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Full Length Research Paper

Effect of dietary crude protein level on performance and lysine requirements of male broiler chickens

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An experiment was conducted to evaluate crude protein level on lysine requirements and performance of male broiler chickens. From 21 to 42 day old chicks were fed one combination of dietary lysine and CP (18, 20 and 22% crude protein and 0.08, 0.9, 1 and 1.1% lysine) in a diet containing 3.200 kcal/kg ME. Variables measured consisted of feed intake, body weight gain, feed conversion ratio, percentage of fat pad carcass, breast and thigh weight. The lysine requirement was estimated by broken line methodology based on body weight gain, feed conversion ratio, carcass and breast weight recorded in the grower period. There were significant effects of crude protein level on body weight gain, feed intake, feed conversion ratio and percentage of fat pad that existed. The body weight gain and feed intake increased and percentage of fat pad decreased as crude protein increased in the diet. However, increasing lysine in the diets significantly increased body weight gain, breast meat, thigh and carcass weight and decreased feed conversion ratio and percentage of fat. Body weight gain, feed conversion ratio, carcass weight and percentage of fat pad were significantly affected by lysine × crude protein interaction. Predicted lysine requirements for body weight gain, feed conversion ratio, carcass and breast meat weight with increasing crude protein level were increased as percentage of the diet. The quadratic-broken line model estimated higher requirements than the straight-broken line model for all response criteria. The highest (1.097±0.073) and the lowest (0.907±0.0046) lysine requirement with straight-broken line analysis were estimated for breast meat weight at 22% crude protein level and body weight gain at 18% crude protein, respectively. The results suggest that lysine requirement affected by dietary crude protein level, and for estimation lysine requirement must be defined best criterion response.

Key words: lysine, crude protein, broiler, broken line

INTRODUCTION

Lysine (Lys) is the second limiting amino acid (AA) for poultry fed corn-soybean meal diets, and because it is only used for protein synthesis, it has been chosen to express all other essential AA as a percentage of Lys, under the ideal protein concept (Baker and Han, 1994; Emmert and Baker, 1997; Baker et al., 2002). Therefore, by using this system it is crucial to obtain an accurate Lys requirement. However, many factors must be considered in estimating AA requirements, such as the strain of the birds, type of diets, levels of other nutrients, age, sex, and rearing environment (Baker et al., 2002). Baker and Han (1994), Mack et al. (1999), and Baker et al. (2002) reported that Lys requirement was higher for optimum feed efficiency than it was for body weight gain (BWG). Lys needed for optimizing breast meat yield may be higher than the amount needed for optimal BWG and feed efficiency (Jackson et al., 1989; Hickling et al., 1990; Moran and Bilgili, 1990; Acar et al., 1991; Gorman and Balnave, 1995).

In the early 1950s Almquist (1952) concluded that the level of an indispensable amino acid required for optimum chick performance was a positive linear function of the dietary CP level. Almquist noted that the relationship between the lysine and methionine requirements and

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dietary crude protein (CP) level were not similar and also as the dietary CP level increased the requirements decreased as a proportion of CP. This assumption was later challenged by Boomgaardt and Baker (1973) and Nelson et al. (1960), who reported that lysine, tryptophan, and methionine were required as constant proportions of CP, respectively. However, more recent studies have found that lysine requirements as a percentage of CP decreased as the level of CP increased (Abebe and Morris, 1990; Surisdiarto and Farrell, 1991; Hurwitz et al., 1998). Morris et al. (1987) assumed that apparent changes in the determined amino acid requirements with the level of protein in the diet result from changes in the amino acid balance. In a later study, however, Morris and Abebe (1990) could not confirm the hypothesis that the change in lysine requirement with dietary protein resulted from a dietary arginine imbalance. In addition, Hurwits et al. (1998) concluded that when the CP level is reduced, the requirements for individual amino acid decreased due to growth retardation resulting from single or multiple amino acid deficiencies. Responses to amino acids, and therefore amino acid requirement estimates, can vary depending on the dietary protein source and quality, dietary energy level, genetic strain, sex, experimental conditions, and statistical evaluation.

