Estimation of optimal lysine in quail chicks during the second and third weeks of age

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Abstract

An experiment was conducted to assess the optimal levels of dietary lysine (Lys) in Japanese quail from 7 to 21 days of age. A dose-response diet was formulated to be adequate in all amino acid concentrations with the exception of Lys. Different levels of supplemental L-lysine.HCl were added to the dose-response diet at the expense of corn starch, sodium bicarbonate, and NaCl to create 6 levels of Lys ranging from 0.91% to 1.51% in diet. Optimal Lys for feed conversion ratio, breast meat yield, and thigh meat yield were estimated at 1.15%, 1.21%, and 1.16% of diet, respectively, based on linear broken-line regression. With quadratic broken-line regression, the Lys requirements for body weight gain, feed conversion ratio, thigh meat yield, and breast meat yield were estimated at 1.27%, 1.21%, 1.32%, and 1.34% of diet, respectively. Overall, Lys requirements of starting Japanese quail may be at least 1.34% of diet for optimizing carcass attributes fed low-CP dose-response diet.

Materials and methods

Bird management
Quail chicks were obtained from the hatchery of Research Center of Special Domestic Animals at the University of Zabol (RCSDA, Zabol, Iran) and fed starter diet according NRC (1994) from 0 to 7 days of age. At d 7 of age and after 3 h starvation, the birds (15 male and female without sexing) were weighed and randomly assigned to 24 floor pens with similar body weight (36.8±0.09). The pens were equipped with feeder, drinker, and wood shavings. The room temperature during second and third weeks of age was 30ºC and 28ºC, respectively. The relative humidity was 55-60% throughout the study.

Experimental diets
A basal diet containing corn, wheat, soybean meal, and corn gluten meal was formulated to meet or exceed the requirements recommended by NRC (1994) except for Lys (Table 1). Six graded levels of L-lysine.HCl were added to the basal diet at the expense of corn starch, sodium bicarbonate, and NaCl to generate six levels of Lys ranging from 0.91% to 1.51% of diet. Different proportions of sodium bicarbonate and NaCl help to keep dietary electrolyte balance (DEB) in the experimental diets. Before diet formulation, protein-containing ingredients were analyzed for crude protein (CP) and amino acid contents using near infrared reflectance spectroscopy (Fontaine et al., 2001, 2002). The analyzed values of amino acids in feed ingredients were used for diet formulations. Experimental diets were offered from 7 to 21 days of age and birds consumed feed (provided in whole mash form) and water on an ad libitum basis. At the end of experiment, 4 birds of each replicate were randomly selected and were dissected for carcass portions by cervical dislocation (Kim et al., 2012). The breast and thigh sections were harvested as skinless boned-meat.

Statistical analysis
In this experiment, gradient treatment structure was conducted as a completely randomized design. The 6 dose-response diets for Lys were fed to each pen with 4 replicates. All data were subjected to MIXED procedure using linear and quadratic responses to explain potential effects of Lys (SAS, 2002). Differences among means (P≤0.05) were separated using LSMEANS option of SAS (2002). Both broken-line linear and broken-line quadratic models were used for estimation of Lys needs using NLIN procedure (Robbins et al., 2006).

Results and discussion
Starting quail chicks fed gradient concentra-
tation of Lys showed significant (P<0.05) linear and quadratic trends for body weight (BW), BW gain, feed conversion ratio (FCR), chilled carcass, breast mass (BM) yield and the weight of thigh meat (TM) from 7 to 21 d of age (Tables 2 and 3). The quadratic effect of Lys levels was significant for feed intake (Table 2; P=0.007) and TM yield (Table 3; P=0.0433) but no linear trends were observed both parameters (Tables 2 and 3).

Two statistical methods including linear broken-line (LBL) and quadratic broken-line (QBL) models were fitted to estimate the Lys requirements of quail chicks. Lysine requirements for FCR, TM yield, and BM yield were estimated at 1.15%, 1.21%, 1.16% of diet, respectively, based on LBL model (Table 4; Figures 1, 2, and 3). The LBL model could not fit the data of BW gain. The nutritional needs of Lys were estimated at 1.27%, 1.21%, 1.32%, and 1.35% of diet, respectively, for BW gain, FCR, TM yield, and BM yield based on QBL model (Table 5; Figures 4, 5, 6, and 7). NRC (1994) suggested the 1.3% Lys level for growing Japanese quail. The Lys requirement of quail chick with practical diets containing 25% protein has been reported as 1.35% of diet (Svacha et al., 1970). The estimated nutritional needs of Lys for BW gain was higher than FCR using quadratic broken-line model (1.27% vs. 1.21% of diet). Dozier et al. (2010) reached to the same result with broiler chickens. However, some reports revealed that the Lys requirements for FCR might be higher than growth rate (Mehri et al., 2010; Zaboli et al., 2011; de Lima et al., 2013). Baker et al. (2002) argued that as Lys exceeds the concentration for the requirement of BW gain, feed intake decreases without decline in BW gain, so resulting in higher Lys requirement for FCR. The method of statistical analysis had a profound effect on the estimated Lys require-

