RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

ISSN 2221-1896 (PRINT) www.roavs.com ISSN 2223-0343 (ONLINE)

Effects of different levels of lysine on carcass yields and composition in broiler

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Abstract

An experiment was conducted to evaluate the effects of four different lysine levels, High (120% NRC), Medium (110% NRC), Standard (100% NRC) and Low Lysine (90% NRC) in a completely randomized design on carcass yields and chemical composition of thigh and breast muscle of 400 male and female broilers. All diets were isocaloric and isonitrogenous. Body weight of male broilers receiving 120% of NRC lysine at 42 days of age increased compared with standard group (P<0.05). High Lysine level (120% NRC) significantly increased abdominal fat percentage, liver, gizzard and heart weights at 42 days of age in male Arian broilers (P<0.05). Supplementing the diets with high lysine led to an increase of 73.2 g in breast and 104.7 g in thigh weights of male broilers (P<0.05) but it had no effect on breast and thigh weights of female. Significant increase (P<0.05) in female carcass and breast percentage was obtained in chickens receiving 90% of NRC lysine. Feeding broilers with High Lysine diet (120% NRC) significantly increased lysine percentage in male breast and thigh meat. The results of this study suggested that additional lysine at the level of 120% of NRC (1994) improved body weight, carcass weight, thigh weight and breast percentage; breast and thigh weights of male but decreased carcass and thigh percentage of female broiler chicks.

Keywords: Lysine, Breast, Thigh, Female, Male.

Introduction

Methionine (Met) and lysine (Lys) are the first and second limiting amino acids (AA) in poultry diets respectively. Amino acids requirements of broilers have been extensively studied, as well as related factors of influence, such as sex, age, genetic strain, heat stress, energy concentration, and interactions with crude protein level (Baker and Han, 1994; Vazquez and Pesti, 1997; Garcia et al., 2006; Sterling et al., 2006). The importance of utilizing the correct amount of balanced dietary protein and AA for poultry is a high priority issue for two reasons. First, protein and AA are some of the most expensive nutrients in feeds/per unit weight. Second, there are environmental concerns about nitrogen losses in poultry waste.

In the past, poultry diets were formulated to meet crude protein requirements. However, the growth of the synthetic AA industry permitted the reduction of crude protein (CP) levels in diets and nutritionists were then able to formulate diets considering the specific requirements of essential AA. This allows nutritionists to utilize lower levels of CP in formulations and research has shown that for each 1% reduction in dietary CP through improved AA formulations, there is a 10% reduction in nitrogen losses in poultry waste.

The concentration of protein and AA in broiler diets will have a large impact on breast meat yield, feed/gain ratio and number of days required to produce the appropriate body weight for each type of market. Depending upon genetic strain and the market objectives for each broiler complex, a broiler integrator will probably utilize several different protein and AA dietary programs (Acar et al., 1991). In commercial practice, formulating diets to adequate AA is critical to optimize production and meat yield of broiler chickens. Within the last 10 years, demand for breast fillets and value-added products has contributed to increasing market weights of broiler chickens. Market weight, product mix, live cost and genetic strain are factors that may govern AA supplementation. Amino acids are critical for muscle development (Tesseraud et al., 1996)

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and Lys content in breast muscle is relatively higher than other AA (Munks et al., 1945). Lysine represents approximately 7% of the protein in breast meat (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. Han and Baker (1991) studied the Lys requirement of both sexes from 3 to 6 weeks of age. The requirement for Lys in a diet containing 20% CP for maximum weight gain was 0.99% for males and 0.91% for females. Lysine, which is one of 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 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 adisseo, 2010). Lysine needed for optimizing breast meat yield may be higher than the amount needed for optimal body weight gain and feed efficiency (Gorman and Balnave, 1995; Geraert and Mercier adisseo, 2010). Holsheimer and Ruesink (1998) showed that breast meat yield was increased in male broilers fed diet containing increasing Lys from 1 to 14 days of age; however, the performance of broilers was not affected by dietary Lys from 15 to 49 days of age. It is well known that protein and Lys and its interaction are considered as important factors which affect performance and carcass quality of growing chicks. As a result, 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 acids 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 effects of four different Lys levels, High Lys (120% NRC), Medium Lys (110% NRC), Standard (100% NRC) and Low Lys (90% NRC) with same protein and energy requirements recommended by NRC (1994) on the carcass quality and chemical composition of thigh and breast of Arian broiler.

