**Effect of different lysine levels on Arian broiler performances**

Javad Nasr¹, Farshid Kheiri²

¹Department of Animal Science, Saveh Branch, Islamic Azad University, Saveh, Iran
²Department of Animal Science, Shahrekord Branch, Islamic Azad University, Shahrekord, Iran

**Abstract**

An experiment was conducted to evaluate the performance and carcass yield of Arian male broilers fed diets (starter and grower) with different levels of lysine requirements, high lysine (120% National Research Council, NRC), medium lysine (110% NRC), standard (100% NRC) and low lysine (90% NRC) in a completely randomized experimental design. All diets were isocaloric and isonitrogenous. In broilers receiving 120% of NRC Lysine, body weight in 42 d significantly increased by 248 g compared with standard lysine diet. Feeding broilers with high lysine diets (120% NRC) significantly increased feed intake and body weight gain (22-42 and 0-42 day of age) compared with standard group (P<0.05). Body weight was significantly different in all weeks of trial (P<0.05). Lysine levels had no effect on feed conversion ratio. This study showed that increasing lysine level (120% NRC) in diet significantly increased abdominal fat pad, gizzard and heart weight compared with standard group (P<0.05). The results of this study suggest that additional lysine at the level of 120% of NRC in starter and grower diets optimized body weight gain in Arian broiler, whereas reductions in lysine level reduced growth and live weight.

**Introduction**

Lysine (Lys) is one of the most limiting amino acids in practical corn-soybean meal and sorghum-soybean meal diets for broilers. The level of dietary Lys needed in the grower and finisher period to optimize breast meat yield may be higher than that needed for optimal live performance traits (Kidd et al., 1997; Moran and Bilgili, 1990). Different recommended levels of dietary lysine have been determined across laboratories because numerous variations have existed among experiments (genetic strain, environmental temperature, feed ingredients, protein source and quality, and sex (Han and Baker, 1991; 1993; 1994). It has been shown that current NRC (1994) recommendations for lysines up to d 21 are too low for today’s commercial broiler (Vasquez and Pesti, 1997; Kidd and Fancher, 2001). The NRC dietary total lysine recommendation for starting broiler chicks from 0 to 21 days of age was 1.2% of the diet in the 1984 edition. In the 1994 edition the NRC lowered this recommendation to 1.1% of the diet. Genetic selection by primary breeding companies has resulted in vastly improved growth rate, feed conversion, and breast meat yield of broiler chickens compared with broilers of the previous decade (Havenstein et al., 2003a,b; Dozier et al., 2008a,b). As a result, modern broilers require higher dietary amino acid concentrations to optimize performance and breast meat yield compared with the broilers of past years (Kidd et al., 2004; Dozier et al., 2008b). Amino acids are critical for muscle development (Tesseraud et al., 1996) and Lysine (Lys) content in breast muscle is relatively higher than other AA (Munks et al., 1945). Dietary Lys inadequacy has been shown to reduce breast meat yield compared with other muscles (Tesseraud et al., 1996). Therefore, defining dietary AA needs for optimum growth and meat yield is of utmost importance. Lysine, one the key AA for protein synthesis and muscle deposition has also been demonstrated to be involved in the synthesis of cytokines, proliferation of lymphocytes and thus in the optimum functioning of immune system in response to infection. An inadequate supply of Lys would reduce antibody response and cell-mediated immunity in chickens (Geraert and Mercier, 2010). It is well known that protein and Lys and its interaction is considered as an important factor which affects performance and carcass quality of growing chicks and so, dietary requirement of protein is actually a requirement for the Lys contained in the protein.

The objective of the nutritionists has long been to optimize growth and tissue accretion by increasing nutrient density such as AA. The question remains about the potential benefits of AA beyond the protein synthesis for muscle developments. Essential amino acid recommendations for broilers by the NRC (1994) are largely based on experimentation conducted several decades ago. Therefore the objective of this study was to evaluate the four different lysine requirement levels, High Lysine (120% NRC), Medium Lysine (110% NRC), Standard (NRC) and Low Lysine (90% NRC) with same protein and energy requirements recommended by NRC (1994) effects on the Arian broiler performance and carcass composition.

**Materials and methods**

An experiment with Arian male broilers was conducted from 1 to 6 weeks of age. At day 1, 200 male chicks were placed in 20 floor pens (10 chicks per pen and 0.1 m² floor space/chick). Water and feed were also supplied ad libitum. The lighting regimen was continuous, with 24 hours of light daily in first three days and then was standard 23L:1D, until the end of trial.

