Dietary Lysine Requirement of 5-8-Week-Old Jinghong No. 1 Laying Hens Postprint

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Abstract

This study aimed to investigate the dietary lysine (Lys) requirement of Jinghong No. 1 laying hens aged 5-8 weeks. A total of 360 female Jinghong No. 1 chicks at 4 weeks of age were randomly allocated to 5 groups with 6 replicates per group and 12 birds per replicate. Dietary Lys levels were 0.70%, 0.84%, 0.98%, 1.12%, and 1.26%, and the experimental period lasted 4 weeks. The results showed that: the 0.84% Lys group had significantly higher average daily gain, body weight at 8 weeks, and flock uniformity compared with the 1.26% Lys group ($P<0.05$). The 0.98% and 1.12% Lys groups exhibited significantly better physical development than the 1.26% Lys group ($P<0.05$). The duodenal weight and jejunal length in the 0.98% and 1.12% Lys groups were significantly higher than those in the 0.70% and 1.26% Lys groups ($P<0.05$). The thymus index in the 0.84% Lys group was significantly higher than that in the 0.98%, 1.12%, and 1.26% Lys groups ($P<0.05$); the bursa of Fabricius index in the 0.84%, 0.98%, and 1.12% Lys groups was significantly higher than that in the other groups ($P<0.05$). The serum total protein and albumin contents in the 0.84%, 0.98%, and 1.12% Lys groups were significantly higher than those in the 0.70% and 1.26% Lys groups ($P<0.05$); the serum urea nitrogen and uric acid contents in the 0.98% Lys group were significantly lower than those in the 1.26% Lys group ($P<0.05$); the serum alkaline phosphatase activity and plasma growth hormone content in the 0.84% Lys group were significantly higher than those in the 0.70% Lys group ($P<0.05$). Based on body weight at 8 weeks, flock uniformity, eviscerated weight, carcass weight, heart index, liver index, tibia length, duodenal weight, and serum uric acid content, quadratic curves were fitted individually, yielding optimal dietary lysine levels of 0.906%, 0.888%, 0.931%, 0.928%, 0.889%, 0.902%, 0.902%, 1.071%, and 0.958%, respectively. In conclusion, the recommended dietary lysine requirement for Jinghong No. 1 laying hens aged 5-8 weeks is 0.93%.

Full Text

Dietary Lysine Requirement for Jinghong-1 Laying Hens from 5 to 8 Weeks of Age

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Abstract

This study aimed to determine the optimal dietary lysine (Lys) requirement for Jinghong-1 laying hens aged 5–8 weeks. Three hundred sixty 4-week-old Jinghong-1 pullets were randomly allocated to 5 groups with 6 replicates of 12 birds each. The dietary lysine levels were 0.70%, 0.84%, 0.98%, 1.12%, and 1.26%, respectively, and the experimental period lasted 4 weeks. The results showed that the average daily gain, body weight at 8 weeks, and flock uniformity in the 0.84% lysine group were significantly higher than those in the 1.26% lysine group ($P < 0.05$). Birds fed 0.98% and 1.12% lysine diets exhibited significantly better physical development compared to the 1.26% lysine group ($P < 0.05$). The duodenum weight and jejunum length in both the 0.98% and 1.12% lysine groups were significantly greater than those in the 0.70% and 1.26% lysine groups ($P < 0.05$). The thymus index in the 0.84% lysine group was significantly higher than that in the 0.98%, 1.12%, and 1.26% lysine groups ($P < 0.05$), while the bursa of Fabricius index in the 0.84%, 0.98%, and 1.12% lysine groups was significantly higher than in the other groups ($P < 0.05$). Serum total protein and albumin contents in the 0.84%, 0.98%, and 1.12% lysine groups were significantly higher than those in the 0.70% and 1.26% lysine groups ($P < 0.05$). The 0.98% lysine group had significantly lower serum uric nitrogen and uric acid contents compared to the 1.26% lysine group ($P < 0.05$). Serum alkaline phosphatase activity and plasma growth hormone content in the 0.84% lysine group were significantly higher than those in the 0.70% lysine group ($P < 0.05$).