Materials and Methods

An experiment with Arian male and female broilers was conducted from 1 to 6 weeks of age. At day 1, 400 male and female chicks were placed in 20 floor pens (20 chicks per pen and 0.1 m^2 floor space/chick). Water and feed were supplied *ad libitum*. The lighting regimen was continuous, with 24 hours of light daily in first three days and then was standardized 23L:1D, until the end of trial.

The basic chemical composition of the feedstuffs and breast and thigh muscles was determined according to AOAC (2006). Before formulation of the experimental diets, samples of the protein-contributing ingredients (corn, soybean meal) were analyzed for total amino acid concentration. The total amino acid values of the ingredients were assayed by high-pressure liquid chromatography analysis. The treatments were as follow:

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

Feeds provided were in mash form and milled with 3 mm screen to obtain a similar particle size in all diets. Broiler diets were formulated according to NRC (1994) recommendations to contain 22.5% CP and 3,040 kcal of ME/kg in starter diets and 18.5% CP and 3,170 kcal ME/kg in grower diets. Diets were isocaloric and isonitrogenous, based on corn and soybean meal (Table 1).

At the end of the experimental period (42 days of age), two birds with body weights close to the average body weight of the experimental unit were slaughtered per replication in order to evaluate carcass quality. These birds were weighed, defeathered, eviscerated, and weighed again to obtain carcass weight (without head and feet), breast, thigh, liver, heart, gizzard and abdominal fat weight. Breast, thigh and carcass yield were determined as the carcass weight in relation to body weight, and expressed as percentage of body weight (%). Parameters were tested for normal distributions before analyses. Data were analyzed by completely randomized design using GLM procedure of SAS Institute, 2001. Treatment means were compared with the Duncan multiple range tests.

Results and Discussion

The results of carcass characteristics of thigh and breast of male and female broilers are given in Tables 2 and 3. Increasing level of supplemental lysine significantly improved body weight at 42 days of age in male and unaffected in female Arian broilers. These results are similar to those of others for dietary Lys (Labadan and Austic, 2001; Sterling et al., 2002). Postnatal protein accretion results from an increase in protein synthesis or a decrease in protein degradation. Diets containing L Lys (90% NRC) can limit breast meat formation early in development by reducing protein accretion from protein synthesis and RNA content (Tesseraud et al., 1992, 1996). The results confirmed the previous studies which demonstrated that

Table1: Composition of experimental diets in starter (0-21day) and grower (22-42 day) period

Period	Starter				Grower			
Lysine requirement levels	120%	110%	100%	90%	120%	110%	100%	90%
Ingredient (%)	1	2	3	4	1	2	3	4
Corn, Grain	54.01	55.01	55.39	57.32	64.97	65.87	67.6	66.78
Soybean Meal 48%	37	36.21	36.01	33.94	28.93	28.1	27.01	27.14
Soybean Oil	2.8	2.8	2.8	3	3.27	3.4	3	3.22
Fish Meal	2	2	2	2	0	0	0	0
Oyster Shells	1.88	1.88	1.88	1.88	1.15	1.5	1.4	1.8
Dical. Phos.	1	1	1	1	0.23	0.23	0.23	0.2
Common Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vitamin Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.11	0.1	0.1	0.1	0.1	0.1	0.1	0.11
L-Lysine HCl	0.5	0.3	0.12	0.05	0.2	0.1	0	0.05
Nutrients calculated								
ME (Mcal/Kg)	3.04	3.04	3.04	3.04	3.17	3.17	3.17	3.17
Protein (%)	22.5	22.5	22.5	22.5	18.5	18.5	18.5	18.5
Ether Extract (%)	5	5	5	5	5.5	5.5	5.5	5.5
Linoleic Acid (%)	2.5	2.5	2.5	2.5	2.5	3	2.5	2.5
Calcium (%)	1.00	1.00	1.00	1.00	0.9	0.9	0.9	0.9
Avail. Phosphorus (%)	0.5	0.5	0.5	0.5	0.42	0.42	0.42	0.42
Sodium (%)	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12
Analyzed								
LYS (%)	1.367	1.245	1.141	1.013	1.11	1.001	0.923	0.909
D LYS (%)	1.222	1.101	1.013	0.922	1.078	0.977	0.867	0.789
MET (%)	0.511	0.512	0.509	0.51	0.461	0.463	0.459	0.458