The requirement for nutrients, including Lys, is usually defined as the minimum dietary concentration required for maximum performance. Maximum performance is difficult to define because there are often several response criteria for each nutrient. There may be different maximum responses for different criteria such as growth, feed efficiency, carcass composition, and bone ash, etc. The selected parameters as a response for defining nutrient requirements are important. Leclercq (1998) stated that the required concentration of Lys is greatest for minimizing abdominal fat pad percentage followed by minimizing feed conversion ratio (FCR) and maximizing breast meat yield and BWG. Nutritionists usually build in some margin of error above the requirement and, therefore, feed a concentration in excess for the maximum response. The mathematical model used will also influence the estimated requirement. Barbour et al. (1993) found the dietary Lys requirement to be higher when estimated by a quadratic response model compared with a 2-slope model and depended on the dietary CP source.

In the present study, the effects of dietary protein level, several response criteria and two different statistical models used to estimate Lys requirements and effects of several protein and dietary Lys levels on performance and carcass quality of broiler chicken were evaluated.

MATERIALS AND METHODS

A total of 600 one-day-old male Ross broiler chicks were raised from 1 to 21 day of age before commencement of the trail. During this period, the birds were submitted to conventional broiler chicken management and housed in floor pens in an environmentally controlled broiler house with litter floors. Birds were maintained on 23L: 1D schedule lighting. They received a commercial broiler starter diet, formulated to meet or exceed the nutritional requirements of broilers, as recommended by the NRC (1994). After an overnight fast, at 21 day of age, 480 chicks of similar weight were randomly assigned to 48 clean pens in the same broiler house for the starter period. Average body weights (means ±standard error) at day 21 were 650±15 g. Feed and water fed *ad libitum*. The ambient temperature was gradually decreased from 32°C when the birds were 1 day old to 22°C when 28 day old. The protein and AA levels of the corn, soybean meal, and corn gluten meal were analyzed before diets formulation. Experimental diet was formulated to meet or exceed the NRC (1994) nutrition recommendations from 21 to 42 day of age for all nutrients except Lys and protein (Table 1). Dietary nitrogen (N×6.25) was measured by the Kjeldahl procedure. Dietary amino acid content was determined by ion-exchange chromatography on an autoanalyzer. The analyzed values of protein and amino acid contents agreed with calculated values (Table 1).

The chicks were divided into 12 treatment groups, with 4 replicates per treatment and 10 chicks per replicate. The treatments were 18% CP with 0.8, 0.9, 1.0, or 1.1% Lys; 20% CP with 0.8, 0.9, 1.0, or 1.1% Lys; and 22% CP with 0.8, 0.9, 1.0, or 1.1% Lys. L-Lys HCl was added at the expense of the diet. Diets were adequately fortified with vitamins and trace minerals using supplements obtained from a commercial integrator.

Chicks were weighed at the end of the week, feed consumption was recorded weekly and mortalities were recorded as they occurred. On day 42, three randomly chosen chickens from each pen were wing-banded and moved to separate floor pens for an overnight fast (approximately 12 h); water was provided *ad libitum*. The following morning, chickens were randomly crated and transported to the processing room where each was weighed, euthanized by cervical dislocation and then scalded, defeathered, and eviscerated. Abdominal fat pads and livers were collected from the birds after they were partially eviscerated by a mechanical eviscerator. Carcasses were weighed and chilled on ice in a walk-in cooler at 5°C overnight. The following day, breast (without skin), and thigh were excised, and weights were recorded. The abdominal fat pad percentage was calculated based on chilled carcass weight. The experimental protocol was subjected to Iranian animal ethics society and Tehran university rules.

Experimental design and statistical analysis

The experimental design was a completely randomized design with complete factorial arrangement of treatments. The factorial included 3 dietary CP levels, and 4 dietary Lys levels per CP level. The experimental unit was the pen mean. All data were analyzed by two-way ANOVA using the GLM procedure of SAS (SAS Institute, 2004). A nonlinear procedure of SAS was applied to determine the Lys requirement based on BWG, FCR carcass and breast weight. The iterative procedure makes repeated estimates for coefficients and minimizes residual error until the best-fit lines are achieved: one line with a slope of zero and the other with a marked slope. The two lines are fitted to the values using the following equations:

For linear broken line: $y = L + U \times (R - X) \times I$
For quadratic broken line: $L + U \times (R - X) \times (R - X) \times I$

Where X = independent variable, R = requirement, y = dependent variable, L = theoretical maximum, I = 1 (if $X < R$) or I = 0 (if $X > R$), and U = rate constant. The coefficient of determination (R^2 value) was determined as follows: $R^2 = 1 -$ (residual sum of squares/corrected total sum of squares). A t-test ($\alpha < 0.05$) was performed to determine if differences existed for the requirements

Table 1. Composition of experimental diets.