Based on quadratic curve fitting for body weight at 8 weeks, flock uniformity, eviscerated carcass weight, carcass weight, heart index, liver index, tibial length, duodenum weight, and serum uric acid content, the optimal dietary lysine levels were estimated to be 0.906%, 0.888%, 0.931%, 0.928%, 0.889%, 0.902%, 0.902%, 1.071%, and 0.958%, respectively. In conclusion, the recommended dietary lysine requirement for Jinghong-1 laying hens from 5 to 8 weeks of age is 0.93%.

Keywords: lysine; Jinghong-1; growth and development; pullets

Introduction

As the second limiting amino acid in poultry diets, lysine serves as the reference amino acid for "ideal protein" and participates in body protein synthesis while promoting growth. Appropriate dietary lysine provision is crucial for determining the supply of other amino acids. Jinghong-1 is an excellent brown-shell layer strain independently developed in China, characterized by strong adaptability, high egg production, and low feed consumption, making it a recommended breed in China. However, research on its lysine requirements during the brooding period remains limited.

Current studies on amino acid requirements for Jinghong-1 have focused primarily on the peak laying phase and methionine requirements for chicks. Different nutritional standards vary in their classification of growth stages for layer chicks: NRC (1994) divides it into 1–6, 7–12, and 13–18 weeks; China' s *Feeding Standard of Chickens* (NY/T 33–2004) uses 1–8 and 9–18 weeks; Canada' s *Applied Poultry Nutrition* uses 1–6, 7–10, 11–16, and 17–18 weeks; the Hy-Line Brown management guide uses 1–6, 7–12, and 13–15 weeks; and the Lohmann Brown standard divides it into 1–4, 5–8, and 9–15 weeks. Undoubtedly, finer stage division enables diets to better meet chicks' nutritional needs.

Moreover, recommended lysine levels for brown-shell layers vary across standards: NRC (1994) recommends 0.80% (0–6 weeks), NY/T 33–2004 recommends 1.00% (0–8 weeks), Canada' s *Applied Poultry Nutrition* recommends 0.90% (7–10 weeks), and the Hy-Line Brown manual recommends 1.10% (0–6 weeks). Blindly applying these standards may cause nutrient waste and affect future laying performance, whereas appropriate nutrient supply can improve nutritional efficiency, reduce excretion, lower feeding costs, and enhance production efficiency. Researching and updating lysine requirements for layer chicks can better adapt to the growth needs of Jinghong-1 pullets and prepare them for sustained high production during the laying phase. Therefore, this study investigated the effects of dietary lysine levels (0.70%–1.26%) on growth performance, blood indices, and immune and intestinal development in Jinghong-1 layers to determine the appropriate lysine requirement for 5–8-week-old birds.

Materials and Methods

1.1 Experimental Material L-lysine hydrochloride (purity 98.5%) was provided by Evonik Degussa.

1.2 Experimental Design and Diets Three hundred sixty healthy 4-week-old Jinghong-1 pullets with similar body weight [(265.70$±$3.04) g] and no significant differences between groups or replicates ($P > 0.05$) were randomly divided into 5 groups with 6 replicates of 12 birds each using a single-factor design. Experimental diets were formulated based on NRC (1994), NY/T 33–2004, and the Jinghong layer management guide. Crystalline lysine was added to achieve dietary lysine levels of 0.70%, 0.84%, 0.98%, 1.12%, and 1.26% (Ta-

ble 1). All diets were sampled at multiple points (500 g each) and stored at 4°C for analysis of crude protein, calcium, phosphorus, methionine, lysine, and threonine contents.

1.3 Management Birds were housed in two-tier cages with ad libitum access to feed and water. Each cage housed one replicate of 12 birds. Feed was provided three times daily at 07:00, 13:00, and 17:00. Bird health was monitored daily, and mortality was recorded. The lighting schedule was 8 h light:16 h dark. Conventional vaccination protocols were followed. The experimental period lasted 4 weeks.

1.4 Measurements 1.4.1 Growth Performance

All birds were weighed individually at the start of the experiment and on days 8, 15, and 22 after overnight fasting at 06:00. Weekly feed consumption was measured each Sunday at 20:00 to calculate average daily feed intake (ADFI). At the end of the experiment, all birds were weighed individually to determine community evenness (CE), average daily gain (ADG), and feed/gain ratio (F/G).

CE (%) = (number of birds within $±$10% of mean body weight / total birds per replicate) × 100.