*Provides per kg of diet. vitamin A (7,000 IU), vitamin D3 (1,400 IU), vitamin E (16.65 mg), vitamin K (1.5 mg), vitamin B1 (0.6 mg), vitamin B2 (2.36 mg), vitamin B6 (0.6 mg), vitamin B12 (0.013 mg), biotin (0.15 mg), choline (1.54 g), pantothenic acid (9.32 mg), niacin (30.12 mg), folic acid (1.42 mg), selenium (0.65 mg), iodine (0.35 mg), iron (57.72 mg), copper (12.30 mg), zinc (141.48 mg), manganese (173 mg).

Table 2: Effects of lysine levels on body weight and carcass characteristics in male Arian broiler

Lysine levels	Body Weight (g)	Carcass (%)	Breast (g)	Breast (%)	Thigh (g)	Thigh (%)	Abdominal Fat (%)	Liver (g)	Liver (%)	Heart (g)	Heart (%)
High	2227[a]	65.18[a]	472.3[a]	21.07[a]	523.8[a]	23.30[a]	1.82[a]	60.4[a]	2.70[ab]	17.1[a]	0.78
Medium	2015[b]	66.49[a]	396.9[b]	21.46[a]	429.2[b]	23.16[ab]	0.81[b]	51.6[ab]	2.81[ab]	12.3[ab]	0.67
Standard	1979[b]	64.60[b]	398.9[b]	21.19[a]	419.1[b]	22.2[ab]	1.25[ab]	54.7[a]	2.93[a]	13.1[b]	0.74
Low	1925[b]	60.94[b]	345.5[b]	18.88[b]	399.9[b]	21.88[b]	1.04[b]	42.6[b]	2.33[b]	9.88[ab]	0.56
P-value	0.051	0.013	0.005	0.029	0.020	0.030	0.044	0.047	0.046	0.025	0.571
SEM	80.02	0.864	15.268	0.469	19.801	0.514	0.23	3.018	0.18	1.446	0.10

a–c Means followed by different superscript letters are significantly different (P< 0.05)

Table 3: Effects of lysine levels on body weight and carcass characteristics in female Arian broiler

Lysine levels	Body Weight (g)	Carcass (%)	Breast (g)	Breast (%)	Thigh (g)	Thigh (%)	Abdominal Fat (%)	Liver (g)	Liver (%)	Heart (g)	Heart (%)
High	1.990	60.87[b]	401	20.17	413	20.77[b]	1.03	40.9	2.27[b]	10.8	0.59
Medium	1.975	64.80[ab]	413	20.89	426	21.57[ab]	1.44	52.8	2.97[a]	11.6	0.65
Standard	1.891	63.86[ab]	398	21.02	433	22.91[ab]	1.33	49.3	2.90[a]	11.5	0.69
Low	1.928	67.87[a]	421	21.85	447	23.19[a]	1.44	50.4	2.92[a]	163.6	9.26
P-value	0.807	0.029	0.936	0.624	0.794	0.011	0.668	0.223	0.021	0.180	0.179
SEM	83.9	2.01	24.1	0.77	18.0	0.71	0.25	3.88	0.15	51.44	2.90

c a–c Means followed by different superscript letters are significantly different (P< 0.05)

Lys requirement for growing male chicks is higher than that of NRC (1994) recommendation which is supplemented in the diet for maximal growth. It also confirmed that increasing dietary Lys level increases breast meat yield of male broiler. This study showed that the dietary H Lys levels significantly increased (P<0.05) carcass, thigh and breast percentage in male and significantly decreased (P<0.05) carcass and thigh percentage in female Arian broilers (Table 2).