Ingredients[1]	CP (% of diet)		
	18	**20%**	**22**
Corn, grain	71.99	69.48	65.68
Soybean meal	16.32	15.36	16.18
Corn gluten meal	6.42	10.47	13.54
Soybean oil	1.69	1.2	1.2
Dicalcium phosphate	1.21	1.2	1.18
Oyster-shell	1.51	1.53	1.54
DL-Methionine	0.08	0.0	0.0
L-Lys Hcl	0.1	0.08	0.0
Common salt	0.33	0.33	0.33
Vitamin premix[2]	0.25	0.25	0.25
Mineral premix[3]	0.1	0.1	0.1
Calculated composition			
ME (kcal/g)	3200	3200	3200
CP (%)	18	20	22
Ether extract (%)	2.8	3.23	2.95
Lys (%)	0.8	0.8	0.8
Methionine	0.32	0.37	0.42
Methionine + cystine (%)	0.72	0.73	0.82
Ca	0.9	0.9	0.9
Available phosphorus	0.35	0.35	0.35
Na	0.15	0.15	0.15
Analyzed compostition			
CP (%)	17.6	19.5	22.4
Ether extract (%)	2.5	3.04	2.84
Lys (%)	0.78	0.79	0.82
Methionine (%)	0.3	0.34	0.44
Methionine + cystine (%)	0.68	0.69	0.87

[1]Based on NRC (1994) feed composition tables.
[2]Vitamin premix provided the following per kilogram of diet: vitamin A, 5,500 IU (as all trans-retinyl acetate); cholecalciferol, 1,100 IU; vitamin E, 11 IU (as all-rac-α-tocopherol acetate); riboflavin, 4.4 mg; Ca pantothenate, 12 mg; nicotinic acid, 44 mg; choline Cl, 220 mg; vitamin B12, 6.6 µg;vitamin B6, 2.2 mg; menadione, 1.1 mg (as menadione sodium bisulfitecomplex); folic acid, 0.55 mg; d-biotin, 0.11 mg; thiamine, 1.1 mg (asthiamine mononitrate); ethoxyquin, 125 mg.
[3]Provided per kilogram of diet: Mn (from MnSO4_H2O), 100 mg; Zn (from ZnSO4_7H2O), 100 mg; Fe, (from FeSO4_7H2O), 50 mg; Cu (from CuSO4_5H2O), 10 mg; I (from Ca (IO3)2_H2O), 1 mg.

established between CP levels for each experiment. The following equation was used to determine the absolute value of

$| t | = (R_1 - R_2)/[\text{square root of } ((SER_1)2 + (SER_2)2)]$

where R = requirement and SER = SE of the requirement. If | t | > t, then reject the null hypothesis where tα < 0.05, df = 15 = 2.179 (df = n - r where n = number of experimental units and r = number of replications).

RESULTS

Responses to dietary CP level were significant (P < 0.001) for BWG, feed intake, FCR and percentage of fat pad (Table 2). The BWG increased, FCR increased and then decreased, percentage of fat pad and feed intake decreased as CP increased in the diet. Breast meat, thigh and carcass weights were not affected by CP level, however, increasing Lys in the diets significantly (P < 0.001) increased BWG, breast meat, thigh and carcass weight and decreased FCR and percentage of fat pad (Table 2). BWG, FCR, carcass weight and percentage of fat pad were significantly (P < 0.05) affected by Lys×CP interaction (Table 3). The BWG and carcass weight in all CP levels with increasing Lys level increased and highest BWG (1591.0±27) was achieved in 1% dietary Lys and 18% CP. FCR and percentage of fat in all level of CP

Table 2. Main effects of dietary CP and Lys on body weight gain, feed intake, feed conversion ratio, breast meat, thigh weight, carcass weight and abdominal fat pat percentage of male broiler chicks (21 to 42 d).

