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Digestible Lysine Requirements of Straight-Run Broiler Chickens from Fifteen to Twenty-Eight Days of Age

M. Mehri, H. Nassiri-Moghaddam, H. Kermanshahi and M. Danesh-Mesgaran
Center of Excellence, Department of Animal Sciences,
Ferdowsi University of Mashhad, Mashhad, 91775-1163, Iran

Abstract: There is little information on Lysine (Lys) requirements of mixed-sex broiler chickens during the grower period. An experiment was conducted to determine the digestible Lys requirements of straight-run Ross 308 broilers from 15-28 days of age. Basal diet consisting of wheat, triticale and corn gluten meal was formulated to be adequate in all essential amino acids except for Lys. Graduation levels of supplemental Lys-HCl were added to the basal diet at expense of corn starch generating six treatments to provide a range from 0.60-1.20% of digestible Lys. Both male and female birds were randomized across 48 floor pens (4 replicates and 12 birds per each replicate) in a completely randomized design and each pen was fed one of six amino acid levels from 15-28 days of age. Body weight gain, feed intake, feed conversion, digestible Lys intake and mortality were measured during the experimental period. Body Weight Gain (BWG) and Feed Conversion (FC), Feed Intake (FI) and daily Lys intake responded quadratically to graded levels of digestible Lys (0.60-1.20%). Digestible Lys requirements were estimated using a linear broken-line and quadratic broken-line models. Based on broken-line linear model, digestible Lys requirement for straight-run Ross 308 broilers was determined to be 0.95 and 1.08% for BWG and FC, respectively. However, using broken-line quadratic model, digestible Lys was estimated at 1.05% for BWG.

Key words: Digestible lysine, straight-run, broken-line model, adequate, requirements, digestible

INTRODUCTION

In poultry diets, lysine as a second limiting amino acid has a profound effect on productivity. Dietary Lys is critical to breast meat yield and Lys deficiency in starting broiler chicks significantly decreases development of satellite cells of breast muscle (Tesseraud *et al*., 1996) and increases protein degradation in pectoralis major muscle due to heightening the expression of m-calpain and cathepsin B in breast muscle (Tesseraud *et al*., 2008). Although, Methionine (Met) is the first limiting amino acid in broiler diets, Lys is considered as reference amino acid in ideal protein concept because it is used almost for protein accretion and unlike Met, Lys requirement is only affected very little by other metabolic functions (i.e., maintenance requirement) or feathering (Lemme, 2003).

Therefore, accurate estimation of Lys requirement is critical to establishing ideal ratios of essential amino acids. Male and female broilers responded differently to dietary amino acid concentrations (Dozier *et al*., 2008) and researchers often used male or female (Corzo *et al*., 2009) broilers separately for their experiments. The results showed that Lys requirement of male broilers is higher than female chickens (Dozier *et al*., 2009; Han and Baker, 1994). More recently, Dozier *et al*. (2009) also demonstrated that digestible Lys needs for body weight gain and feed conversion were 10% higher for male than female broilers.

Although, rearing broiler males and females separately may result in beneficial feeding strategies (Corzo *et al*., 2005) but in practical situation, diets for straight-run broiler flocks are often formulated based on male broiler requirements assuming this procedure will meet the nutrient needs of the females. On other hand, under and over-feeding of essential amino acids will decrease growth rate and increase N excretion, respectively.

In addition, over-feeding of indispensible amino acids may lead to increases the cost of the diet and economical efficiency would be decreased. Since data on the amino acid requirements of straight-run broilers are

Corresponding Author: M. Mehri, Center of Excellence, Department of Animal Sciences, Ferdowsi University of Mashhad, Mashhad, 91775-1163, Iran

sparse especially from 2-4 weeks of age an experiment was conducted to determine the digestible Lys requirements of mixed-sex broiler chickens during the grower period.

MATERIALS AND METHODS

An experiment was conducted using Ross 308 broiler chickens from 15-28 days of age. Broiler chicks (288 birds: 144 males and 144 females) were obtained from commercial hatchery with both male and female chicks originated from the same breeder flock.

The birds were fed with common mesh starter diets according NRC (1994) recommendations until 1800 h of day 14 posthatching. At 15 days of age after overnight feed withdrawal, chickens were weighed; wing-banded and randomly allotted to pens (12 birds per pen) in order to have equal numbers of males and females and to have same average body weight between pens.

Birds and feed were weighted on days 15 and 28 for the determination of BWG, FC, FI and digestible Lys intake per day. Lighting program was 23L:1D during the experimental period.

The temperature at day 1 was 33°C and was decreased to 28°C by 14 days of age. The high and low temperatures for the 15-28 days period were 26 and 24°C, respectively.

Basal diet consisting of wheat, triticale, corn gluten meal and soybean meal was formulated to meet or exceed the requirements recommended by NRC (1994) containing different levels of dietary digestible Lys (Table 1). Six graded levels of L-Lys.HCL were added to the basal diet at the expense of corn starch to generate six levels of digestible Lys that ranged from 0.60-1.2% in 0.12% increments.