1.4.2 Physical Development and Indices of Digestive and Immune Organs

At the end of week 4, two birds per replicate were randomly selected, weighed, and euthanized by cervical venous bleeding. Carcass weight, eviscerated carcass weight, and heart and liver weights were measured to calculate heart and liver indices. Tibial length was measured with vernier calipers.

Heart (liver) index (%) = [heart (liver) weight / live body weight] × 100.

The pancreas was weighed. The duodenum, jejunum, and ileum were removed, straightened naturally, and measured for length. The thymus, spleen, and bursa of Fabricius were dissected, surface connective tissue was removed, and organs were weighed to calculate immune organ indices.

Immune organ index (%) = (immune organ weight / live body weight) × 100.

1.4.3 Blood Indices

At the end of week 4, two birds per replicate were randomly selected, and 10 mL of blood was collected from the jugular vein. Six milliliters was allowed to clot at room temperature, then centrifuged at 3,500 r/min for 15 min to obtain serum. The remaining 4 mL was placed in heparinized tubes and centrifuged at 3,500 r/min for 10 min to obtain plasma. Both serum and plasma samples were stored at -20°C.

Serum total protein (TP), albumin (ALB), urea nitrogen (UN), uric acid (UA) contents, and alkaline phosphatase (ALP) activity were determined using an

automatic biochemical analyzer with kits purchased from Shanghai Kehua Bioengineering Co., Ltd. Plasma growth hormone (GH) content was measured by radioimmunoassay (RIA) at Beijing Northern Biotechnology Research Institute using kits from Nanjing Jiancheng Bioengineering Institute.

1.4.4 Dietary Nutrient Content

Dietary crude protein was determined according to GB/T 6432–1994, calcium according to GB/T 13885–2003, phosphorus according to GB/T 6437–2002, and methionine, lysine, and threonine according to GB/T 18246–2000.

1.5 Statistical Analysis Results are expressed as "mean ± standard deviation." Data were analyzed using one-way ANOVA in SPSS 19.0, with LSD multiple comparison tests for significance ($P < 0.05$). Quadratic curves were fitted using regression curve estimation. When significant quadratic effects were obtained, the lysine level for maximum response was calculated using the method recommended by Wasserman et al. [10], and the appropriate lysine requirement was determined as 95% of this value.

Results

2.1 Effects of Dietary Lysine Level on Growth Performance of Jinghong-1 Hens from 5 to 8 Weeks As shown in Table 2 , dietary lysine level had no significant effect on feed/gain ratio (F/G) during the experimental period ($P > 0.05$), with the 0.98% lysine group showing the lowest F/G. Both ADG and body weight at 8 weeks increased initially and then decreased with increasing dietary lysine levels. The 0.84% lysine group achieved the highest ADG, which was significantly higher than that of the 1.26% lysine group ($P < 0.05$). This group also had the highest body weight at 8 weeks, significantly exceeding all other groups ($P < 0.05$). Average daily feed intake (ADFI) decreased initially then increased with lysine level, with the 0.98% and 1.12% lysine groups showing significantly lower ADFI than the 0.70% lysine group ($P < 0.05$). Community evenness (CE) exhibited a quadratic trend (increasing then decreasing) with dietary lysine level, and the 0.84%, 0.98%, and 1.12% lysine groups had significantly higher CE than the 1.26% lysine group ($P < 0.05$). Overall, dietary lysine levels between 0.84% and 1.12% supported better growth performance in Jinghong-1 pullets.

2.2 Effects of Dietary Lysine Level on Physical Development of Jinghong-1 Hens at 8 Weeks Table 3 shows that eviscerated carcass weight increased initially then decreased quadratically with dietary lysine level, with the 0.98% and 1.12% lysine groups being significantly higher than the 0.70% and 1.26% lysine groups ($P < 0.05$). Carcass weight and heart index also increased then decreased, with the 0.84%, 0.98%, and 1.12% lysine groups significantly exceeding the 1.26% lysine group ($P < 0.05$). The 0.98% lysine group had significantly higher liver index and tibial length than all other groups ($P < 0.05$). In summary, dietary lysine level significantly affected

carcass weight, eviscerated carcass weight, heart index, liver index, and tibial length, with the 0.84% and 0.98% lysine groups showing superior physical development.