Main effects (%)	n	BWG[1] (g)	Feed intake(g)	FCR (g/g)	Breast (g)	Thigh (g)	Carcass (g)	Fat pad (%)
CP								
18	16	1381.31^{c}	2696.30^{b}	1.89^{b}	332.7	395.1	1537.2	3.53^{a}
20	16	1427.84^{b}	2691.71^{b}	1.98^{a}	336.0	403.6	1547.2	3.01^{b}
22	16	1497.12^{a}	2873.37^{a}	1.93^{b}	339.9	408.0	1566.4	2.56^{c}
SEM		16	23	0.014	4.89	6.11	13.22	0.037
Lys								
0.8	12	1278.64^{c}	2715.13	2.13^{a}	297.0^{d}	376.4^{c}	1438.8^{c}	3.32^{a}
0.9	12	1450.98^{b}	2762.57	1.90^{b}	319.8^{c}	397.2^{b}	1511.9^{b}	3.08^{b}
1	12	1527.50^{a}	2749.26	1.80^{c}	351.3^{b}	422.7^{a}	1623.9^{a}	2.90^{c}
1.1	12	1484.58^{ab}	2788.21	1.88^{b}	376.7^{a}	412.7^{ab}	1626.4^{a}	2.84^{c}
SEM		18.4	26	0.016	5.65	7.05	15.2	0.043
ANOVA	df				**Probabilities**			
Lys	3	<.0001	0.2921	<.0001	<.0001	0.0003	<.0001	<.0001
CP	3	<.0001	<.0001	0.0004	0.5861	0.3303	0.2956	<.0001
Lys ×CP	6	0.0005	0.8936	<.0001	0.0875	0.0804	0.0221	0.0046
Error	36							
REGRESSION								
Lys	1	0.0016	0.7698	<.0001	0.9134	0.1012	0.0004	0.0005
Lys ×Lys	1	<.0001	0.8686	<.0001	0.8356	0.0508	0.0340	0.0586
CP	1	0.2713	0.0005	0.0152	0.8694	0.8666	0.7028	0.0359
CP ×CP	1	0.6322	0.0013	0.0168	0.9737	0.8077	0.2568	0.3908
Lys ×CP	1	0.0323	0.3107	0.5452	0.5040	0.6555	0.0027	0.0011
Error	42							
R^2		0.6943	0.561	0.6941	0.7074	0.34	0.7146	0.9026

Table 3. interaction effects of dietary CP and Lys on body weight gain, feed intake, feed conversion ratio, breast meat, thigh weight, carcass weight and abdominal fat pat percentage of male broiler chicks (21to 42 d).

CP (%)	Lys (%)	BWG, g	Feed intake, g	FCR (g/g)	Breast meat, g	Thigh, g	Carcass, g	Percentage fat pad
18	0.8	1144.1±29	2653.0±48	2.03±0.05	289.7±53.0	369.0±22	1479.6±20	4.03±0.40
18	0.9	1380.9±8	2679.5±112	1.88±0.01	327.2±4.54	415.4±25	1508.1±21	3.53±0.17
18	1	1591.0±27	2695.5±113	1.82±0.02	354.6±7.81	429.3±33	1604.9±42	3.28±0.04
18	1.1	1409.0±74	2757.0±103	1.81±0.01	388.0±6.72	418.5±19	1596.2±26	3.30±0.10
20	0.8	1306.4±18	2639.9±183	2.31±0.05	310.9±31.9	377.9±28	1455.7±61	3.30±0.12
20	0.9	1444.2±20	2719.3±60	1.94±0.07	307.1±0.92	392.6±11	1478.9±45	3.09±0.04
20	1	1453.0±61	2667.2±61	1.70±0.02	363.7±1.29	444.5±1	1613.4±24	2.85±0.03
20	1.1	1507.6±38	2740.3±80	1.96±0.12	362.6±3.94	399.4±7	1600.8±12	2.79±0.07
22	0.8	1385.3±11	2852.3±38	2.06±0.03	290.4±4.8	382.3±54	1381.2±110	2.64±0.10
22	0.9	1527.7±13	2888.8±110	1.89±0.08	325.1±11.4	383.7±2	1548.7±80	2.62±0.12
22	1	1538.4±9	2885.0±16	1.87±0.00	335.8±15.1	394.5±12	1653.5±43	2.57±0.08
22	1.1	1536.9±6	2867.2±52	1.88±0.03	379.4±15.5	420.2±20	1682.4±54	2.42±0.07

1Means ± standard error of the mean for 10 chicks per replicate per treatment.

decreased from 0.8 to 1% Lys, lowest FCR (1.70±0.02) in 20% dietary CP and 1% Lys and the lowest percentage of fat pad (2.42±0.07) in 22% CP and 1.1% Lys was achieved (Table 3).

Table 4. Dietary Lys requirement based on broken line model analyses.

