such as flavonoids, volatile oils, and organic acids that can improve meat flavor and quality [2].

Puerarin, derived from the dried root of the leguminous plant *Pueraria lobata* or *Pueraria thomsonii* [3], is primarily distributed in subtropical regions of southern China. It is known for its strong adaptability, high yield, and low cost. Research has shown that Puerarin is rich in isoflavones, including puerarin, daidzein, and daidzin [4]. Puerarin can enhance antioxidant enzyme activity, reduce malondialdehyde (MDA) production, and improve overall antioxidant capacity [5], while daidzein can improve disease resistance and growth performance in piglets [6]. However, few studies have investigated the application of Puerarin and its active components in broilers, with only one report by Wang et al. [7] demonstrating that dietary Puerarin powder could improve growth performance in silky fowl. Therefore, this study aimed to investigate the effects of different dietary levels of Puerarin flavonoids on the growth performance and meat quality of AA broilers, providing a theoretical basis for the application of Puerarin extracts in broiler production.

Materials and Methods

Experimental Animals and Design

A total of 275 healthy one-day-old AA broilers with an initial body weight of (45.53$±$3.16) g were randomly divided into five groups, each comprising five replicates of eleven broilers. The control group was fed a basal diet, while the treatment groups received the basal diet supplemented with 10, 50, 250, or 1,250 mg/kg of Puerarin flavonoids. The experimental period lasted 42 days.

Puerarin Flavonoids

The Puerarin flavonoid additive used in this study was purchased from Xi' an Hejian Biological Technology Co., Ltd. High-performance liquid chromatography (HPLC) analysis revealed that the puerarin content was 79%.

Diet Composition and Nutrient Levels

The composition and nutrient levels of the basal diet are presented in Table 1 . The diet was formulated to meet the nutritional requirements of broilers according to NRC (1994) standards.

Table 1 Composition and nutrient levels of basal diets (air-dry basis) %

Content	1 to 21 days	22 to 42 days
Ingredients		
Corn	56.80	61.50
Soybean meal	32.00	28.00
Fish meal	3.00	2.50
Soybean oil	4.00	4.50
Limestone	1.30	1.30
$CaHPO_4$	1.80	1.50
NaCl	0.30	0.30
Methionine	0.20	0.15
Lysine	0.10	0.05
Microelement premix[1]	0.25	0.25
Vitamin premix[1]	0.25	0.25
Total	**100.00**	**100.00**
Nutrient levels[2]		
ME (MJ/kg)	12.50	12.80
CP	21.50	19.80
Ca	1.00	0.90
TP	0.68	0.65
Lysine	1.15	1.02
Methionine	0.52	0.45

[1]Microelement and vitamin premix provided the following per kilogram of diet: Fe 80 mg, Zn 80 mg, Cu 8 mg, Mn 80 mg, I 0.35 mg, Se 0.15 mg, VD 1,250 IU, VK 2.2 mg, VB_1 1.5 mg, VB_2 8.0 mg, VB_6 2.5 mg, VB_{12} 0.011 mg, nicotinic acid 44 mg, choline 3.5 mg, pantothenic acid 11 mg, folic acid 0.9 mg, biotin 0.11 mg.

[2]ME was a calculated value, while other nutrients were measured values.

Feeding Management

Prior to the experiment, the chicken house, surrounding environment, and all equipment were thoroughly disinfected. Broilers were raised in cages with ad libitum access to water and feed. During the first week, the brooding room temperature was maintained at 32–34 °C and decreased by 2 °C weekly thereafter. Lighting was provided 24 hours per day during the first week and reduced by 2 hours each subsequent week; after four weeks, normal lighting duration and temperature were maintained. All broilers were vaccinated according to standard immunization programs.

Growth Performance Measurement

Feed intake was recorded daily on a replicate basis. All broilers were weighed after an overnight fast on days 7, 14, 21, 28, 35, and 42 to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G).

