Effects of Dietary Riboflavin Level on Growth Performance and Plasma Biochemical Parameters in 15- to 42-Day-Old Pekin Ducks (Postprint)

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Abstract

This experiment was conducted to investigate the effects of dietary riboflavin levels on growth performance and plasma biochemical indices of 15- to 42-day-old Beijing ducks. A single-factor completely randomized design was employed, and 288 15-day-old male Beijing ducks with similar body weight were randomly allocated to 6 groups with 6 replicates per group and 8 ducks per replicate. The control group was fed a basal diet (riboflavin content of 1.38 mg/kg), while the treatment groups were fed experimental diets supplemented with 1.00, 2.00, 3.00, 4.00, and 5.00 mg/kg riboflavin to the basal diet, respectively. The experimental period lasted 28 days. The results showed that compared with the control group, dietary riboflavin supplementation significantly increased average daily gain and average daily feed intake of 15- to 42-day-old Beijing ducks ($P<0.05$), significantly elevated plasma riboflavin content ($P<0.05$), and significantly decreased plasma alanine aminotransferase activity and triglyceride content ($P<0.05$). These results indicate that dietary riboflavin supplementation can significantly improve growth performance and plasma riboflavin content in 15- to 42-day-old male Beijing ducks. Using average daily gain, average daily feed intake, feed-to-gain ratio, and plasma riboflavin content as evaluation indices, the riboflavin requirement for 15- to 42-day-old male Beijing ducks was estimated to be 2.24–2.66 mg/kg by the broken-line model.

Full Text

Effects of Dietary Riboflavin Level on Growth Performance and Plasma Biochemical Indices of Pekin Ducks from 15 to 42 Days of Age

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Abstract

This experiment was conducted to investigate the effects of dietary riboflavin level on growth performance and plasma biochemical indices of Pekin ducks from 15 to 42 days of age. Using a one-factor completely randomized design, 288 fifteen-day-old male ducks with similar body weight were randomly allocated to 6 groups, each consisting of 6 replicates with 8 ducks per replicate. The control group was fed a basal diet containing 1.38 mg/kg riboflavin, while the experimental groups were fed the basal diet supplemented with 1.00, 2.00, 3.00, 4.00, and 5.00 mg/kg riboflavin, respectively. The experimental period lasted for 28 days. The results showed that compared with the control group, dietary riboflavin supplementation significantly increased average daily weight gain and average daily feed intake ($P<0.05$), significantly elevated plasma riboflavin content ($P<0.05$), and significantly decreased plasma alanine aminotransferase activity and triglyceride content ($P<0.05$). In conclusion, dietary riboflavin supplementation can significantly improve growth performance and plasma riboflavin content in male Pekin ducks from 15 to 42 days of age. Using average daily weight gain, average daily feed intake, feed-to-gain ratio, and plasma riboflavin content as response criteria, the broken-line model estimated the riboflavin requirement for male Pekin ducks from 15 to 42 days of age to be 2.24–2.66 mg/kg.

Keywords: Pekin ducks; riboflavin; vitamin B2; growth performance; plasma biochemical indices

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1. Materials and Methods

1.1 Basal Diet

The basal diet was formulated according to the NRC (1994) nutrient requirements for meat ducks, with composition and nutrient levels shown in Table 1 . The riboflavin content in the basal diet was measured as 1.38 mg/kg using high-performance liquid chromatography [6].

1.2 Experimental Design and Management

A one-factor completely randomized design was employed. Three hundred healthy one-day-old male Pekin ducks were raised on the basal diet until 14 days of age. At 15 days of age, 288 ducks were selected and randomly divided into 6 groups based on consistent body weight, with 6 replicates per group and 8 ducks per replicate. The control group received the basal diet (1.38 mg/kg riboflavin), while the experimental groups received the basal diet supplemented with 1.00, 2.00, 3.00, 4.00, and 5.00 mg/kg riboflavin, resulting in dietary ri-

boflavin levels of 2.38, 3.38, 4.38, 5.38, and 6.38 mg/kg, respectively. The experimental period lasted for 28 days.

