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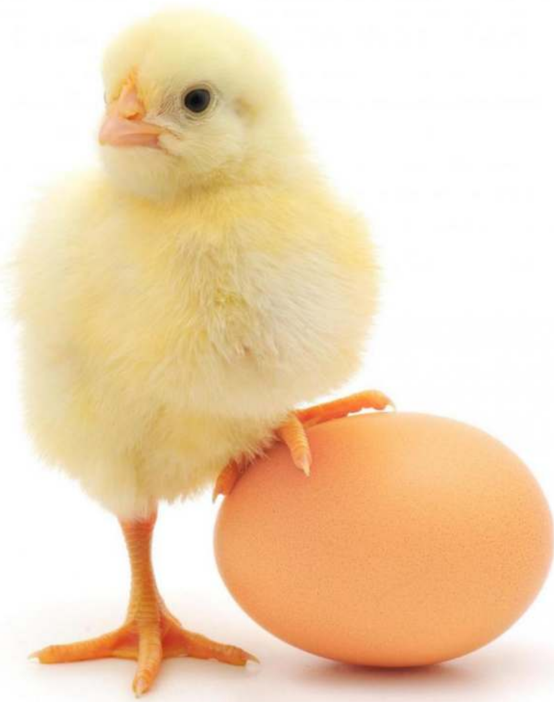

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Influence of Dietary Formulation Methods on Response to Arginine and Lysine in Diets for Young Broiler Chickens

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Abstract: A study was conducted to compare response of young broiler chicks to various levels of Lys and Arg using two different dietary approaches. In both diet types, a 4 x 5 factorial arrangement with Lys levels of 1.1, 1.2, 1.3, and 1.4% and Arg levels of 1.25, 1.35, 1.45, 1.55, and 1.65% was used. All other essential amino acids were at least 110% of NRC (1994). Corn, soybean meal, and corn gluten meal (CGM) of known composition were used. In the first diet set (BASAL + AA) a diet that contained 1.1% Lys and 1.25% Arg was fortified with L-Lysine HCl and L-Arg to provide the various levels of Lys and Arg. In the second dietary set (INTACT) each of the 20 diet combinations was formulated independently using intact protein sources to provide the desired Lys and Arg levels with the primary difference being in amount of CGM that varied from 0 to 33%. Data were subjected to ANOVA as factorial arrangement of treatments. Conflicting results between the two diet types existed. In BASAL+AA diets there were no significant differences in BW or FCR due to Lys; 1.35 to 1.45% Arg was necessary for optimum FCR. Although the Lys x Arg interaction was not significant the reduction in BW or FCR at high Lys with low Arg interaction was not significant, the reduction in BW or FCR at high Lys with low Arg appeared primarily responsible for the increased Arg needs. In the INTACT series there were significant interactions in BW and FCR for Arg and Lys, but these appeared to be associated with reduced performance on diets high (15-30%) in CGM. In a parallel study these levels of CGM reduced performance due to reduced feed intake. Thus, differences in diet type may influence response to Arg and Lys due to factors other than amino acid level per se.

Key words: Broilers, arginine, lysine, amino acid antagonism

Introduction

The antagonism between lysine (Lys) and arginine (Arg) in poultry diets is well known (D'Mello and Lewis, 1970; Allen *et al.*, 1972; Austic, 1986; D'Mello, 1994). The adverse effects of excess Lys on needs for Arg was first encountered in diets based on casein, an ingredient high in Lys (7.31%) in relation to Arg (3.42%). Other common protein sources such as soybean meal contain Arg (3.48%) at levels equal or greater to that of Lys (2.96%), making it difficult to obtain excessively high levels of Lys in relation to Arg unless crystalline Lys is added to diets.

Recent research has focused on the relationship between these two amino acids in efforts to increase breast meat yield or to reduce the effects of heat stress with conflicting results among authors (Brake *et al.*, 1994; Mahmoud *et al.*, 1996; Mendes *et al.*, 1997; Brake *et al.*, 1998; Waldroup *et al.*, 1998; Balnave *et al.*, 1999; Balnave and Brake, 2000; Veldkamp *et al.*, 2000). One of the difficulties in the interpretation of studies dealing with amino acid needs or interactions is the manner in which the experimental diets are established. Use of ingredients with reduced digestibility, amino acid imbalance, poor palatability, or various antinutritive factors may confound the results and make it difficult to determine whether the final results were due to amino acid levels *per se* or to the types of diets or ingredients used. The present study was conducted to compare the response of young broiler chicks to various levels of Lys and Arg, with two different dietary approaches taken.