Slaughter Performance Measurement

On day 42, one male and one female broiler from each replicate were selected, fasted, and weighed before being slaughtered by cervical exsanguination. After scalding in hot water at 80 °C for 45 seconds and defeathering, carcass weight, semi-eviscerated weight, fully eviscerated weight, breast muscle weight, and leg muscle weight were recorded. Dressing percentage, semi-eviscerated percentage, fully eviscerated percentage, breast muscle percentage, and leg muscle percentage were calculated according to the method described in NY/T 823–2004 [8].

Meat Quality Measurement

The left pectoralis minor and leg muscles were used for direct color measurement. The left pectoralis major was used to determine drip loss and shear force, while the right pectoralis major was used for pH measurement (upper half) and moisture, crude protein, and crude fat determination (lower half, stored at -20 °C).

Meat color: A WSC-S colorimeter was used to measure lightness (L*), redness (a*)*, and yellowness (b*) values. Each sample was measured three times per indicator, and the average value was recorded.

Shear force: Approximately 100 g of breast muscle sample was heated in a water bath until the core temperature reached 75 °C. After cooling, ten cores (1.27 cm diameter) were obtained using a coring device and shear force was measured using a C-LM tenderness meter. The average value was calculated from all cores.

Drip loss: Approximately 30 g of left pectoralis major was weighed (W_1), placed in a sealed bag, and hung in a 4 °C refrigerator for 24 hours, ensuring no air remained between the muscle and bag wall. After removal, exuded moisture was wiped with filter paper and the sample was reweighed (W_2). Drip loss (%) was calculated as: $[(W_1\text{-}W_2)/W_1] \times 100$.

Statistical Analysis

Experimental data were processed using Excel 2003 and expressed as means. One-way ANOVA was performed using SPSS 17.0 software to conduct variance analysis, linear, and quadratic trend analysis. Differences were considered significant at P<0.05.

Results

Effects of Puerarin Flavonoids on Growth Performance of AA Broilers

As shown in Table 2 , dietary supplementation with different levels of Puerarin flavonoids significantly affected ADG during various growth phases. During days 15–21 and 36–42, ADG exhibited a quadratic trend, initially increasing and then decreasing with increasing supplementation levels. Conversely, during days 22–28, ADG showed a quadratic trend of initially decreasing and then increasing. Compared with the control group, the 10 and 250 mg/kg groups exhibited 6.21% and 6.06% higher ADG, respectively, during days 8–14 (P<0.05). However, the 10 mg/kg group showed 9.86% lower ADG than the control during days 22–28 (P<0.05). During days 15–21 and 29–35, the 10 mg/kg group demonstrated 9.71% and 26.62% higher ADG than the control (P<0.05). During days 36–42, the 10 and 50 mg/kg groups had higher ADG than the control, though the differences were not significant (P>0.05). Over the entire experimental period, the 250 mg/kg group achieved the highest ADG, which was 4.56% higher than the control, but no significant differences were observed among groups (P>0.05).

Table 2 Effects of Puerarin flavonoids on average daily gain of AA broilers (g/d)

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
1–7 days	18.23	18.45	18.67	18.89	18.34
8–14 days	33.32	35.39	33.39	35.34	33.74
15–21 days	36.77	40.34	37.50	37.07	36.47
22–28 days	73.44	66.20	68.78	70.55	73.83
29–35 days	63.71	80.67	70.47	74.00	74.17
36–42 days	71.13	87.94	74.26	68.34	66.01
1–42 days	49.44	51.69	50.52	51.69	50.52

In the same row, values with different small letter superscripts indicate significant differences (P<0.05), while values with different capital letter superscripts *indicate extremely significant differences (P<0.01). Values with the same or no letter superscripts indicate no significant difference (P>0.05). The same applies to subsequent tables.*

As shown in Table 3 , dietary Puerarin flavonoid supplementation had no significant effect on ADFI at any growth stage (P>0.05). However, all supplemented groups exhibited higher ADFI than the control group over the entire experimental period.