Response criterion	Linear broken line analysis[1]								
	Estimated requiremen			P-value			R^2		
CP (%)	18	20	22	18	20	22	18	20	22
BWG (g)	0.907^{c}±0.0046	0.925^{b}±0.0135	0.950^{a}±0.030	0.0001	0.0001	0.0001	0.79	0.91	0.79
FCR (g/g)	0.908^{c}±0.018	0.928^{b}±0.024	0.938^{a}±0.0166	0.0001	0.0001	0.0001	0.76	0.75	0.90
Carcass (g)	0.971^{c}± 0.0442	1.004^{ab}±0.0352	1.007^{a}±0.0408	0.0001	0.0001	0.0003	0.75	0.77	0.72
Breast (g)	0.993^{c}± 0.0684	1.033^{b}±0.0584	1.097^{a}±0.073	0.0006	0.0016	0.0004	0.69	0.63	0.70
	Quadratic broken line analysis[2]								
BWG (g)	0.934^{a}± 0.0143	0.982^{b}±0.0314	1.008^{c}±0.060	0.0001	0.0001	0.0001	0.79	0.91	0.79
FCR (g/g)	0.938^{a}±0.054	0.988^{b}±0.057	1.0148^{c}±0.0399	0.0001	0.0001	0.0001	0.76	0.75	0.90
Carcass (g)	1.095±0.0850	1.189± 0.2324	1.268±0.4534	0.0001	0.0003	0.0008	0.75	0.77	0.72

[1]The linear broken-line model is y = L + U × (R − x), where L is the ordinate, R is the abscissa of the breakpoint, and the value R − is zero at values of x > R. Values are reported as ± SEM.
[2]The quadratic broken-line model is y = L + U × (R − x) × (R − x) where L is the ordinate, R is the abscissa of the breakpoint, and the value R - is zero at values of x > R. Values are reported as ± SEM.
[a–]means within a row with different superscripts differ significantly with t test(P ≤ 0.05).

Regression analyses showed significant linear effects due to dietary Lys concentrations for all response parameters except for feed intake, breast meat and thigh weight. In addition, significant biphasic (increase followed by a decrease) responses were observed as dietary Lys concentrations increased for BWG, FCR, thigh and carcass weight (Table 2). A quadratic effect due to dietary CP concentration was noted for feed intake and FCR. The dietary Lys by CP interaction was significant for BWG, fat pad percentage, thigh and carcass weight when regressed as a function of dietary Lys and CP concentrations (Table 2).

The Lys requirement was determined as a percentage of the diets using linear and quadratic broken line analysis (Table 4). A t-test of the estimated requirement showed significant difference (P > 0.05) between the three protein levels. Predicted Lys requirements for BWG, FCR, carcass and breast meat weight with increasing CP level were increased as a percentage of the diet (Table 4, Figures 1 and 2). The quadratic-broken line model estimated higher requirements than the straight-broken line model for all response criterions (Table 4). The highest (1.097±0.073) and the lowest (0.907±0.0046) Lys requirement with straight-broken line analysis were estimated for breast meat weight at 22% CP and BWG at 18% CP, respectively.

DISCUSSION

With increasing CP level on diet, BWG and feed intake increased and fat pad percentage decreased. This result agreed with Sterling et al. (2003) that concluded increasing CP level from 17 to 22% in growing period increased BWG, feed intake as well as Rezaei et al. (2004) reported that reducing dietary CP decreased BWG, and increased fat percentage. The effect of dietary protein in suppressing carcass fat was well documented but the mechanism for this phenomenon remains obscure. A possible reason is that increasing dietary protein decreased the caloric protein ratio, resulting in the lower energy intake as relative to protein intake, consequently resulting in lower carcass fat content, as similarly observed with other studies (Yashamita et al., 1975; Lesson et al., 1988). Also there was a trend for a reduction in fat pad percentage (from 3.32 to 2.84) due to increased Lys level (Table 2). However, decrease in abdominal fat pad percentage is probably related to a more efficient use of Lys.

Increasing Lys level in the diet increased breast meat weight, BWG and decreased FCR as reported by other researches (Bilgili et al., 1992; Han and Baker, 1994; Gorman and Balnave, 1995; Kidd et al., 1998 and Rezaei et al., 2004; Dozier et al., 2008). The concentration of dietary Lys can significantly influence breast meat yield for several reasons: it contains a high concentration of Lys; breast meat represents a large portion of carcass meat. Optimum level of Lys for 21 - 42-day-old broiler chickens in this experiment was 1% because in this level, lower FCR and highest BWG and other performance parameters were observed and with increasing Lys level from 1 to 1.1% had negative effect on performance (Table 2).