### Table 1. Composition of basal diet.

| Ingredient                  | % as fed  |
|-----------------------------|-----------|
| Wheat, red                  | 46.34     |
| Soybean meal, 44% CP        | 20.15     |
| Corn (grain)                | 12.19     |
| Corn gluten meal            | 11.43     |
| Corn starch                 | 3.00      |
| Soybean oil                 | 2.80      |
| Limestone                   | 1.60      |
| Di-calcium phosphate        | 1.44      |
| NaCl                        | 0.36      |
| Vitamin premix°             | 0.25      |
| Mineral premix°             | 0.25      |
| DL-Methionine               | 0.13      |
| L-Thr                       | 0.05      |

### Table 2. Growth performance of Japanese quail fed gradient levels of dietary lysine from 7 to 21 days of age.°

| Lysine, % | BW, g | BW gain, g | Feed intake, g | FCR, g:g |
|----------|-------|------------|----------------|----------|
| 0.91     | 104   | 67         | 245            | 3.65     |
| 1.03     | 107   | 70         | 233            | 3.30     |
| 1.15     | 121   | 84         | 241            | 2.87     |
| 1.27     | 122   | 85         | 244            | 2.75     |
| 1.39     | 117   | 80         | 244            | 3.02     |
| 1.51     | 115   | 78         | 251            | 3.21     |

| SEM      | 2.14  | 1.25       | 2.52           | 0.05     |
| R^2      | 0.79  | 0.67       | 0.90           | 0.05     |
| CV, %    | 2.50  | 3.24       | 2.09           | 3.60     |

| Linear effect | <0.0001 | <0.0001 | 0.933 | <0.0001 |
| Quadratic effect | 0.020 | <0.0001 | 0.007 | <0.0001 |

°Values are least squares means of 4 replicate pens with 15 quail chick per pen. FCR, feed conversion ratio; CV, coefficient of variation.

### Table 3. Processing yield of Japanese quail fed gradient levels of dietary lysine from 7 to 21 days of age.°

| Item                  | Chilled carcass | Breast meat | Thigh meat |
|-----------------------|-----------------|-------------|------------|
|                       | Weight, g | Yield, % | Weight, g | Yield, % | Weight, g | Yield, % |
| Lysine, %             |          |       |          |       |          |       |
| 0.91                  | 68.4     | 65.8  | 27.0     | 26.0   | 16.7     | 16.1   |
| 1.03                  | 69.2     | 64.7  | 27.2     | 25.4   | 16.5     | 15.4   |
| 1.15                  | 80.0     | 66.1  | 31.8     | 26.3   | 19.2     | 15.9   |
| 1.27                  | 82.6     | 67.6  | 33.4     | 27.4   | 19.9     | 16.3   |
| 1.39                  | 79.7     | 68.1  | 32.2     | 27.5   | 19.5     | 16.7   |
| 1.51                  | 77.0     | 67.0  | 31.1     | 27.0   | 18.9     | 16.4   |
| SEM                   | 0.94     | 0.62  | 0.28     | 0.25   | 0.25     | 0.19   |
| R^2                   | 0.81     | 0.54  | 0.87     | 0.43   | 0.74     | 0.18   |
| CV, %                 | 5.67     | 4.23  | 3.23     | 6.32   | 4.72     | 5.12   |

| Linear effect | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.100 |
| Quadratic effect | <0.0001 | <0.0001 | <0.0001 | 0.0006 | 0.0003 | 0.0433 |

°Values are least squares means of 4 replicate pens with 15 quail chick for carcass processing. CV, coefficient of variation.
Figure 1. Break point of feed conversion ratio for quail chick from 7 to 21 d of age using linear broken-line model.

Figure 2. Break point of breast meat yield for quail chick from 7 to 21 d of age using linear broken-line model.

Figure 3. Break point of thigh meat yield for quail chick from 7 to 21 d of age using linear broken-line model.

Figure 4. Break point of body weight gain for quail chick from 7 to 21 d of age using quadratic broken-line model.

Figure 5. Break point of feed conversion ratio for quail chick from 7 to 21 d of age using quadratic broken-line model.