The basic chemical composition of the feed was determined according to AOAC (2006). A completely randomized experimental design was used. The following treatments were applied.

1. Diet with High Lysine (H Lys) requirement level (120% NRC).
2. Diet with Medium Lysine (M Lys) requirement level (110% NRC).
3. Diet with Standard Lysine (S Lys) requirement level (100% NRC).
4. Diet with Low Lysine (L Lys) requirement level (90% NRC).

Feeds provided were in mash form and were
milled with a 3 mm screen to obtain a similar particle size in all diets. Broiler starter diet formulated according to NRC (1994) recommendations to contain 22.5% CP and 3.040 kcal of ME/kg in starter diets and 19.5% CP and 3.170 kcal ME/kg in grower diets. Diets were formulated isonitrogenic and isonitrogenic, based on corn and soybean meal (Table 1). Broiler weight gain, feed intake and feed conversion ratio were measured on a pen basis for the end of week. Prior to selection of birds for processing, feed and water were removed for 10 and 4 hr, respectively. At the end of the experimental period (42 days of age), In order to evaluate carcass quality four birds with body weights as close as possible to the average body weight of the experimental unit were slaughtered per repetition (20 birds/treatment). These birds were weighed, and stunned with a knife, bled for 1.5 min by severing the jugular vein, scalded in water for 1.5 min, and defatted in a rotatory picker for 1 min. Eviscerate were removed and discarded while abdominal fat weights were obtained. Carcasses were chilled in an aerated ice bath for 35 min. Carcass data included cold carcass (without head, feet and skin with bone), breast, thigh and liver weight (Hahn and Spindler, 2002). Breast, thigh and carcass yield (skinless with bone) was determined as the carcass weight in relation to body weight, and expressed as percentage of body weight (%). Data were analyzed by completely randomized design (GLM procedure, ANOVA of SAS Inst., 2004) and where significance occurred, means were compared with the Duncan multiple range tests. Output data were expressed as means with SEM.

### Table 1. Composition of experimental diets in starter (0-21 d) and grower (22-42 d) period.

| Lysine requirement levels | 120% | 110% | 100% | 90% | 120% | 110% | 100% | 90% |
|---------------------------|------|------|------|-----|------|------|------|-----|
| Ingredients, %            |      |      |      |     |      |      |      |     |
| Corn, grain               | 54.01| 55.01| 55.39| 57.32| 64.97| 65.87| 67.60| 66.78|
| Soybean meal 48%          | 37.00| 36.21| 36.01| 33.94| 28.93| 28.10| 27.01| 27.14|
| Soybean oil               | 2.80 | 2.80 | 2.80 | 3.00 | 3.27 | 3.40 | 3.00 | 3.22 |
| Fish meal                 | 2.00 | 2.00 | 2.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oyster shells             | 1.88 | 1.88 | 1.88 | 1.88 | 1.50 | 1.50 | 1.40 | 1.80 |
| Dical. phosphorus         | 1.00 | 1.00 | 1.00 | 1.00 | 0.23 | 0.23 | 0.23 | 0.20 |
| Common salt               | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Vitamin premix c          | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Mineral premix c          | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| DL-Methionine             | 0.11 | 0.10 | 0.10 | 0.10 | 0.20 | 0.10 | 0.06 | 0.11 |
| L-Lysine HCI              | 0.50 | 0.30 | 0.12 | 0.05 | 0.20 | 0.10 | 0.00 | 0.05 |
| Calculated nutrients contents |    |      |      |     |      |      |      |     |
| Metabolizable energy, Mcal/Kg | 3.04 | 3.04 | 3.04 | 3.04 | 3.17 | 3.17 | 3.17 | 3.17 |
| Protein, %                | 22.50| 22.50| 22.50| 22.50| 18.50| 18.50| 18.50| 18.50|
| Ether extract, %          | 5.12 | 5.17 | 5.16 | 4.93 | 5.62 | 5.61 | 5.60 | 5.61 |
| Linoleic acid, %          | 2.58 | 2.74 | 2.63 | 2.54 | 3.21 | 3.10 | 3.20 | 3.22 |
| Calcium, %                | 4.62 | 4.45 | 4.43 | 4.52 | 4.34 | 4.39 | 4.39 | 4.30 |
| Available phosphorus, %   | 0.89 | 0.96 | 0.95 | 0.97 | 0.86 | 0.83 | 0.83 | 0.84 |
| Sodium, %                 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.12 | 0.12 | 0.12 |
| LYS, %                    | 1.37 | 1.25 | 1.14 | 1.03 | 1.22 | 1.13 | 1.00 | 0.91 |
| D LYS, %                  | 1.22 | 1.11 | 1.01 | 0.92 | 1.08 | 0.97 | 0.87 | 0.79 |
| MET, %                    | 0.51 | 0.51 | 0.51 | 0.51 | 0.42 | 0.42 | 0.42 | 0.42 |