The estimated Lys requirements vary with response criterion, and when requirement estimate was based on breast meat, this value was higher than other response criterions (Table 4). Early reports suggested that Lys requirement for maximum breast weight was higher than that of BWG (Hickling et al., 1990; Bilgili et al., 1992). Nevertheless, Han and Baker (1994) reported that the Lys need for maximum breast meat and FCR was similar in birds from 3 to 6 weeks of age. Moreover,

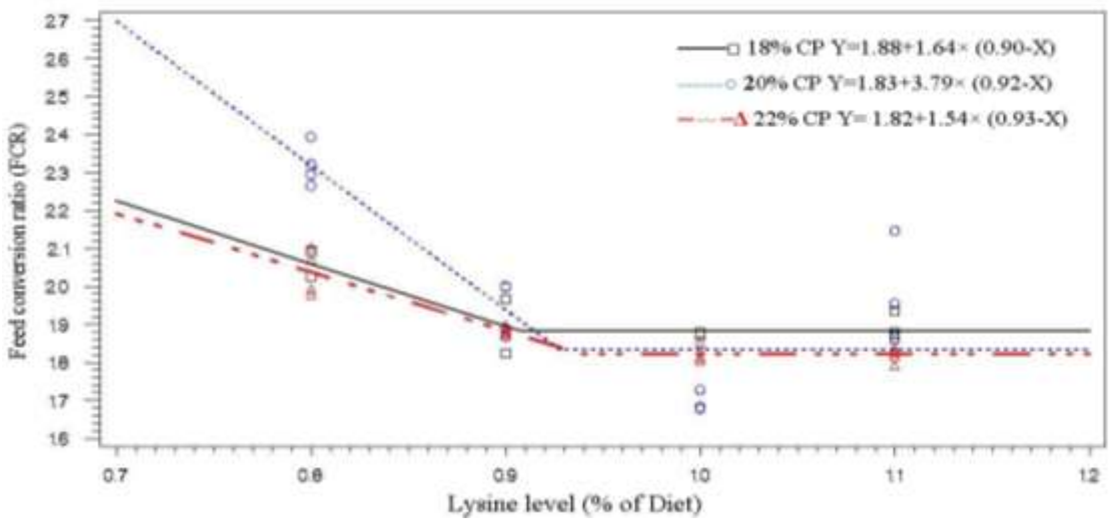

Figure 1. Fitted broken-line plot of feed conversion ratio (FCR) as a function of dietary Lys level (% of diet). The FCR data points are replications of 10 chicks during an 21 d feeding trial. The breakpoint occurred at 0.908±0.018, 0.928±0.024 and 0.9385±0.0166 as a percentage of diet or 5.04, 4.64 and 4.26as a percentage of CP for 18, 20 and 22% CP, respectively, based on calculated values of Lys R^2 = 0.76, 0.75 and 0.90 for 17 and 23% CP, respectively.

