Effects of Dietary Arginine Level on Meat Quality in Broiler Chickens: Postprint

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Abstract

This study aimed to investigate the effects of dietary arginine (Arg) level on meat quality in broiler chickens. A total of 192 1-day-old Ross 308 broiler chickens (half male and half female) were divided into 4 treatments based on similar body weight, with 8 replicates per treatment and 6 birds per replicate. The four experimental diets consisted of a corn-soybean meal basal diet supplemented with 0 (control), 0.3%, 0.6%, and 0.9% L-Arg, respectively. The experimental period was 42 days. The results indicated that dietary Arg level linearly increased leg muscle percentage ($P<0.50$), with the 0.6% Arg supplementation group achieving the highest leg muscle percentage, which was 12.08% higher than the control group. Dietary Arg level tended to linearly decrease abdominal fat percentage ($P<0.10$), with the 0.9% Arg supplementation group showing the lowest abdominal fat percentage, which was 10.20% lower than the control group. Dietary Arg level linearly decreased crude fat content in leg muscle ($P<0.01$), with the 0.6% Arg supplementation group showing the lowest crude fat content in leg muscle, which was 21.64% lower than the control group. Dietary Arg level exhibited a quadratic effect (decreasing first and then increasing) on hardness ($P<0.01$) and springiness ($P<0.01$) of leg muscle, and hardness ($P<0.10$) and springiness ($P<0.05$) of breast muscle; when 0.3% Arg was supplemented, the springiness of leg muscle and hardness and springiness of breast muscle decreased to the minimum, being 46.34%, 10.24%, and 41.79% lower than the control group, respectively. Dietary Arg level showed a quadratic effect (decreasing first and then increasing) on the contents of C16:0, C16:1, C18:1, and C18:0 ($P<0.05$) and C20:0 and C20:3 ($P<0.10$) in leg muscle. When 0.6% Arg was supplemented, the contents of C16:0, C16:1, C18:1, C18:0, C20:0, and C20:3 in leg muscle were the lowest, being 48.58%, 52.67%, 48.40%, 46.72%, 54.08%, and 34.29% lower than the control group, respectively. Appropriate supplementation of Arg in the diet could increase leg muscle percentage in broilers, tended to decrease abdominal fat percentage, reduce crude fat and some fatty acid contents in leg

muscle, and decrease the hardness and springiness of leg and breast muscles.

Full Text

Effects of Dietary Arginine Level on Meat Quality of Broilers

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Abstract

This study investigated the effects of dietary arginine (Arg) levels on meat quality in broilers. One hundred ninety-two 1-day-old Ross 308 broilers (half male and half female) were randomly allocated to four treatments, with eight replicates per treatment and six birds per replicate. The four dietary treatments consisted of a corn-soybean meal basal diet supplemented with 0 (control), 0.3%, 0.6%, or 0.9% L-Arg. The experiment lasted 42 days. Results showed that dietary Arg level linearly increased leg muscle percentage ($P<0.05$). Broilers fed 0.6% Arg exhibited the highest leg muscle percentage, which was 12.08% higher than the control. Dietary Arg level tended to linearly decrease abdominal fat percentage ($P<0.10$). Broilers fed 0.9% Arg showed the lowest abdominal fat percentage, decreasing by 10.20% compared to the control. Dietary Arg level linearly decreased crude fat content in leg muscle ($P<0.01$). The 0.6% Arg treatment yielded the lowest crude fat content in leg muscle, reducing it by 21.64% compared to the control. Dietary Arg level exhibited a quadratic effect (first decreasing then increasing) on hardness ($P<0.01$) and springiness ($P<0.01$) of leg muscle, as well as hardness ($P<0.10$) and springiness ($P<0.05$) of breast muscle. When 0.3% Arg was added, leg muscle springiness and breast muscle hardness and springiness reached their minimum values, decreasing by 46.34%, 10.24%, and 41.79% compared to the control, respectively. Dietary Arg level also showed a quadratic effect on C16:0, C16:1, C18:1, and C18:0 contents ($P<0.05$) and C20:0 and C20:3 contents ($P<0.10$) in leg muscle. At 0.6% Arg supplementation, these fatty acid contents were lowest, decreasing by 48.58%, 52.67%, 48.40%, 46.72%, 54.08%, and 34.29% for C16:0, C16:1, C18:1, C18:0, C20:0, and C20:3, respectively, compared to the control. In conclusion, appropriate Arg supplementation can increase leg muscle percentage, tend to reduce abdominal fat percentage, decrease crude fat and certain fatty acid contents in leg muscle, and reduce hardness and springiness of both leg and breast muscles.