Ducks were raised on wire floors with ad libitum access to feed and water. House temperature was gradually reduced from 33 °C to 22 °C in phases. A 24-hour lighting schedule was provided using artificial lighting, and other routine management practices were followed.

1.3 Sampling and Measurements

1.3.1 Growth Performance At 42 days of age, ducks were individually weighed after fasting, and feed consumption was recorded per replicate to calculate average daily weight gain, average daily feed intake, and feed-to-gain ratio.

1.3.2 Plasma Biochemical Indices At 42 days of age, two ducks per replicate with body weight close to the replicate average were selected for cardiac blood collection (10 mL) using anticoagulant-treated tubes. Plasma was prepared by centrifugation at 3,000 rpm for 10 minutes at 4 °C and stored at -20 °C for subsequent analysis. Plasma riboflavin content was determined by high-performance liquid chromatography [7]. Plasma alanine aminotransferase (ALT), aspartate aminotransferase (AST) activities, and triglyceride and total cholesterol concentrations were measured using a Hitachi 721 automatic biochemical analyzer.

1.4 Statistical Analysis

All data were expressed as "mean ± standard deviation" and analyzed using SAS 9.0 software for variance and regression analysis. Duncan' s multiple range test was used for pairwise comparisons with a significance level of $P<0.05$. The broken-line model was used to fit the response of Pekin ducks to graded dietary riboflavin levels. The model was expressed as: $y=l+u(r-x)$ for $x<r$, where y represents average daily weight gain, average daily feed intake, feed-to-gain ratio, or plasma riboflavin content; x is the dietary riboflavin level (mg/kg); r is the riboflavin requirement; l is the response at the breakpoint (when x=r); and u is the slope of the curve.

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2. Results

2.1 Effects of Dietary Riboflavin Level on Growth Performance of Pekin Ducks from 15 to 42 Days of Age

As shown in Table 2 , dietary riboflavin level significantly affected body weight, average daily weight gain, average daily feed intake, and feed-to-gain ratio of Pekin ducks from 15 to 42 days of age ($P<0.05$). Compared with the control

group, dietary riboflavin supplementation significantly increased average daily weight gain and average daily feed intake ($P<0.05$).

2.2 Effects of Dietary Riboflavin Level on Plasma Biochemical Indices of 42-Day-Old Pekin Ducks

As shown in Table 3 , dietary riboflavin level had no significant effect on plasma AST activity or total cholesterol content ($P>0.05$), but significantly affected plasma ALT activity and riboflavin and triglyceride contents ($P<0.05$). Compared with the control group, riboflavin supplementation significantly increased plasma riboflavin content ($P<0.05$), which gradually increased with dietary riboflavin level and plateaued when dietary riboflavin reached 4.38 mg/kg. Additionally, riboflavin supplementation significantly decreased plasma ALT activity and triglyceride content ($P<0.05$).

2.3 Estimation of Riboflavin Requirement for Pekin Ducks from 15 to 42 Days of Age

Using the broken-line model, the riboflavin requirements for male Pekin ducks from 15 to 42 days of age were estimated based on average daily weight gain, average daily feed intake, feed-to-gain ratio, and plasma riboflavin content, yielding values of 2.33, 2.36, 2.24, and 2.66 mg/kg, respectively (Table 4).

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3. Discussion

3.1 Effects of Dietary Riboflavin Level on Growth Performance of Pekin Ducks

Riboflavin is an essential precursor for synthesizing flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). As coenzymes of numerous flavoproteins, FMN and FAD participate in various metabolic processes, including fatty acid oxidation, the tricarboxylic acid cycle, mitochondrial electron transport, and amino acid degradation [1-2]. Numerous studies have demonstrated that riboflavin deficiency impairs poultry growth and reduces feed efficiency, while riboflavin supplementation significantly improves growth performance [8-11]. In this experiment, riboflavin deficiency (1.38 mg/kg) significantly inhibited growth performance in the later growth stage, decreasing average daily weight gain and average daily feed intake while increasing feed-to-gain ratio. Dietary riboflavin supplementation significantly improved average daily weight gain and average daily feed intake and reduced feed-to-gain ratio, consistent with previous findings in starter Pekin ducks [5]. However, unlike Tang et al. [5] who reported high mortality, neck retraction, partial paralysis, rough feathers, and diarrhea in ducks fed a basal diet (1.20 mg/kg riboflavin), these symptoms were not observed in the current study, possibly because riboflavin requirements are lower during the later growth stage.