Figure 6. Break point of thigh meat yield for quail chick from 7 to 21 d of age using quadratic broken-line model.
ment. Lysine requirements for FCR were 1.15% and 1.21% of diet using linear broken-line and quadratic broken-line models, respectively. Pesti et al. (2009) stated that the linear ascending portion of linear broken-line regression might cause to underestimate the amino acid requirements because the bird response to incremental levels of dietary nutrient is nonlinear. The researchers came to the same result with broiler chicken and using the quadratic broken-line regression may overcome the underestimation (Dozier et al., 2008; Labadan et al., 2001; Mehri et al., 2010).

There is increasingly demand for breast meat of the chickens and interest to optimizing breast meat yield so considering the breast meat yield as a response criterion for determination of Lys requirements (Dozier et al., 2008, 2010; Zaboli et al., 2011). In the present study, the Lys requirements for carcass portions including breast meat and thigh meat yield were higher than quail performance. Considering the estimated values of quadratic broken-line model, the average Lys requirements for bird performance and processing yields were 1.24% and 1.33% of diet, respectively. Muscle accretion in poultry depends on protein degradation and protein synthesis. Tesseraud et al. (1996) showed the critical effects of dietary Lys on proteolysis in breast muscle. Some studies revealed the higher Lys requirement for maximizing breast meat yield than bird performance (Dozier et al., 2008; Labadan et al., 2001) supporting the pivotal role of Lys in breast muscle development (Tesseraud et al., 1999). It should be noted that despite of genetic progress in the modern Japanese quail and higher nutritional needs of modern strains (Havenstein et al., 2003) the estimated Lys requirements reported herein are lower than suggested by Hajkhodadadi et al. (2013). This phenomenon may related to the CP level of basal diet and statistical procedure in the current research. In the present study, we used a 23% CP dose-response diet and spline models for analyzing data. Hurwitz et al. (1998) and Morris et al. (1987) demonstrated that dietary CP could affect the Lys requirements of broiler chicks. The recommended CP requirements for quail chick by NRC (1994) and Hyankova et al. (1997) were 24 and 26% of diet, respectively; therefore, the lower CP level of dose-response diet of this experiment could be resulted in lower estimation of Lys requirement. In addition, Pesti et al. (2009) stated that an appropriate model should be used to analyze dose-response data and regression models would be suitable for amino acid studies. Hajkhodadadi et al. (2013) have used multiple range Duncan for determination of optimal Lys. As stated by Pesti et al. (2009) the mean comparison method could not estimate accurately the amino acid requirements using experimental data.

Conclusions

In conclusion, the estimated Lys requirement of quail chick fed low-CP diet may be at least 1.34% of diet; and Lys requirement for processing yield was approximately 7% higher than growth performance. More studies may be needed to address the amino acid requirements of modern Japanese quail for different classes of age.

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Table 4. Estimated optimal dietary lysine in Japanese quail based on linear broken-line analyses.

| Response criteria   | Estimated requirement° | 95% CI                  | SEM |
|---------------------|------------------------|-------------------------|-----|
| Performance         |                        |                         |     |
| BW gain             | 1.15                   | 0.9967 to 1.2990        | 0.07|
| FCR                 | 1.21                   | 1.1533 to 1.2583        | 0.02|
| Processing yields   |                        |                         |     |
| Breast meat yield   | 1.21                   | 1.1533 to 1.2583        | 0.02|
| Thigh meat yield    | 1.16                   | 1.1076 to 1.2164        | 0.02|

°The linear broken-line model is as follow: $y = L + U \times (R - x)$, where $L$ is the ordinate, $U$ is the slope of the line at values of $x<R$, $R$ is the abscissa of the breakpoint. FCR, feed conversion ratio; CI, confidence interval; nc, not converge, because data did not conform to the regression model.

Table 5. Estimated optimal dietary lysine in Japanese quail based on quadratic broken-line analyses.

| Response criteria   | Estimated requirement° | 95% CI                  | SEM |
|---------------------|------------------------|-------------------------|-----|
| Performance         |                        |                         |     |
| BW gain             | 1.27                   | 1.0813 to 1.4594        | 0.09|
| FCR                 | 1.32                   | 1.0232 to 1.3844        | 0.08|
| Processing yields   |                        |                         |     |
| Breast meat yield   | 1.34                   | 1.2133 to 1.4264        | 0.06|
| Thigh meat yield    | 1.32                   | 1.1404 to 1.4985        | 0.08|

°The linear broken-line model is as follow: $y = L + U \times (R - x) \times (R - x)$, where $L$ is the ordinate, $U$ is the slope of the line at values of $x<R$, $R$ is the abscissa of the breakpoint. FCR, feed conversion ratio; CI, confidence interval; nc, not converge, because data did not conform to the regression model.

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Figure 7. Break point of breast meat yield for quail chick from 7 to 21 d of age using quadratic broken-line model.
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