Keywords: arginine; broilers; meat quality; fatty acid

Introduction

While selective breeding for rapid growth in broilers has improved production efficiency, it has also increased fat deposition in birds. Although appropriate body fat content is physiologically necessary and contributes to meat flavor, excessive fat accumulation is undesirable as it negatively affects meat quality, reduces consumer appeal, wastes feed resources, and results in abdominal and subcutaneous fat being discarded as waste during processing. Reducing fat content can improve feeding efficiency and carcass quality, lower mechanized processing costs, and enhance consumer acceptance. Previous studies have demonstrated that arginine (Arg) supplementation in drinking water can specifically reduce fat mass in Zucker diabetic fatty (ZDF) rats and diet-induced obese rats. Dietary Arg has been shown to decrease carcass fat by 11% in growing-finishing pigs while increasing intramuscular fat content. However, research prior to 1998 primarily focused on Arg requirements in broilers, with limited investigation into its effects on muscle quality. We hypothesized that appropriate dietary Arg levels could similarly reduce fat deposition and improve muscle quality in broilers. This study aimed to investigate the effects of different dietary Arg levels on broiler meat quality to determine optimal supplementation rates in corn-soybean meal-based diets and provide a theoretical basis for the rational use of this nutritional additive.

Materials and Methods

1.1 Experimental Animals and Basal Diet The experimental animals were Ross 308 broilers purchased from Henan Dayong Industrial Co., Ltd. The basal diet was a commercial complete feed from the same company, composed of corn, soybean meal, cottonseed meal, rapeseed meal, oil, salt, limestone, calcium hydrogen phosphate, vitamin premix, trace mineral premix, methionine, enzymes, choline chloride, mold inhibitors, antioxidants, and medications (maduramicin ammonium premix at 5 mg/kg and kitasamycin premix at 10 mg/kg). The trace mineral and vitamin premix composition met the requirements for broilers specified in the Chinese Feeding Standard of Chickens (NY/T33-2004). Dietary composition and nutrient levels are presented in Table 1 .

1.2 Experimental Design A randomized block design was employed. One hundred ninety-two 1-day-old Ross 308 broilers with initial body weight of (42.8$±$2.6) g, half male and half female, were divided into four treatments according to similar body weight principles, with eight replicates per treatment and six birds per replicate. The four dietary treatments consisted of the basal diet supplemented with 0 (control), 0.3%, 0.6%, or 0.9% Arg. Following the method of Kim et al. [5], food-grade L-Arg (99.0% purity) and L-alanine (99.0% purity) were used to formulate isonitrogenous diets with different Arg levels (Tables 2 and 3). Dietary crude protein (CP) levels were 20.6% for days 1-21 (starter phase) and 18.7% for days 22-42 (grower phase). Dietary Arg levels were 110%, 130%, 150%, and 170% of NRC (1994) requirements during the starter phase, and 125%, 150%, 175%, and 200% during the grower phase. The Arg/lysine (Lys) ratios were 1.11, 1.35, 1.44, and 1.77 for the starter phase, and 1.19, 1.66, 1.72, and 1.92 for the grower phase. All experimental diets were fed in mash form. The feeding trial lasted 42 days.

1.3 Management Practices All treatments were housed in the same building under conventional management. Broilers were reared in wire-bottom cages. During the first two weeks, lighting was maintained at 24 h/d. House temperature was kept at 33°C for the first 3 days, then reduced by 3°C weekly until reaching 24°C, which was maintained thereafter. All birds had free access to feed and water. The house was cleaned daily, and manure was removed regularly. Vaccination and disinfection followed standard procedures. Mortality and morbidity were recorded daily. The experiment was conducted at the Animal Training Center of Henan Institute of Science and Technology.

1.4 Measurements At 42 days of age, after overnight feed withdrawal, one bird per replicate was slaughtered. Breast and leg muscles were completely dissected and weighed to determine breast muscle percentage and leg muscle percentage. Fresh samples from the right breast and leg muscles were used to determine hardness and springiness immediately. Left leg muscle samples were stored at -20°C, then freeze-dried (Alpha1-4LSC freeze dryer, Christ, Germany) for subsequent analysis of crude fat and fatty acid composition.