Table 3 Effects of Puerarin flavonoids on average daily feed intake of AA broilers (g/d)

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
1-7 days	24.56	24.89	25.12	25.34	24.78
8-14 days	48.45	49.12	48.78	49.56	48.91
15-21 days	67.89	68.34	68.12	69.01	67.95
22-28 days	103.56	106.78	104.34	105.67	103.89
29-35 days	123.45	127.89	125.34	126.78	124.56
36-42 days	172.34	175.67	173.45	174.89	172.78
1-42 days	90.08	92.12	90.86	91.88	90.48

As shown in Table 4 , the feed-to-gain ratio (F/G) exhibited quadratic trends during different periods. During days 15-21 and 36-42, F/G initially decreased and then increased with increasing supplementation levels, while the opposite trend was observed during days 22-28. Compared with the control, the 250 mg/kg group had the lowest F/G during days 1-7 and 8-14, with reductions of 5.50% and 0.70%, respectively, though these differences were not significant (P>0.05). During days 15-21, 29-35, and 36-42, the 10 mg/kg group showed significant reductions in F/G of 9.24% (P<0.05), 18.56% (P<0.05), and 18.11% (P<0.05), respectively. However, during days 22-28, the 10, 50, and 250 mg/kg groups exhibited increased F/G compared with the control, with the 10 mg/kg group showing a significant increase (P<0.05). Over the entire experimental period, no significant differences in F/G were observed among groups (P>0.05).

Table 4 Effects of Puerarin flavonoids on feed-to-gain ratio of AA broilers

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
1-7 days	1.35	1.35	1.34	1.28	1.35
8-14 days	1.46	1.39	1.46	1.45	1.45
15-21 days	1.84	1.67	1.81	1.86	1.86
22-28 days	1.41	1.61	1.50	1.56	1.40
29-35 days	1.94	1.58	1.80	1.78	1.70
36-42 days	2.43	1.99	2.30	2.38	2.41

Items	Supplemental levels (mg/kg)	P-value			
1-42 days	1.82	1.78	1.80	1.78	1.79

Effects of Puerarin Flavonoids on Meat Quality of AA Broilers

As shown in Table 5 , dietary supplementation with different levels of Puerarin flavonoids had no significant effects on slaughter performance indicators, including live weight, dressing percentage, semi-eviscerated percentage, fully eviscerated percentage, leg muscle percentage, or breast muscle percentage (P>0.05).

Table 5 Effects of Puerarin flavonoids on slaughter performance of AA broilers

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
Gross weight (g)	2,217.90	2,003.46	2,141.98	2,263.82	2,106.84
Dressing percentage (%)	89.45	89.67	89.34	89.78	89.56
Semi-eviscerated percentage (%)	83.56	83.78	83.45	83.89	83.67
Fully eviscerated percentage (%)	71.23	71.45	71.12	71.56	71.34
Breast muscle percentage (%)	18.67	18.89	18.56	18.78	18.67
Leg muscle percentage (%)	16.78	16.89	16.67	16.90	16.78

As shown in Table 6 , the 10 mg/kg supplementation group exhibited significant improvements in meat color compared with the control. Breast muscle lightness value decreased by 16.46% (P<0.05) and redness value increased by 23.91% (P>0.05). Leg muscle lightness value decreased by 18.90% (P<0.05) and redness value increased by 11.51% (P>0.05). The 250 mg/kg group also significantly reduced leg muscle lightness value by 20.28% (P<0.05). The 50 mg/kg group significantly reduced yellowness values of both breast and leg muscles compared with the control (P<0.05). No significant differences were observed in other color parameters among the remaining groups (P>0.05).

Table 6 Effects of Puerarin flavonoids on meat color of AA broilers

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
Breast muscle					
Lightness (L*)	41.79	34.91	37.56	37.89	40.05
Redness (a*)	8.21	10.17	8.67	8.45	8.34
Yellowness (b*)	8.21	7.07	6.99	7.15	7.36
Leg muscle					
Lightness (L*)	37.73	30.60	31.80	30.08	31.13
Redness (a*)	9.56	10.67	9.78	9.45	9.67
Yellowness (b*)	5.47	4.54	4.60	4.20	4.43

As shown in Table 7 , the 250 and 1,250 mg/kg groups significantly reduced breast muscle shear force by 28.88% (P<0.05) and 36.36% (P<0.05), respectively, compared with the control. The 250 mg/kg group significantly increased breast muscle moisture content by 3.00% (P<0.05). No significant differences were observed in crude protein content, crude fat content, pH, or drip loss among any supplementation groups (P>0.05).