Materials and Methods

Male chickens of a commercial broiler strain were obtained from a local hatchery where they had been vaccinated in ovo for Marek's disease and had received vaccinations for Newcastle disease and Infectious Bronchitis post hatch via a coarse spray. They were randomly distributed among compartments in electrically heated battery brooders with raised wire floors. Five chicks were placed in each compartment with 24-h fluorescent lighting. The experimental feeds and tap water were provided for ad libitum consumption. Care and management of the birds followed recommended guidelines (FASS, 1999).

Group body weights by pen were obtained at 1 and 21 d of age with feed intake determined at the conclusion of the study by weighing residual feed. Birds were checked twice daily for mortality; weight of dead birds was used to adjust feed conversion ratio (FCR).

Using two different dietary types, a 4 x 5 factorial arrangement of Arg and Lys levels was evaluated with Lys levels of 1.1, 1.2, 1.3 and 1.4% and Arg levels of 1.25, 1.35, 1.45, 1.55 and 1.65%. Corn, soybean meal, and corn gluten meal (CGM) of known moisture and

Table 1: Composition of basal diet to be supplemented with crystalline amino acids for Arg and Lys study

Ingredients	g/kg
Yellow corn	622.15
Soybean meal (47.5% CP)	222.99
Corn gluten meal (62% CP)	51.52
Poultry oil	42.70
Dicalcium phosphate	18.59
Ground limestone	12.36
Lysine HCL (98%)	2.65
DL-methionine	1.84
L-Threonine	1.32
L-Tryptophan	0.18
Constant ingredients[1]	6.75
Variable[2]	16.95
Total	1000.00
Nutrient analysis[3]	
Crude protein	19.49
Met	0.55
Lys	1.10
Arg	1.25
TSAA	0.85

[1]Includes 1.0 g/kg choline chloride, 2.0 g/kg vitamin premix, 1.0 g/kg trace mineral mix, 0.75 g/kg Coban 60, and 2.0 g/kg sodium bicarbonate. Provides per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; choline 465 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; thiamin (from thiamine mononitrate) 1.54 mg; pyridoxine (from pyridoxine hydrochloride) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg; Mn (from $MnSO_4 \cdot H_2O$) 100 mg; Zn (from $ZnSO_4 \cdot 7\,H_2O$) 100 mg; Fe (from $FeSO_4 \cdot 7\,H_2O$) 50 mg; Cu (from $CuSO_4 \cdot 5\,H_2O$) 10 mg; I (from $Ca\,(IO_3)_2 \cdot H_2O$) 1 mg. Coban 60 is a product of Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. [2]Variable amounts of washed builders sand, L-Lysine HCl, L-Arginine free base, sodium chloride, sodium bicarbonate, and potassium bicarbonate. [3]Calculated from NRC (1994) adjusted to crude protein and moisture content of actual ingredients used. All diets calculated to contain 3200 ME kcal/kg.

crude protein content were used to formulate the diets, with amino acid compositional values (NRC, 1994) adjusted accordingly. All diets were fortified with complete vitamin and trace mineral mixes obtained from a commercial poultry company.

In the first diet type (BASAL + AA), a diet was formulated that provided a minimum of 110% of all essential amino acids (NRC, 1994) other than Lys and Arg (Table 1). This diet was calculated to contain exactly 1.10 % Lys and 1.25 % Arg. A quantity of inert filler, equivalent to the amount of L-Lys HCl and L-Arg free base needed to provide the maximum levels of 1.4% Lys and 1.65% Arg, was included in the formulation. A large amount of this basal diet, void of inert filler, was mixed and aliquots supplemented with varying amounts of Lys HCl, Arg free base, sodium chloride, sodium bicarbonate, potassium bicarbonate, and washed builders sand to provide desired levels of Lys and Arg while maintaining dietary electrolyte balance [DEB; (Na + K)-Cl)] at 250 mEq/kg with a minimum of 0.2% sodium (Na) and 0.15% chloride (Cl).

In the second diet type (INTACT), each of the 20 dietary combinations of Lys and Arg was formulated independently to provide exactly the desired level of Lys and Arg, while maintaining other amino acids at a minimum of 110% of NRC (1994) recommendations with a DEB of 250 mEq/kg. Selected examples of these diets are shown in Table 2. The most striking difference in these diets was the variation in CGM, ranging from 0 to 33%. To facilitate uniformity among the treatments in this series, a "least common amount" mixture was prepared incorporating the lowest common amount of each of the ingredients in the diet. This constituted approximately 66.4% of the total diet. For each test diet, sub-lots of this mixture were blended with additional amounts of the various ingredients to provide the final diets. Overall, the combination of four Lys levels and five Arg levels and two dietary sets resulted in 40 diets. Each of the diets was fed to six replicate pens of five Cobb-500 male chicks each from day-old to 21 days of age.