αVitamin and mineral premix includes the following per kilogram of diet: vitamin A (vitamin A acetate), 4960 U; vitamin D (cholecalciferol), 1653 U; vitamin E (dl-α tocoferol acetate), 27 U; menadione (menadione sodium bisulfate complex), 0.59 mg; vitamin B₁₂ (cyanocobalamin), 0.015 mg; folic acid, 0.8 mg; d-pantothenic acid (calcium pantothenate), 15 mg; riboflavin, 5.4 mg; niacin (niacinamide), 45 mg; thiamin mononitrate, 2.7 mg; d-biotin, 0.07 mg; pyridoxine hydrochloride, 5.3 mg; manganese (manganese oxide), 90 mg; zinc oxide, 83 mg; iron sulfate monohydrate, 121 mg; copper sulfate pentahydrate, 12 mg; iodine (calcium iodate), 0.5 mg; selenium (sodium selenite), 0.3 mg.

### Table 2. Effects of lysine levels on broiler performance.

| Lysine levels | Feed intake 0-21 d, g | Feed intake 22-42 d, g | Feed intake 0-42 d, g | Gain 22-42 d, g | Gain 0-42 d, g | FCR 0-21 d | FCR 22-42 d | FCR 0-42 d |
|---------------|-----------------------|------------------------|----------------------|----------------|----------------|----------|----------|----------|
| 120% NRC      | 1163 kg               | 3263 kg                | 4426 kg              | 558 kg         | 1625 kg        | 2183 kg  | 2.12     | 2.02     | 2.03     |
| 110% NRC      | 1031 kg               | 3009 kg                | 4040 kg              | 551 kg         | 1419 kg        | 1970 kg  | 1.88     | 2.13     | 2.06     |
| NRC           | 1000 kg               | 2871 kg                | 3873 kg              | 545 kg         | 1390 kg        | 1934 kg  | 1.86     | 2.08     | 2.01     |
| 90% NRC       | 950 kg                | 3005 kg                | 3962 kg              | 468 kg         | 1394 kg        | 1880 kg  | 1.97     | 2.17     | 2.11     |
| P-value       | 0.033                 | 0.045                  | 0.029                | 0.046          | 0.031          | 0.197    | 0.302    | 0.383    |
| SEM           | 54.96                 | 79.19                  | 97.56                | 18.63          | 48.68          | 56.59    | 0.073    | 0.043    | 0.034    |

FCR, feed conversion rate. **Means followed by different superscript are significantly different (P<0.05).
days of age (P<0.05). There was a significantly higher in body weight in broilers fed H Lys diet in all of weeks (Figure 1). Maximum weight gain occurred at 120% dietary lysine from 0 to 42 d (2183 g). These results indicated that the lysine requirement of Arian male broilers for maximum body weight gain was similar to those of values reported for other strains (Han and Baker, 1991; 1993) and higher than NRC (1994) recommended. The results of previous experiments by Zaghari et al. (2002; 2007) indicated that the digestible lysine requirements of Arian male broilers to achieve maximum body weight gain in the starter period was 1.075 %, but in this study showed that this requirements were 1.22%. The lysine requirement for maximum performance of broiler chicks, for both sexes from 0 to 3 wk of age, is 1.209% of the diet for maximum body weight gain and 1.32% for feed efficiency (Vazquez and Pesti, 1997).