3.2 Effects of Dietary Riboflavin Level on Plasma Biochemical Indices of Pekin Ducks

Plasma riboflavin content is a sensitive indicator of riboflavin nutritional status [5,12-15]. Xu et al. [12] reported that rats fed a riboflavin-deficient diet for 4 weeks had plasma riboflavin levels only 8.1% of control values. Similarly, 21-day-old Pekin ducks fed a riboflavin-deficient diet for 3 weeks showed plasma riboflavin levels at 15% of controls [16]. In this study, 42-day-old ducks fed a riboflavin-deficient diet from 15 days of age exhibited plasma riboflavin levels at 15.3% of control values, confirming that plasma riboflavin content sensitively reflects riboflavin status in Pekin ducks [12,16]. Plasma riboflavin content plateaued when dietary riboflavin reached 4.38 mg/kg, consistent with previous reports [5,10].

Numerous studies have confirmed the antioxidant function of riboflavin [10-11,17-18]. Riboflavin deficiency alters cell membrane function and fluidity, reducing antioxidant capacity [18]. Plasma ALT and AST activities are sensitive indicators of liver function, with their activities positively correlated with liver damage [19]. This study demonstrated that riboflavin deficiency significantly increased plasma ALT activity in later-stage Pekin ducks, indicating cell membrane damage likely caused by lipid peroxidation due to insufficient riboflavin, which increased membrane permeability.

Studies in rats have shown that riboflavin deficiency can cause fatty liver [20]. In this experiment, riboflavin deficiency significantly increased plasma triglyceride content in later-stage Pekin ducks, possibly due to reduced activity of acyl-CoA dehydrogenase (an FAD-dependent enzyme) that impairs fatty acid β-oxidation [21].

3.3 Determination of Riboflavin Requirement for Pekin Ducks from 15 to 42 Days of Age

The NRC (1994) recommends 4 mg/kg riboflavin for 1- to 3-week-old meat ducks, but this recommendation was based on only two early 20th-century references [3-4], and no literature reports the requirement for later-stage ducks. Therefore, this study aimed to determine the riboflavin requirement for later-stage Pekin ducks to provide a reference for establishing feeding standards.

The broken-line model has been widely used to estimate riboflavin requirements in animals [5,22-24]. Tang et al. [5] estimated riboflavin requirements for starter male Pekin ducks to be 3.31, 3.24, 5.20, 3.82, and 3.91 mg/kg based on average daily weight gain, average daily feed intake, feed-to-gain ratio, plasma riboflavin content, and liver riboflavin content, respectively. Using the same model, this study estimated riboflavin requirements for later-stage male Pekin ducks to be 2.33, 2.36, 2.24, and 2.66 mg/kg based on average daily weight gain, average daily feed intake, feed-to-gain ratio, and plasma riboflavin content, respectively. These results indicate that riboflavin requirements are lower during the later growth stage than during the starter stage, consistent with Heuser et al. [25]

who found that riboflavin requirements for White Leghorn chickens gradually decreased with age. The estimated requirements in this study are lower than the NRC (1994) recommendation of 4 mg/kg for 2- to 7-week-old Pekin ducks.

Conclusion

Under the conditions of this experiment, dietary riboflavin supplementation significantly improved growth performance and plasma riboflavin content in Pekin ducks from 15 to 42 days of age. Using average daily weight gain, average daily feed intake, feed-to-gain ratio, and plasma riboflavin content as response criteria, the broken-line model estimated the riboflavin requirement for male Pekin ducks from 15 to 42 days of age to be 2.24–2.66 mg/kg.

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