H Lys requirement levels resulted in higher abdominal fat deposition in male broilers (P<0.05). This increase in abdominal fat percentage is probably related to the imbalance of AA in diet (Summers et al., 1965; Griffiths et al., 1977; Rosebrough and Steele, 1985).

This study showed that increasing Lys level (120% NRC) in the diet significantly increased breast percentage in male broilers, as shown in other reports (Han and Baker, 1991; Gorman and Balnave, 1995; Bilgili et al., 1992; Kerr et al., 1999). Although feeding H Lys diet throughout production optimizes male breast meat yield (Kerr et al, 1999; Kidd et al, 1999), it may not always be economically justified. However, evidence in the literature suggests that feeding diet high in Lys during the starter period impacts subsequent breast meat yield at marketing (Kerr et al., 1999; Kidd et al., 1999; Holsheimer and Ruesink, 1993). The concentration of dietary Lys can significantly influence breast meat yield for several reasons: it contains a high concentration of Lys (Table 3). Breast meat represents a large portion of carcass meat. Breast muscle development is also affected by sex, age, breed and genetics strain (Moran and Bilgili, 1990; Acar et al., 1991; Han and Baker, 1991; Bilgili et al., 1992; Gorman and Balnave, 1995). Their studies have also shown that an additional Lys increase breast meat accretion (P<0.05). Labadan and Austic (2001) reported total lysine requirement for broiler chicks from 1 to 21 days in order to increase breast muscle yield is 1.32%. This level is 20% higher than NRC (1994) recommendation. The NRC estimated the lysine requirement of broilers to be 1.1% of the diet up to 3 weeks, 1.0 % from 3 to 6 weeks, and 0.85% from 6 to 8 weeks of age (NRC, 1994).

Carcass, breast and thigh percentage (male) for Treatment 1 (120% NRC) were significantly higher than other treatments (Table 2). The higher efficiency of these diets might have allowed a better transformation of AA intake into tissue synthesis and accretion. This is possibly related to a higher Lys and AA availability to synthesize muscle. This suggests that the excess of AA intake caused by the diet with H Lys but imbalance was deposited as fat. It was also observed that the H Lys diet promoted better conversion of AA into carcass, breast and thigh yields of male Arian broilers (Table 2).

Genetic differences have been observed for breast meat yield, abdominal fat pad percentage and other parts yields (Acar et al., 1991; Holsheimer and Veerkamp, 1992; Smith and Pesti, 1998; Smith et al., 1998). Leclercq (1998) stated that the required level of Lys is optimum for minimizing abdominal fat pad percentage followed by maximizing breast meat yield and body weight gain. Acar et al. (1991) found significant interactions of genotype by Lys for abdominal fat, breast fillet yields, and breast tender yields. However, dietary protein level has been found to affect the Lys requirement (Morris et al., 1987; Hurwitz et al., 1998; Sterling et al., 2002). Feeding H Lys diet to broilers increased breast meat yield (Eits et al., 2003; Dozier et al., 2007). Dietary AA responses that influence breast meat yield may be additive among AA (Hickling et al., 1990; Kerr et al., 1999; De Leon, 2006). Si et al. (2004) found no interactions between Lys and Met. Differences in dietary AA density responses among published research (Corzo et al., 2004; Corzo et al., 2005) may be related to strain sources. The response to dietary AA/CP density (Sterling et al., 2006; Smith and Pesti, 1998) and dietary Lys (Acar et al., 1991; Han and Baker, 1991; Bilgili et al, 1992; Pesti et al., 1994) differs among strain sources. A high-yielding strain was shown to contain more breast muscle total RNA and protein on a weight basis and total DNA content over a low-yielding strain (Acar et al., 1993). According to Kang et al. (1985), muscle growth is largely related to the number of nuclei or total DNA. Hence, strains exhibiting rapid muscle growth should have balanced high dietary AA needs for muscle accretion. Ferguson et al. (1998) and Jacob et al. (1994) reported that feeding low protein diets to broilers decreased growth performance. It has been suggested that AA requirements in broiler increases linearly with dietary CP (Morris et al., 1987; Garu, 1984; Morris and Abbeb, 1990). Although in this study, H Lys was significantly higher in carcass, breast, thigh and abdominal fat percentage, liver, gizzard and heart weight in male (Table 2), it was significantly lower in carcass, breast and liver percentage in female Arian broilers (Table 3).