Feed intake was significantly different in 2, 3 and 5 weeks, starter, grower and total experiment (Figure 2). Feed intake was significantly highest in broilers fed H Lys diet in starter and grower periods (P<0.05). At the end of experiment (42 day of age) feed intake was still higher for birds that consumed the H Lys diet during the starter and grower phase. In turn, BW was significantly highest in birds that received H Lys starter and grower diets (P<0.05). Body weight and feed intake were highest for birds consuming the H Lys starter diet (P<0.05), but feed conversions were similar when compared to the other lysine levels diets in starter and grower periods (P>0.05) (Figure 3). Furthermore, recent studies have shown an increase in performance when dietary lysine during the starter phase is higher than recommended (NRC, 1994) levels (Kidd et al., 1998; Kidd and Fancher, 2001). Such effects were observed for the Ross x Ross 508 male (Kidd and Fancher, 2001) and the Avian 34 x Avian male (Kidd et al., 1998).

Improvements in body weight gain, carcass, and breast percentage for birds fed the H Lys starter diet may have occurred in part due to a higher feed intake. H lysine treatment was highest body weight then need more energy than other treatments, resulted more feed intake. Higher feed intake results higher nutrient intake such as other essential AA and energy. If chicks consumed more feed, so more nutrients such as energy, essential amino acids, micro and macro minerals and vitamins would be absorbed.

This study showed that increasing Lys level in diet increased carcass and breast percent-
age, as shown in other researches (Gorman and Balnave 1995; Han and Baker, 1994; Kidd et al., 1998). Feeding H Lys diet throughout production optimizes breast meat yield (Kidd et al., 1998, Kerr et al., 1999), it may not always be economically justified. Postnatal protein accretion results from an increase in protein synthesis or a decrease in protein degradation. Diets containing low Lys can limit breast meat formation early in development by reducing protein accretion from protein synthesis and RNA content (Tesseraud et al., 1996). The results of carcass characteristics are given in Table 3. Dietary lysine requirements levels significantly influenced carcass and breast percentage (Table 3). Dietary lysine requirement levels had no influence thigh percentage.

The concentration of dietary Lys can significantly influence carcass and breast yield for two reasons. Breast meat contains a high concentration of Lys (Table 3) and represents a large portion of carcass meat. Breast muscle development is also affected by sex, age, breed and genetics strain (Moran and Bilgili, 1990; Gorman and Balnave, 1995; Han and Baker, 1991). Their studies have also shown that an additional Lys increase breast meat accretion.

Extensive studies with lysine, for example, have shown that maximal feed efficiency (gain/feed ratio) requires a higher dietary level of lysine than maximal body weight gain (Dozier et al., 2008a; Garcia et al., 2006). In this study showed that broiler fed H Lys level (1.37%) had significantly highest weight gain and feed intake (from 0 to 42 d) and no significantly different in feed efficiency (Table 2).

Han and Baker (1994) studied the lysine requirement of both sexes during the period from 3 to 6 wk of age. The requirement of lysine in a diet containing 20% CP for maximum weight gain was 0.99% for males and 0.91% for females; the requirement for optimum feed efficiency for males was 1.03% and for females is 0.99% lysine in the diet, however in current study Lys requirements for male broiler during the period from 3 to 6 wk of age was 1.22% (120% NRC) for maximum weight gain and feed intake. There was a significant increase in abdominal fat weight of H Lys level group. H Lys level resulted in higher abdominal fat deposition (P<0.01). In this study diets were formulated in the same amino acids (Isonitrogenic) and energy requirements (Isocaloric) but different in lysine requirement levels. Therefore broilers fed H Lys diet intake more lysine than other treatments. This increase in abdominal fat weight is probably related to the imbalance ideal AA in diet (Rosebrough and Steele, 1985).

Low lysine level treatment in carcass percentage was significantly lower than other treatments (Table 3). This study showed the higher efficiency of these diets (M and H) as they allowed a better transformation of AA intake into tissue synthesis and accretion. This is possibly related to a higher AA availability to synthesize muscle. Diets formulated by H Lys level promoted a better conversion of AA into carcass and breast yield. This suggests that the excess of AA intake caused by the diet with H Lys but imbalancel was deposited as fat. It was also verified that the H Lys diet promoted better conversion of AA into carcass and breast percentage and significantly increased weight of liver, heart and gizzard (Table 3).