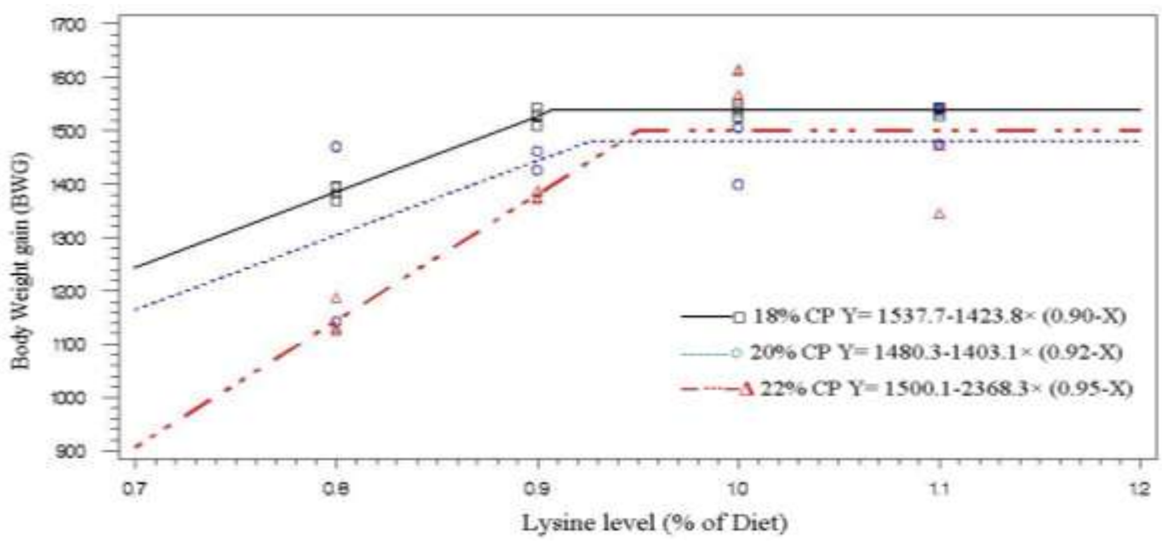

Figure 2. Fitted broken-line plot of body weight gain (BWG) as a function of dietary Lys level (% of diet). The BWG data points are replications of 10 chicks during a 21-d feeding trial. The breakpoint occurred at 0.907±0.00464, 0.9257±0.0135and 0.950±0.03 as a percentage of diet or 5.03, 4.62 and 4.31 as a percentage of CP for 18, 20 and 22% CP, respectively, based on calculated values of Lys. R^2 = 0.79, 0.91and 0.79 for 18, 20 and 22% CP, respectively.

Mack et al. (1999) and Labadan et al. (2001) observed that the Lys requirement of broilers from 3 to 6 weeks for maximum breast meat and BWG was similar. Garcia et al. (2006) has been estimating Lys requirement for growing period of male broiler based on BWG, FCR, carcass weight and breast meat at 20% dietary CP 0.97, 0.96, 0.97 and 0.98 respectively; his results show that the requirement of Lys for considered parameters were lower than this experiment results in 20% CP.

Dietary CP level affected Lys requirement in this experiment and by increasing CP level in diet, amount of estimated Lys requirement as a percentage of diet increased (Table 4, Figures 1 and 2) but as a percentage of CP decreased (Figures 1 and 2). This result is in agreement with results of Morris et al. (1987), Hurwitz et al. (1998) and Sterling et al. (2003). In according to the present study results, Hurwitz et al. (1998) found significant differences in the Lys requirements expressed as a percentage of the diet between an 18 and 23% CP diet. The present results confirm previous observations changes in the amino acid requirements when protein supplementation is varied. Hence, CP can be a factor that limits the dietary Lys requirement in dose-response research.

The method of statistical evaluation can influence the relationship between an amino acid and dietary CP levels. The most common statistical models used to determine amino acid requirements are the broken-line (one-slope), two-slope, quadratic, and ascending quadratic with plateau models. Estimated Lys requirement values with quadratic-broken line model in all CP levels and response criterions in this experiment were higher than estimated values with straight-broken line model (Table 4). The result of this experiment coupled with that of Barbour et al. (1993) found that along with protein source, statistical evaluation influences the estimate of amino acid requirement and the quadratic procedure estimates were higher for all protein sources when compared with straight-broken line model. In addition, Vazquez and Pesti (1997) concluded that "ascending quadratic with plateau" model may theoretically be more realistic and adequate than the "ascending line with plateau" model for predicting the Lys requirement for broiler chicks. In conclusion, the results of the present study suggest that by increasing CP level, the percentage of lysine in diet must be increased but lysine level as a percentage of CP decreased and for estimation of lysine requirement the best criterion response must be chosen based on aviculture purpose.

REFERENCES

Abebe S, Morris TR (1990). Note on the effects of protein concentration on responses to dietary lysine by chicks. Br. Poult. Sci. 31: 255-260.

Acar N, Moran Jr. ET, Bilgili SF (1991). Live performance and carcass yield of male broiler from two commercial strain crosses receiving rations containing lysine below and above the established requirement between six to eight weeks of age. Poult. Sci. 70: 2315-2321.

Almquist HJ (1952). Amino acid requirements of chickens and turkeys—a review. Poult. Sci. 31: 969-981.

Baker DH, Han Y (1994). Ideal amino acid profile for chicks during the first three weeks posthatching. Poult. Sci. 73: 1441-1447.

Baker DH, Batal AB, Parr TM, Augspurger NR, Parsons CM (2002). Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks posthatch. Poult. Sci. 81: 485-494.

Barbour G, Latshaw JD, Bishop B (1993). Lysine requirement of broiler chicks as affected by protein source and method of statistical evaluation. Br. Poult. Sci. 34: 747-756.

Bilgili SF, Moran Jr. ET, Acar N (1992). Strain-cross response of heavy male broilers to dietary lysine in the finisher feed: Live performance and further processing yields. Poult. Sci. 71: 850-858.

Boomgaardt J, Baker DH (1973). The lysine requirement of growing chicks fed sesame meal-gelatin diets at three protein levels. Poult. Sci. 52: 588-591.