As previous research from our laboratory (Waldroup *et al.*, 2002) had indicated that high levels of CGM may reduce feed intake in young birds, a companion study evaluating effects of levels of CGM was conducted simultaneously using hatchmates of the chicks in the Arg-Lys study and the same lot of ingredients. As a positive comparison, 12 replicate pens of chicks were fed a corn-soybean-meal-based diet formulated to provide 22% CP with a minimum of 110% of essential amino acid recommendations, with no restriction for exceeding minimum levels of Lys or Arg (Table 3). Additional diets were fed with these same stipulations but with CGM included at levels ranging from 5 to 30% in increments of 5% (Table 3). The purpose of this series of diets was to ascertain the possible influence of inclusion of CGM *per se* in diets formulated under commercial conditions. Although CGM is a widely used ingredient with good amino acid digestibility (NRC, 1994), it is not typically included at the high levels seen in some of the INTACT diet series.

Total amino acid assays were conducted on the lowest (1.1% Lys, 1.25% Arg) and highest (1.4% Lys, 1.65% Arg) diets in both the BASAL + AA and INTACT series. All diets, including the CGM series, were analyzed for CP content. Supplemental amino acids were determined on all diets in the Lys and Arg study.

Pen means served as the experimental unit. Data were subjected to analysis of variance as a complete factorial arrangement with diet type, Lys level, and Arg level as main effects and all two-way and three-way interactions included. Analysis used the general linear models procedure of SAS (SAS Institute, 1991). Mortality data were transformed $\sqrt{n+1}$ to prior to analysis; data are presented as natural numbers. Statements of probability

Table 2: Composition (g/kg) of selected diets formulated using intact ingredients to provide varying levels of Arg and Lys

Ingredients	1.10% Lys					1.40% Lys				
	1.25% Arg	1.35% Arg	1.45% Arg	1.55% Arg	1.65% Arg	1.25% Arg	1.35% Arg	1.45% Arg	1.55% Arg	1.65% Arg
Yellow corn	638.53	624.47	593.02	502.92	407.36	630.17	616.10	584.72	553.08	521.18
Soybean meal (47.5% CP)	221.13	275.80	306.73	260.44	212.11	222.08	276.75	307.82	338.52	369.25
Corn gluten meal (62% CP)	50.95	0.51	0.00	162.54	330.39	51.24	0.79	0.00	0.00	0.00
Poultry oil	36.77	50.79	55.75	31.36	5.93	37.95	51.97	56.99	61.85	66.72
Dicalcium phosphate	18.55	18.34	18.11	17.82	17.54	18.57	18.36	18.14	17.91	17.68
Ground limestone	12.39	12.25	12.22	12.58	12.94	12.37	12.23	12.21	12.18	12.16
L-Lysine HCL (98%)	2.69	1.18	0.03	0.00	0.00	6.47	4.97	3.81	2.66	1.51
DL-methionine	1.84	2.45	2.28	0.00	0.00	1.84	2.45	2.29	2.11	1.93
L-Threonine	1.31	1.31	0.81	0.00	0.00	1.31	1.32	0.81	0.30	0.00
L-Tryptophan	0.18	0.02	0.00	0.00	0.00	0.18	0.02	0.00	0.00	0.00
Constant ingredients[1]	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75
Sodium chloride	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Potassium bicarbonate	6.41	3.63	1.80	3.09	4.48	8.57	5.79	3.96	2.14	0.32
TOTAL	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Nutrient Analysis[2]										
Crude protein	19.50	18.77	19.81	26.73	34.03	19.86	19.12	20.15	21.21	22.29
Met	0.55	0.55	0.55	0.59	0.87	0.55	0.55	0.55	0.55	0.55
Lys	1.10	1.10	1.10	1.10	1.10	1.40	1.40	1.40	1.40	1.40
Arg	1.25	1.35	1.45	1.55	1.65	1.25	1.35	1.45	1.55	1.65
TSAA	0.85	0.84	0.85	1.03	1.45	0.85	0.84	0.85	0.87	0.89

[1]Includes 1.0 g/kg choline chloride, 2.0 g/kg vitamin premix, 1.0 g/kg trace mineral mix, 0.75 g/kg Coban 60, and 2.0 g/kg sodium bicarbonate. Amount of vitamins and trace minerals provided is shown in Table 1. Coban 60 is a product of Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. [2]Calculated from NRC (1994) adjusted to crude protein and moisture content of actual ingredients used. All diets calculated to contain 3200 ME kcal/kg.

are based upon $P \leq 0.05$. When significant differences among or between treatment means were found, means were separated using repeated t-test using probabilities generated by LSMEANS option. Data from the CGM level study were analyzed by one-way ANOVA.