Genetic differences have been observed in breast meat yield, abdominal fat pad percentage, and other parts yields (Holsheimer and Veerkamp 1992; Smith et al., 1998). Leclercq (1998) stated that the required level of lysine is highest for minimizing abdominal fat pad percentage followed by maximizing breast meat yield and body weight gain. Feeding H Lys and AA dense diets to broilers increases breast meat yield (Dozier et al., 2007; Eits et al., 2003). Dietary AA responses influencing breast meat yield may be additive among AA (Kerr et al., 1999; De Leon, 2006) but other research found no interactions between lysine and Met (Si et al., 2004). Differences in dietary AA density responses among published research (Corzo et al., 2004, 2005; Kidd et al., 2004) may be related to strain sources. Therefore broilers fed H Lys diet intake more lysine than other treatments. This increase in abdominal fat weight is probably related to the imbalance ideal AA in diet (Rosebrough and Steele, 1985).

Although in this study treatment No.1 (H Lys) was highest in body weight, feed intake and also abdominal fat, liver, heart and gizzard weights (Table 3). Improvements in gizzard, liver and heart weights for broilers fed the H Lys starter diet may have occurred in part due to a higher feed intake and body weight.

Conclusions

i) Feeding Arian male broilers high lysine density diets (120% NRC) significantly increased abdominal fat, gizzard and heart weight. ii) Feeding Arian broilers concentrations of dietary Lys above NRC recommendations (20%) in starter and grower diets increased body weight gain and feed intake, but no effect on feed conversion ratio. iii) Male Arian broilers fed the low Lysine diet had reduced growth, feed intake, carcass and breast percentage when compared with those fed additional (+10 and +20% NRC) Lysine diets. iv) Feeding male broilers medium lysine density diet (110% NRC) improved carcass percentage by 1.89% more than broilers fed standard lysine level diet.

References

AOAC, 2006. Official Methods of Analysis. 18th ed., Association of Official Analytical Chemists Int., Arlington, VA, USA.