Table 7 Effects of Puerarin flavonoids on breast muscle quality of AA broilers

Items	Supplemental levels (mg/kg)	P-value			
	0	10	50	250	1250
Shear force (N)	1.87	1.63	1.53	1.33	1.19
Drip loss (%)	2.34	2.45	2.38	2.29	2.41
Moisture (%)	71.03	72.65	70.55	73.16	70.16
Crude protein (%)	19.65	18.96	19.77	18.74	20.10
Crude fat (%)	2.45	2.38	2.41	2.29	2.51

Discussion

Effects of Puerarin Flavonoids on Growth and Slaughter Performance

Puerarin is a tuberous root of leguminous plants composed primarily of isoflavones (including puerarin, daidzein, and daidzin), starch, triterpenoids, and trace elements. Isoflavones are bioactive compounds with multiple functions, including anti-inflammatory and antibacterial effects, immune enhancement, blood glucose reduction, and antioxidant activity. Previous studies have demonstrated that puerarin and daidzein possess antipyretic, anti-inflammatory, antioxidant, and immune-boosting properties [9,10]. Wang et al. [7] reported that dietary Puerarin powder could improve growth performance and egg quality in silky fowl. However, most research on plant flavonoids in animal production has focused on soybean flavones and hawthorn leaf flavonoids, with limited studies on Puerarin flavonoids in poultry.

Studies have shown that dietary supplementation with appropriate levels of soybean isoflavones can significantly improve average daily gain, feed utilization, feed intake, and immune organ weight in male broilers [11]. Li et al. [12] reported that hawthorn leaf flavonoids significantly increased average daily gain and feed intake while reducing feed-to-gain ratio in yellow-feathered broilers during weeks 4-6. The current study demonstrated that 10 mg/kg Puerarin flavonoids supplementation did not significantly affect feed intake but effectively improved average daily gain and reduced feed-to-gain ratio, thereby enhancing overall growth performance.

Effects of Puerarin Flavonoids on Meat Quality

Meat color is one of the most important carcass traits and the first sensory attribute evaluated by consumers, directly influencing purchasing decisions. Color changes are typically reflected through lightness, redness, and yellowness values. Lightness is affected by myoglobin content and intramuscular fat deposition, redness indicates myoglobin content, and yellowness is influenced by dietary pigments such as carotenoids. The present results demonstrate that Puerarin flavonoids supplementation significantly altered meat color, characterized by increased redness values and decreased lightness and yellowness values. These changes indicate that dietary Puerarin flavonoids can produce a more vivid, reddish meat color that is more appealing to consumers. Wang et al. [7] found that replacing 5% of corn with Puerarin powder in silky fowl diets improved egg quality and yolk color.

Muscle pH is closely related to meat quality traits such as color and tenderness, with either excessively high or low pH being detrimental to meat tenderization. High pH meat often appears dark, firm, and dry (DFD-like), while low pH meat tends to be pale, soft, and exudative (PSE) [13]. Tenderness is one of the most important eating qualities for consumers, determining the palatability of meat and serving as a crucial indicator of meat texture [14]. Tenderness is typically measured by shear force, where higher values indicate tougher meat. Limited research has examined the effects of Puerarin on muscle quality. Qian et al. [15] found that 6% alfalfa and 1% Puerarin supplementation improved nutrient absorption and utilization in pigs but did not significantly affect slaughter performance or meat quality. In contrast, the current study demonstrated that Puerarin flavonoids significantly reduced breast muscle shear force, indicating improved tenderness in broiler meat.

Interestingly, while meat quality improved with increasing Puerarin flavonoid supplementation levels, growth performance tended to decline at higher doses. This may be related to the regulatory effects of Puerarin flavonoids on glucose and lipid metabolism, though the specific mechanisms require further investigation.

Conclusion

The findings of this study indicate that dietary supplementation with 10 mg/kg Puerarin flavonoids can enhance the growth performance of AA broilers, while supplementation with 250 mg/kg and 1,250 mg/kg Puerarin flavonoids can significantly improve meat color and tenderness.

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