2.3 Effects of Dietary Lysine Level on Digestive Organ Development of Jinghong-1 Hens at 8 Weeks As presented in Table 4 , dietary lysine level had no significant effect on pancreas weight, duodenal length, jejunal weight, or ileal length ($P > 0.05$), though the 0.84% lysine group had the highest pancreas weight and the 0.98% lysine group had the highest jejunal weight and ileal length. However, lysine level significantly affected duodenal weight, jejunal length, and ileal weight ($P < 0.05$). The 0.84%, 0.98%, and 1.12% lysine groups had significantly higher duodenal weight than other groups ($P < 0.05$). The 0.98% and 1.12% lysine groups showed significantly greater jejunal length than the 0.70% and 1.26% lysine groups ($P < 0.05$). The 0.84% and 0.98% lysine groups had significantly higher ileal weight than the 0.70% lysine group ($P < 0.05$). Overall, from the perspective of digestive organ development, the appropriate dietary lysine level ranged from 0.84% to 1.12%.

2.4 Effects of Dietary Lysine Level on Immune Organ Development of Jinghong-1 Hens at 8 Weeks Table 5 indicates that dietary lysine level significantly affected thymus index and bursa of Fabricius index ($P < 0.05$) but had no significant effect on spleen index ($P > 0.05$). The thymus index in the 0.84% lysine group was significantly higher than that in the 0.98%, 1.12%, and 1.26% lysine groups ($P < 0.05$). The bursa of Fabricius index in the 0.84%, 0.98%, and 1.12% lysine groups was significantly higher than in other groups ($P < 0.05$). The spleen index was highest in the 0.84% lysine group. These results suggest that when immune organ indices are used as criteria, the appropriate dietary lysine level for Jinghong-1 hens is 0.84%–1.12%.

2.5 Effects of Dietary Lysine Level on Blood Indices of Jinghong-1 Hens at 8 Weeks As shown in Table 6 , dietary lysine level significantly affected serum biochemical indices and plasma growth hormone content ($P < 0.05$). Serum total protein (TP) and albumin (ALB) contents in the 0.84%, 0.98%, and 1.12% lysine groups were significantly higher than those in the 0.70% and 1.26% lysine groups ($P < 0.05$). The 0.98% lysine group had the lowest serum urea nitrogen (UN) content, which was significantly lower than that of the 1.26% lysine group ($P < 0.05$). Serum uric acid (UA) content in the 0.84% and 0.98% lysine groups was significantly lower than in other groups ($P < 0.05$). Alkaline phosphatase (ALP) activity in the 0.84% lysine group was significantly higher than in the 0.70% lysine group ($P < 0.05$), with no significant differences among other groups ($P > 0.05$). Plasma growth hormone (GH) content in the 0.84% lysine group was significantly higher than in the 0.70%, 1.12%, and 1.26% lysine groups ($P < 0.05$). These results indicate that the appropriate dietary lysine level for Jinghong-1 hens is 0.84%–1.12%.

2.6 Estimation of Dietary Lysine Requirement for Jinghong-1 Hens from 5 to 8 Weeks Using Quadratic Regression Model Table 7 presents the quadratic regression analysis based on body weight at 8 weeks, community evenness, eviscerated carcass weight, carcass weight, heart index, liver index, tibial length, duodenal weight, and serum uric acid content. The optimal dietary lysine levels derived from these individual parameters were 0.906%, 0.888%, 0.931%, 0.928%, 0.889%, 0.902%, 0.902%, 1.071%, and 0.958%, respectively. Overall, the best dietary lysine level for Jinghong-1 hens from 5 to 8 weeks of age was 0.931%.

Discussion

3.1 Effects of Dietary Lysine Level on Growth Performance and Physical Development of Jinghong-1 Hens from 5 to 8 Weeks Lysine is an essential amino acid for poultry. Appropriate dietary lysine levels can increase average daily gain, reduce average daily feed intake, and promote animal growth. The present results support this view, showing that dietary lysine level significantly affected body weight at 8 weeks in Jinghong-1 pullets, consistent with findings by Wang et al. [12]. Previous research demonstrated that increasing dietary lysine levels appropriately could improve body weight gain in Pekin ducks during early and late growth stages [13]. Similarly, this study found that an appropriate lysine level (0.84%) enabled Jinghong-1 pullets to achieve greater body weight and average daily gain at 8 weeks.