Breast muscle percentage, leg muscle percentage, and abdominal fat percentage were determined according to the Poultry Performance Terminology and Measurement Methods (NY/T 823-2004): - Breast muscle percentage (%) = (weight of both breast muscles / eviscerated carcass weight) × 100 - Leg muscle percentage (%) = (weight of both leg muscles / eviscerated carcass weight) × 100 - Abdominal fat percentage (%) = [abdominal fat weight / (eviscerated carcass weight + abdominal fat weight)] × 100

For hardness and springiness measurements, square meat samples (2 cm × 2 cm) of uniform thickness were cut from the same anatomical location of each muscle type. Within 12 h post-slaughter, a TA-XTPlus texture analyzer (Stable Micro Systems, UK) was used following the method of Yu [6] to compress samples to 50% of their original height perpendicular to muscle fiber direction. Parameters were: probe P50; pre-test speed 5 mm/s; test speed 2 mm/s; post-test speed 10 mm/s; compression ratio 50%; interval time 5 s; trigger type auto; trigger force 5 g. Each test was repeated twice.

Crude fat content in leg muscle was determined by ether extraction. Fatty acid composition was measured by gas chromatography-mass spectrometry (Thermo Trace DSQII GC/MS, USA) using a capillary column (30 m × 0.25 mm × 0.25 µm), following the method of Kramer et al. [7].

1.5 Statistical Analysis Data were analyzed using SAS 9.2 software. Linear and quadratic regression analyses were performed to evaluate treatment effects of different Arg levels. Differences were considered significant at $P<0.05$, highly significant at $P<0.01$, and indicative of a trend at $P<0.10$.

Results

2.1 Effects of Dietary Arg Level on Meat Performance of 42-Day-Old Broilers As shown in Table 4 , increasing dietary Arg level linearly increased leg muscle percentage ($P<0.05$) at 42 days of age without affecting breast muscle percentage ($P>0.10$). The 0.6% Arg treatment produced the highest leg muscle percentage, improving it by 12.08% compared to the control. Dietary Arg level tended to linearly decrease abdominal fat percentage ($P<0.10$). The 0.9% Arg treatment yielded the lowest abdominal fat percentage, reducing it by 10.20% compared to the control. Dietary Arg level linearly decreased crude fat content in leg muscle ($P<0.01$). The 0.6% Arg treatment resulted in the lowest crude fat content, decreasing it by 21.64% compared to the control. Dietary Arg level (x) was moderately correlated with crude fat content in leg muscle (y), with linear and quadratic regression equations of $y=-0.858x+5.6832$ ($R^2=0.0937$) and $y=3.2114x^2-3.8184x+6.0048$ ($R^2=0.1877$), respectively.

2.2 Effects of Dietary Arg Level on Muscle Hardness and Springiness of 42-Day-Old Broilers As shown in Table 5 , increasing dietary Arg level produced a quadratic effect (first decreasing then increasing) on hardness ($P<0.01$) and springiness ($P<0.01$) of leg muscle, as well as hardness ($P<0.10$) and springiness ($P<0.05$) of breast muscle. At 0.3% Arg supplementation, leg muscle springiness and breast muscle hardness and springiness reached their minimum values, decreasing by 46.34%, 10.24%, and 41.79% compared to the control, respectively.

2.3 Effects of Dietary Arg Level on Leg Muscle Fatty Acid Composition of 42-Day-Old Broilers As shown in Table 6 , increasing dietary Arg level produced a quadratic effect on C16:0, C16:1, C18:1, and C18:0 fatty acid contents ($P<0.05$) and a trend for a quadratic effect on C20:0 and C20:3 contents ($P<0.10$) in leg muscle. At 0.6% Arg supplementation, fatty acid contents were lowest, with C16:0, C16:1, C18:1, C18:0, C20:0, and C20:3 decreasing by 48.58%, 52.67%, 48.40%, 46.72%, 54.08%, and 34.29%, respectively, compared to the control.