Standardized amino acid digestibility (SID) values were calculated using published digestible coefficients of raw materials (Lemme *et al*., 2004) and analyzed total amino acid content of the ingredients (method 985.28, 994.12; AOAC, 2006). 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 digestible Lys (SAS, 2004). Differences among means ($p \leq 0.05$) were separated using LSMEANS option of SAS (2004). Both broken-line linear and broken-line quadratic models were used for estimation of digestible Lys needs using NLIN procedure (Robbins *et al*., 2006).

Table 1: Chemical composition of basal diet

Ingredients	Percent
Wheat, red	60.00
Triticale	11.95
Corn gluten meal	10.50
Soybean meal	5.00
Sunflower oil	5.00
Corn starch	2.75
Dicalcium phosphate	1.76
Limestone	1.21
L-Lysine HCl	0.26
DL-methionine	0.20
L-Thr	0.24
L-Arg	0.30
L-Ile	0.20
L-Trp	0.03
NaCl	0.10
Vitamin premix[1]	0.25
Mineral premix[2]	0.25
Calculated nutrient content	
ME (MJ kg^{-1})	13.08
CP (g kg^{-1})	187.80
SID Lys (g kg^{-1})	6.00
SID Met (g kg^{-1})	4.80
SID Met+Cys (g kg^{-1})	7.60
SID Thr (g kg^{-1})	7.00
SID Arg (g kg^{-1})	9.80
SID Ile (g kg^{-1})	7.70
SID Val (g kg^{-1})	6.70
SID Trp (g kg^{-1})	1.70
Ca (g kg^{-1})	8.90
AP[3] (g kg^{-1})	4.60
Sodium (g kg^{-1})	2.20
DEB[4] (mEq kg^{-1})	155.00

[1]Mineral premix provided per kg^{-1} of diet: Mn (from MnSO4•H_2O), 65 mg; Zn (from ZnO), 55 mg; Fe (from FeSO4•7H_2O), 50 mg; Cu (from CuSO4•5H_2O), 8 mg; I [from Ca (IO3)2•H_2O], 1.8 mg; Se, 0.30 mg; Co (from Co_2O_2), 0.20 mg; Mo, 0.16 mg; [2] Vitamin premix provided per kg^{-1} of diet: vitamin A (from vitamin A acetate), 11,500 IU; cholecalciferol, 2,100 IU; vitamin E (from dL-α-tocopheryl acetate), 22 IU; vitamin B12, 0.60 mg; riboflavin, 4.4 mg; nicotinamide, 40 mg; calcium pantothenate, 35 mg; menadione (from menadione dimethyl-pyrimidinol), 1.50 mg; folic acid, 0.80 mg; thiamine, 3 mg; pyridoxine, 10 mg; biotin, 1 mg; choline chloride, 560 mg; ethoxyquin, 125 mg, 3- Available Phosphorus, 4- Dietary Electrolyte Balance, represents dietary Na+K-Cl in mEq kg^{-1} of diet

RESULTS AND DISCUSSION

Least square means comparison among treatments was significant for growth performance and significant quadratic responses ($p<0.0001$) were observed for BWG, FC, FI and daily Lys intake to incremental levels of dietary Lys (Table 2).

Based on broken-line linear model, digestible Lys requirement was estimated at 0.95 and 1.08% for BWG and FC, respectively (Table 3). The Lys requirement for BWG was obtained to be 1.05% using broken-line quadratic model (Table 3 and Fig. 1). However, broken-line quadratic model was failed to converge FC data. Because of low R-square of estimated model for FI, the resultant digestible Lys requirement was ignored. Dose-response experimental diets are necessary to determination of amino acid requirements. As shown in Table 2, feeding low-Lys diets resulted in performance reduction and addition

Table 2: Growth performance of straight-run broilers fed graded levels of digestible Lys from 15-28 days of age

Dietary digestive Lys	BWG (g)	Feed intake (g)	Lys intake (mg day^{-1})	FCR (g:g)	Mortality (%)
0.60	752^{e}	1344^{c}	576^{f}	1.78^{a}	1.37^{b}
0.72	784^{d}	1360^{c}	700^{e}	1.73^{b}	1.50^{a}
0.84	817^{c}	1423^{a}	854^{d}	1.71^{c}	0.17^{c}
0.96	884^{a}	1457^{a}	999^{c}	1.64^{d}	0.02^{c}
1.08	836^{b}	1357^{b}	1046^{b}	1.55^{e}	0.00^{c}
1.20	837^{b}	1365^{b}	1170^{a}	1.63^{d}	0.05^{c}
SEM	4.02	8.65	6.23	-	0.24
Source of variation					
Linear response	<0.0001	0.0003	<0.0001	<0.0001	<0.0001
Quadratic response	<0.0001	<0.0001	<0.0001	0.0001	0.3520