Early flock uniformity directly affects laying performance during the production period [14]. Carcass development and tibial length can be used to evaluate poultry development, and synchronized body weight, tibial length, and breast width enable timely onset of lay and improved laying performance [15]. The results showed that dietary supplementation with 0.84%–1.12% lysine during the 5–8 week period produced satisfactory community evenness, eviscerated carcass weight, carcass weight, heart index, liver index, and tibial length, ensuring proper preparation for timely sexual maturity and optimal laying performance.

3.2 Effects of Dietary Lysine Level on Digestive and Immune Organ Development of Jinghong-1 Hens at 8 Weeks Amino acids are fundamental components of the immune system and closely related to immune organ development. Indices of the thymus, spleen, and bursa of Fabricius can be used to evaluate chick immune status [16,17]. Appropriate dietary lysine levels can significantly increase thymus and spleen indices in laying hens [18], and the present results are similar, showing that 0.84%–1.12% dietary lysine yielded higher thymus, spleen, and bursa of Fabricius indices. As the second limiting amino acid in poultry, inappropriate lysine levels affect the utilization of other amino acids and consequently influence immune function. However, current research on lysine effects on poultry immunity remains limited to apparent indices such as immune organ weights, requiring further in-depth investigation.

The intestine is the primary site for nutrient digestion and absorption, with the

small intestine being the main organ for digesting and absorbing nutrients in poultry. The pancreas secretes digestive enzymes to assist digestion and absorption; therefore, digestive organ weights and pancreatic development can be used to evaluate the development of the animal' s digestive system. Previous research from our group confirmed that dietary amino acid levels significantly affect the development of the pancreas, duodenum, and jejunum in layer chicks [19]. In this study, dietary lysine levels of 0.84%–1.12% resulted in higher duodenal and jejunal weights, consistent with the lysine range that optimized growth performance. This is likely because increased digestive organ weight and length prolong nutrient retention time in the small intestine, enhancing nutrient absorption and consequently improving growth performance.

3.3 Effects of Dietary Lysine Level on Blood Indices of Jinghong-1 Hens Serum biochemical indices are important indicators of metabolic status and organ function in animals. Serum total protein maintains normal colloidal osmotic pressure and pH in blood vessels, transports various metabolites, and is closely related to immune function, providing indirect information about nutritional status. Albumin also maintains osmotic pressure and provides energy for tissue repair [20]. Total protein and albumin contents reflect the body' s protein synthesis capacity. This study showed that dietary lysine level significantly affected serum total protein and albumin contents, with appropriate lysine levels significantly increasing these parameters in 8-week-old Jinghong-1 hens, consistent with previous findings [11] and indicating that appropriate lysine promotes protein synthesis and growth.

Serum urea nitrogen and uric acid are end products of protein and amino acid metabolism in poultry. Their concentrations indirectly reflect protein and amino acid utilization—high levels indicate imbalanced dietary amino acid composition and accelerated catabolism, while lower levels suggest higher nitrogen utilization efficiency and increased protein synthesis [21]. Appropriate dietary lysine levels reduced serum uric acid and urea nitrogen contents in layer ducklings [11], consistent with the present results showing that dietary lysine significantly affected these parameters in 8-week-old Jinghong-1 hens, with the 0.84% and 0.98% lysine groups showing superior growth performance, indicating better amino acid balance and protein synthesis.

Alkaline phosphatase is primarily produced by osteoblasts, and enhanced blood ALP activity benefits animal weight gain [11]. This study showed that plasma ALP activity in the 0.84% lysine group was significantly higher than in the 0.70% lysine group, corresponding to higher body weight and ADG in the 0.84% lysine group, suggesting that appropriate lysine levels promote chick growth. Growth hormone is an important endocrine hormone with high plasma concentrations during embryonic and early growth periods that promotes protein synthesis and amino acid transport [22]. In this study, plasma GH content increased initially then decreased with dietary lysine level, consistent with previous research [11], indicating that appropriate lysine levels promote GH secretion and maintain

optimal growth status in 5–8-week-old Jinghong-1 hens.

Conclusion

Dietary lysine level significantly affects growth performance, carcass development, and immune organ development in Jinghong-1 hens from 5 to 8 weeks of age. Based on quadratic regression analysis of growth performance and physical development parameters, the recommended dietary lysine requirement for Jinghong-1 pullets during this stage is 0.93%.

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