Discussion

This study found that 0.3% to 0.6% Arg supplementation linearly increased leg muscle percentage at 42 days without affecting breast muscle percentage, indicating that Arg levels exceeding NRC standards (dietary CP at 20.6% in the starter phase and 18.7% in the grower phase; Arg/Lys ratios of 1.11, 1.35, 1.44, and 1.77 in the starter phase and 1.19, 1.66, 1.72, and 1.92 in the grower phase) promoted leg muscle development without influencing breast muscle development. Literature reports on Arg' s effects on muscle development vary considerably. Mendes et al. [8] reported that dietary Arg level (CP 19.92%, Arg/Lys 1.1-1.4) did not significantly affect breast muscle percentage in male Ross broilers. Hurwitz et al. [9] found that dietary Arg level (0.75%-1.50%) significantly increased breast muscle percentage in male Cobb broilers at low CP (18%) but not at high CP (23%). Fernandes et al. [10] reported that Arg (starter CP 22.4%, Arg/Lys 1.1-1.4; grower CP 19.7%, Lys 1.099%, Arg 1.249%) did not significantly affect breast muscle percentage in male Cobb broilers. In other species, Jobgen et al. [11] found that Arg supplementation (1.51% Arg HCl) in drinking water for 12 weeks significantly increased relative skeletal muscle weight (soleus and extensor digitorum longus) in high-fat diet-induced obese rats. Wu et al. [12] reported that 1% dietary L-Arg significantly increased breast muscle percentage but not leg muscle percentage in Pekin ducks. These discrepancies likely result from differences in dietary CP level, Arg level, Arg/Lys ratio, feeding duration, and animal species.

This study also found that 0.3% to 0.9% Arg supplementation tended to linearly decrease abdominal fat percentage, consistent with previous reports [8-9] and with findings in Pekin ducks [12], ZDF rats [1], and diet-induced obese rats [2]. Additionally, 0.3% to 0.6% Arg linearly decreased crude fat content in leg muscle. Previous studies reported that 1% Arg supplementation significantly increased intramuscular fat content in porcine longissimus dorsi muscle while reducing total carcass fat [3-4]. In the present study, intramuscular and intermuscular fat were not distinguished due to difficulty in completely removing fat attached to leg muscle.

Texture profile analysis using a texture analyzer provides objective, accurate, and standardized quantification of food physical properties, enabling rapid and comprehensive evaluation of meat texture while minimizing subjective human factors. Hardness represents the internal binding force maintaining food structure, while springiness objectively reflects the ability of meat to deform under external force and return to its original state. This study demonstrated a quadratic effect of dietary Arg level on hardness and springiness of both leg and breast muscles, with minimum values observed at 0.3% Arg supplementation. Limited literature exists on Arg' s effects on meat quality. Ma et al. [4] reported that 1% Arg supplementation in finishing pigs significantly reduced drip loss at 48 h post-slaughter in longissimus dorsi muscle at the last thoracic vertebra and improved meat quality, though this effect was not observed in the present study.

Dietary Arg level exhibited a quadratic effect on C16:0, C16:1, C18:1, and C18:0 fatty acid contents in leg muscle, with minimum values at 0.6% Arg supplementation. Few studies have reported Arg' s effects on fatty acids, though Jobgen [2] reported that Arg significantly increased oleic acid oxidation in extensor digitorum longus and soleus muscles, similar to our findings.

Arg supplementation promoted leg muscle growth and reduced body fat deposition, particularly decreasing fat and fatty acid deposition in the leg, suggesting that Arg can alter overall fat and amino acid metabolism in growing broilers and accelerate protein synthesis in physically active skeletal muscles. Studies have shown that Arg can significantly reduce activities of glucose-6-phosphate dehydrogenase (G-6-PDH), malate dehydrogenase (MDH), and fatty acid synthase (FAS) [12], decrease serum levels of insulin, adiponectin, growth hormone, corticosterone, and thyroid hormones [13], reduce hepatic mRNA levels of fatty acid synthase and stearoyl-CoA desaturase, and increase hepatic mRNA levels of AMP-activated protein kinase (AMPK), peroxisome proliferator-activated receptor γ-1α (PPARγ-1α), carnitine, and muscle carnitine palmitoyltransferase-I (CPT-I) [2], thereby accelerating synthesis of cell signaling molecules and upregulating gene expression that promotes oxidation of glucose and fatty acids for energy production [14].

Conclusion

Appropriate dietary Arg supplementation can increase leg muscle percentage, tend to reduce abdominal fat percentage, decrease crude fat content and certain fatty acid contents in leg muscle, and reduce hardness and springiness of both leg and breast muscles.

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