Dozier WA, Corzo A, Kidd MT, Schilling MW (2008). Dietary digestible lysine requirements of male and female broilers from forty-nine to sixty-three days of age. Poult. Sci. 87: 1385-1391.

Emmert JL, Baker DH (1997). Use of the ideal protein concept for precision formulation of amino acid levels in broiler diets. J. Appl. Poultry Res. 6: 462-470.

Garcia AR, Batal AB, Baker DH (2006). Variations in the digestible lysine requirement of broiler chickens due to sex, performance parameters, rearing environment and processing yield characteristics. Poult. Sci. 85: 498-504.

Gorman I, Balnave D (1995). The effect of dietary lysine and Methionine on the growth characteristics and breast meat yield of Australian broiler chickens. Aust. J. Agric. Res. 46: 1569-1577.

Han Y, Baker DH (1994). Digestible lysine requirement of male and female broiler chicks during the period three to six weeks post hatching. Poultry Sci, 73: 1739-1745.

Hickling D, Guenter W, Jackson ME (1990). The effects of dietary methionine and lysine on broiler chicken performance and breast meat yield. Can. J. Anim. Sci, 70: 673-678.

Hurwitz S, Sklan D, Talpaz H, Plavnik I (1998). The effect of dietary protein level on the lysine and arginine requirements of growing chickens. Poult. Sci. 77: 689-696.

Jackson MR, Li S, Day EJ, Omar S (1989). The effect of different lysine level fed in constant proportion to different crude protein level on the live performance and carcass characteristics of broiler chicken. Poult. Sci. 68: 186.

Kidd MT, Kerr BJ, Halpin KM, McWard GW, Quarles CL (1998). Lysine levels in starter and grower-finisher diets affect broiler performance and carcass traits. J. Appl. Poult. Res. 7: 351-358.

Labadan Jr. MC, Hsu KN, Austic RE (2001). Lysine and arginine requirements of broiler chickens at two- to three-week intervals to eight weeks of age. Poult. Sci. 80: 599-606.

Leclercq B (1998). Specific effects of lysine on broiler production: comparison with threonine and valine. Poult. Sci. 77: 118-123.

Lesson S, Caston LT, Summer JD (1988). Response of male and female broiler to diet protein. Can. J. Anim. Sci. 68: 882-889.

Mack S, Bercovici D, De Groote G, Leclerq B, Lippens M, Pack M, Schutte JB, Van Cauwenberghe S (1999). Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. Br. Poult Sci. 40: 257-265.

Moran Jr ET, Bilgili SF (1990). Processing losses, carcass quality, and meat yields of broiler chickens receiving diets marginally deficient to adequate in lysine prior to marketing. Poult. Sci. 69: 702-710.

Morris TR, Al-Azzawi K, Gous RM, Simpson GL (1987). Effects of protein concentration on responses to dietary lysine by chicks. Br. Poult. Sci. 28: 185-195.

Morris TR, Abbeb S (1990). Effect on arginine and protein on chicks response to dietary lysine. Br. Poult. Sci. 31: 261-266.

National Research Council (1994). Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, DC.

Nelson TS, Young RJ, Bradfield RB, Anderson JB, Norris LC, Hill FW, Scott ML (1960). Studies on the sulfur amino acid requirement of the chick. Poult. Sci. 39: 308-314.

SAS Institute (2004). SAS(r) User's Guide. Statistics. Version 9.1 ed. SAS Institute Inc., Cary, NC.

Sterling KG, Pesti GM, Bakalli RI (2003). performance of broiler chicks fed various levels of dietary lysine and crude protein. Poult. Sci. 82: 1939-1947.

Surisdiarto, Farrell D (1991). The relationship between dietary crude protein and dietary lysine requirement by broiler chicks on diets with and without the “ideal” amino acid balance. Poult. Sci. 70: 830-836.

Rezaei M, Nassiri MH, Pour Reza J, Kermanshahi H (2004). The effects of dietary protein and lysine levels on broiler performance, carcass characteristics and N excretion. Int. J. Poult. Sci. 3(2): 148-152.

Vazquez M, Pesti GM (1997). Estimation of lysine requirement of broiler chicks for maximum body gain and feed efficiency. J. Appl. Poult. Res. 6: 241-246.

Yashamita C, Ishimoto Y, Yamada T, Medada HS, Ebisava S, (1975). Effect of dietary protein and energy levels on abdominal fat content and meat taste. Jpn. Poult. Sci. 12: 78-84.