Means in each columns with different superscripts are significantly different ($p<0.05$)

Table 3: Digestible Lys requirement of straight-run broilers from 15-28 days of age fed graded levels of digestible Lys based on broken-line regression models

Response criteria	Estimated requirement	95% CI**	R^2
Broken-line linear model*			
BW gain	0.95±0.04	0.86-1.03	0.88
Feed intake	1.04±0.14	0.75-1.33	0.41
Feed conversion	1.08±0.04	0.98-1.18	0.84
Broken-line quadratic model*			
BW gain	1.05±0.07	0.89-1.20	0.84

*The linear broken-line model is $y = L+[U\times(R-x)]$ and the quadratic broken-line model is $y = L+[U\times(R-x)\times(R-x)]$ where L is the ordinate, U is the abscissa of the breakpoint and R is zero if $x>R$. Requirement estimates are presented with ±SEM, **95% confidence interval of the digestible Lys requirement

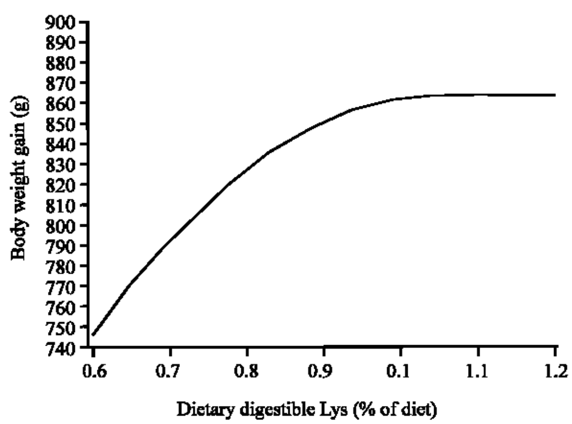

Fig. 1: Digestible Lys requirement of straight-run broilers using broken-line quadratic model from 15-28 days of age

graded levels of L-Lys.HCl to the basal diet improved growth rate providing evidence that the low-Lys basal diet was deficient from 15-28 days of age. Variation in Lys requirement estimates is attributed to the response criteria, sex, strain and statistical model (Han and Baker, 1993; Dozier *et al*., 2009; Pesti *et al*., 2009).

In this experiment, using broken-line linear model digestible Lys requirement was estimated at 0.95 and 1.08% for BWG and FC, respectively.

Higher estimated Lys requirement for FC than BWG was parallel with previous researches (Dozier *et al*., 2009; Han and Baker, 1993, 1994). This result was in contrast to stated regardless of which model to predict the requirement in the case of Lys when BWG and FI reach their highest point, BWG remains constant but FI decreases as incremental levels of Lys is added to the diet. The resultant is continuous response of FC to the higher levels of dietary Lys, therefore higher estimated Lys requirement for FC than BWG could be obtained.

More recently, Dozier *et al*. (2009) clearly showed that Lys requirement of male broilers is higher than female broilers (1.09 vs 0.98% of diet). In current research, mixed-sex broilers were used for determination of digestible Lys needs. Using broken-line quadratic model, digestible Lys requirements were estimated at 1.05% for BWG. Dozier *et al*. (2009) using the same statistical model and response criterion, estimated digestible Lys requirements at 1.09 and 0.98% for male and female broilers, respectively. A digestible Lys requirement estimate of straight-run broilers was between the requirements of male and female broilers which were obtained by Dozier *et al*. (2009) estimated the digestible Lys requirement of Ross×Avian mixed-sex broilers at 0.99% which was 5.7% lower than digestible Lys requirement estimated in this study.

The higher digestible Lys requirement reported by the current research likely related to muscle development and decreased feed intake of the modern broiler strains (Dozier *et al*., 2008; Havenstein *et al*., 2003). So, strains with rapid muscle growth should have high dietary amino acid needs for muscle accretion. Feed intake is another factor influencing needs of dietary amino acid percentages among strains. Actually, two strains may be similar in terms of the breast meat yield but differ in feed intake. Therefore, the dietary amino acid requirements would be higher for broilers having the lower feed intake.

Statistical model used to determination of amino acid requirements has a profound effect on estimated value of requirements. Digestible Lys requirements for BWG were 0.95 and 1.05% using broken-line linear and broken-line quadratic models, respectively. Pesti *et al*. (2009) suggested that broken-line model with linear ascending portion lead to underestimation resulting in over-feeding the amino acids. Broken-line model with quadratic ascending portion follows diminishing marginal productivity until the level of the requirement is reached, resolving the problem of underestimation of broken-line linear model because of nonlinear response to different doses of dietary amino acids (Pesti *et al*., 2009) since, male and female broilers responded differently to dietary amino acid concentrations.

CONCLUSION

It is concluded that further research is warranted for determination of amino acid requirements of straight-run broilers to minimize amino acid catabolism (Klasing, 2009) and improve efficiency.

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