Corzo, A., Kidd, M.T., Dozier, W.A., Walsh, T.J., Peak, S.D., 2005. Impact of dietary amino acid density on broilers grown for the
small bird market. Jpn. Poultry Sci. 42:329-336.
Corzo, A., McDaniel, C.D., Kidd, M.T., Miller, E.R., Boren, B., Fancher, B.I., 2004. Impact of dietary amino acid concentration on growth, carcass yield, and uniformity of broilers. Aust. J. Agric. Res. 55:1133-1138.
De Leon, A.C., 2006. Limiting dietary amino acids and metabolizable energy response surface estimates for growing broilers. Degree Diss., Mississippi State University, USA.
Dozier, III.W., Corzo, A., Kidd, M.T., Branton, S.L., 2007. Dietary apparent metabolizable energy and amino acid density effects on growth and carcass traits of heavy broilers. J. Appl. Poultry Res. 16:192-205.
Dozier, III.W., Corzo, A, Kidd M.T., Schilling M.W., 2008a. Dietary digestible lysine requirements of male and female broilers from forty-nine to sixty-three days of age. Poultry Sci. 87:1385-1391.
Dozier, III.W., Kidd, M.T., Corzo, A., 2008b. Dietary amino acid responses of broiler chickens. J. Appl. Poultry Res. 17:157-167.
Eits, R.M., Kwakkel, R.P., Verstrepen, M.W.A., Emmans, G.C., 2003. Responses of broiler chickens to dietary protein. Effects of early life protein nutrition on later responses. Brit. Poultry Sci. 44:398-409.
Garcia, A.R., Batal, A.B., Baker, D.H., 2006. Variations in the digestible lysine requirement of broiler chickens due to sex, performance parameters, rearing environment and processing yield characteristics. Poultry Sci. 85:498-504.
Geraert, P.A., Mercier, Y., 2010. Amino Acids: Beyond the Building Blocks! Available from: http://www.thepoultryfederation.com/public/userfiles/files/3-1%20Thr%20AA%20Beyond%20Building%20Blocks.pdf
Gornorn, I., Bahnave, 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.
Hahn, G., Spindler, M., 2002. Method of Dissection of Turkey Carcasses. World. Poultry Sci. J. 58:179-197.
Han, Y., Baker, D.H., 1991. Lysine requirement of fast- and slow-growing broiler chicks. Poultry Sci. 70:2108-2114.
Han, Y., Baker, D.H., 1993. Effects of sex, heat stress, body weight and genetic strain on the lysine requirement of broiler chicks. Poultry Sci. 72:701-708.
Han, Y., Baker, D.H., 1994. Digestible lysine requirement of male and female broiler chicks during the period three to six weeks post hatching. Poultry Sci. 73:1739-1745.
Havenstein, G.B., Ferket, P.R., Qureshi, M.A., 2003a. Carcass composition and yield of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poultry Sci. 82:1509-1518.
Havenstein, G.B., Ferket, P.R., Qureshi, M.A., 2003b. Growth, livability, and feed conversion of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poultry Sci. 82:1500-1508.
Holtsheimer, J.P., Veerkamp, C.H., 1992. Effect of dietary energy, protein, and lysine content on performance and yields of two strains of male broiler chicks. Poultry Sci. 71:872-879.
Kerr, B.J., Kidd, M.T., Halpin, K.M., McWard, G.W., Quares, C.L., 1999. Lysine level increases live performance and breast yield in male broilers and breast yield in male broilers. J. Appl. Poultry Res. 8:381-390.
Kidd, M.T., Fancher, B.I., 2001. Lysine needs of starting chicks and subsequent effect during the growing period. J. Appl. Poultry Res. 10:385-393.
Kidd, M.T., Kerr, B.J., Anthony, N.B., 1997. Dietary interactions between lysine and threonine in broilers. Poultry Sci. 76:608-614.
Kidd, M.T., Kerr, B.J., Halpin, K.M., McWard, G.W., Quares, C.L., 1998. Lysine levels in starter and grower-finisher diets affect broiler performance and carcass traits. J. Appl. Poultry Res. 7:351-358.
Kidd, M.T., McDaniel, C.D., Branton, S.L., Miller, E.R., Boren, B.B., Fancher, B.I., 2004. Increasing amino acid density improves live performance and carcass yields of commercial broilers. J. Appl. Poultry Res. 13:593-604.
Leclercq, B., 1998. Specific effects of lysine on broiler production. Comparison with threonine and valine. Poultry Sci. 77:118-123.
Moran, E.T.Jr., Bilgili, S.F., 1999. Processing losses, carcass quality and meat yield of poultry chickens as influenced by dietary lysine. Poultry Sci. 69:702-709.
Munks, B., Robinson, A., Beach, E.F., Williams, H.H., 1945. Amino acids in the production of chicken egg and muscle. Poultry Sci. 24:459-464.
National Research Council, 1994. Nutrient Requirements of Poultry, 9th rev. ed. National Academy Press, Washington, DC, USA.
Pesti, G.M., Leclercq, B.A., Chagnaud, M., Cochard, T., 1994. Comparative responses of genetically lean and fat chickens to lysine, arginine and non-essential amino acid supply. II. Plasma amino acid responses. Brit. Poultry Sci. 35:697-707.
Rosebrough, R.W., Steele, N.C., 1985. Energy and protein relationships in the broiler. 1. Effect of protein levels and feeding regimens on growth, body composition, and in vitro lipogenesis of broiler chicks. Poultry Sci. 64:119-126.
SAS, 2004. User’s Guide Statistics, version 9.1. SAS Inst. Inc., Cary, NC, USA.
Si, J., Kersey, J.H., Fritts, C.A., Waldroup, P.W., 2004. An evaluation of the interaction of lysine and methionine in diets for growing broilers. Int. J. Poultry Sci. 3:51-60.
Smith, E.R., Pesti, G.M., Bakalli, R.I., Ware, G.O., Menten, J. F.M., 1998. Further studies on the influence of genotype and dietary protein on the performance of broilers. Poultry Sci. 77:1678-1687.
Sterling, K.G., Pesti, G.M., Bakalli, R.I., 2006. Performance of Different Broiler Genotypes Fed Diets with Varying Levels of Dietary Crude Protein and Lysine. Poultry Sci. 85:1045-1054.
Tesseraud, S., Peresson, R., Chagneau, A.M., 1996. Dietary lysine deficiency greatly affects muscle and liver protein turnover in growing chickens. Brit. J. Nutr. 75:853-865.
Vazquez, M., Pesti, G.M., 1997. Estimation of lysine requirement of broiler chicks for maximum body gain and feed efficiency. J. Appl. Poultry Res. 6:241-246.
Zaghari, M., Shivazad, M., Kamyab, A., Nikkhah, A., 2002. Digestible Lysine Requirement of Arian Male and Female Broiler Chicks during the 6-21 Days of Age. J. Agr. Sci. Technol. 4:111-117.
Zaghari, M., Shivazad, M., Kamyab, A., Nikkhah, A., 2007. Reevaluation of the Digestible Lysine Requirement of Arian Male Broiler Chicks by Different Diets with Cottonseed Meal. J. Agr. Sci. Technol. 9:211-218.