In this study, female broiler fed H Lys diet had significantly lower carcass and breast yields while broilers fed L Lys diet had significantly highest carcass and breast yields (P<0.05). The formation of new body proteins from both endogenous and dietary AA can be inefficient with regard to using available metabolic energy. A large amount of metabolic energy is utilized

Table 4: Effects of lysine levels on chemical composition of breast and thigh meat of male

Lysine levels	Breast meat				Thigh meat			
	Lys (%)	Met (%)	Lipid (%)	CP (%)	Lys (%)	Met (%)	Lipid (%)	CP (%)
High	5.89[a]	7.09[a]	4.77[ab]	79.34[a]	5.40[a]	2.91	9.30	86.66[a]
Medium	5.06[ab]	6.32[ab]	4.59[ab]	75.04[a]	4.49[ab]	2.93	9.46	84.85[a]
Standard	4.26[b]	5.00[ab]	3.40[b]	67.18[b]	3.69[bc]	3.66	10.59	71.02[b]
Low	3.92[b]	3.96[b]	6.49[a]	65.64[b]	3.05[c]	2.78	11.39	68.74[b]
P-value	0.022	0.046	0.043	0.039	0.001	0.483	0.458	0.045
SEM	0.335	0.661	0.789	3.584	0.276	0.338	0.816	3.113

[a–c] Means followed by different superscript letters are significantly different (P< 0.05) causing additional body heat production in poultry during the process of eliminating excess nitrogen. The nitrogen that is not used in body must be converted into a non-toxic metabolite (nitrogen waste product) called uric acid and eliminated from the body. The production of uric acid requires a significant amount of metabolic energy that is taken away from the energy needed for growth.

Effects of Lys requirements levels significantly affected protein and lipid content of male breast meat and protein content of male thigh meat. H Lys treatment had significantly highest crude protein percentage in breast and thigh meat of male birds (P<0.05). The breast meat contained a higher percentage of lipids in L Lys diet (P<0.05). In Ross strain of birds, the breast contains a higher percentage of Lys (6.5%) and Met (1.96%) than other body components and the thigh contains 5.86% Lys and 1.93% Met (Coon, 2000).

This study showed that H Lys diet had significantly highest Lys and Met percentage in breast and Lys percentage in thigh meat of male Arian broilers (P<0.05). The AA requirements for different genetic broiler lines will partially dependent upon the Lys content of each body component (breast, thigh, drum) and the extent to which the carcass components change as a percentage of the whole bird. In this study, male breast and thigh's Lys percentages were 4.78 and 4.16, respectively, which were lower than Ross strain.

Amino acids have largely demonstrated effects beyond their roles of building blocks of the protein accretion: from a better gut functioning to an enhanced immune system. Further research is necessary to determine the optimal requirements of AA to improve not only muscle development but also meat quality. It has been identified that the optimal levels of AA were not the same for the maximization of weight gain or breast muscle development (Bilgili et al., 1992)

Conclusions

Feeding male Arian broilers high Lys density diet (120% NRC) increased carcass and breast percentage by 4.24% and 2.19% compared to broilers fed low Lys (90% NRC) density diet respectively.

Feeding female Arian broilers high Lys density diet (120% NRC) decreased carcass and breast percentage lower than broilers fed low Lys (90% NRC) density diet.

Feeding male Arian broilers high Lys density diet (120% NRC) increased body, breast and thigh weight by 248, 73.2 and 104.7 g more than broilers fed standard Lys (100% NRC) density diet.

Feeding male broilers high Lys density diet (120% NRC) significantly increased percentage of Lys and Met in male breast and thigh meat.

Feeding male broilers high Lys density diet (120% NRC) significantly increased liver, gizzard and heart weight.

The percentage of Lys content in breast and thigh of male Arian broiler strain were lower than other strains.

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