Results and Discussion

Results of analysis of diets where amino acids were added to a basal diet to provide the various levels of Lys and Arg are shown in Table 4. Analyzed levels of Lys in the lowest diet were somewhat higher than calculated (1.18 vs 1.10%) but in good agreement in the highest diet (1.42 vs 1.4). Analyzed levels of Arg were in good agreement with calculated values at both the lowest and highest diets. Overall, analyzed CP levels were slightly higher than calculated levels. Supplemental levels of Lys and Met were found to be in good agreement with calculated levels. Results of analysis of diets where dietary ingredients were adjusted to provide the various levels of Lys and Arg are shown in Table 5. The analyzed level of Lys in the lowest diet was higher than calculated (1.19 vs 1.1%) but in good agreement in the highest diet (1.39 vs 1.4%). Analyzed level of Arg was in good agreement with calculated level in the lowest diet but slightly lower in the highest diet (1.55 vs 1.65). Analyzed crude protein levels were somewhat higher than analyzed, with supplemental levels of Lys and Met being in good agreement with calculated values.

The type of diet used to evaluate the response to Arg and Lys had a significant effect on performance of the birds in this study. Main effects of both Lys and Arg as well as the interaction of Lys and Arg were significantly affected by diet type. This indicates that the type of diet used to evaluate interactions between Lys and Arg or to estimate the requirements for these amino acids can be markedly influenced by the type of diet used in the study. Therefore, data for the two diet types was evaluated independently.

Effects of the different levels of Lys and Arg obtained by supplementing the basal diet with crystalline amino acids (BASAL+AA) are shown in Table 6. Overall, there were no significant effects of Lys levels on BW or FCR indicating that the NRC (1994) recommended level of 1.1% Lys was adequate in this study. The BW of chicks fed 1.25% Arg was significantly lower than that of birds fed higher levels of Arg. The FCR was improved as Arg levels increased up to approximately 1.45%. Although there was no significant interaction between lysine and arginine levels, it does appear that performance was reduced at the lowest level of arginine (1.25%) at the higher levels of lysine (1.40%) as indicated in Fig. 1. This is the primary reason that the chicks fed this level of arginine were significantly lower in body weight than those fed the higher levels.

The effects of the different levels of Lys and Arg obtained by varying the amounts of intact ingredients are shown in Table 7. Overall, there were significant main effects of both Lys and Arg levels as well as a significant

Table 3: Composition of diets with different levels of corn gluten meal

Ingredients	% Corn gluten meal						
	0	5	10	15	20	25	30
Yellow corn	528.27	552.55	567.10	560.02	541.75	522.91	501.95
Soybean meal (47.5% CP)	363.77	301.42	246.94	213.16	189.52	165.95	142.66
Corn gluten meal (62% CP)	0.00	50.00	100.00	150.00	200.00	250.00	300.00
Poultry oil	66.05	50.65	36.78	26.21	17.22	8.22	0.00
Dicalcium phosphate	17.72	17.98	18.18	18.24	18.22	18.20	18.19
Ground limestone	12.17	12.32	12.46	12.58	12.70	12.81	12.92
L-Lysine HCL (98%)	0	1.09	2.59	3.32	3.66	4.00	4.34
DL-methionine	3.05	2.34	1.55	0.51	0.00	0.00	0.00
Constant ingredients[1]	6.75	6.75	6.75	6.75	6.75	6.75	6.75
Sodium chloride	2.22	2.18	2.16	2.17	2.19	2.21	2.24
Potassium bicarbonate	0.00	2.72	5.49	7.04	7.99	8.95	9.91
Sand	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Nutrient content[2]							
Crude protein, % (C)	22.00	22.36	23.06	24.48	26.30	28.14	29.98
Crude protein, % (A)	22.7	23.00	24.2	25.1	27.3	29.0	30.8
Lysine, % (C)	1.26	1.21	1.21	1.21	1.21	1.21	1.21
Arg, % (C)	1.63	1.51	1.41	1.38	1.38	1.38	1.38
TSAA, % (C)	0.99	0.99	0.99	0.99	1.05	1.17	1.28
Added Lys, % (C)	0.00	0.09	0.21	0.26	0.29	0.31	0.34
Added Lys, % (A)	0.01	0.11	0.24	0.29	0.32	0.36	0.38
Added Met, % (C)	0.30	0.23	0.11	0.05	0.00	0.00	0.00
Added Met, % (A)	0.33	0.24	0.18	0.06	0.01	0.01	0.01

[1]Includes 1.0 g/kg choline chloride, 2.0 g/kg vitamin premix, 1.0 g/kg trace mineral mix, 0.75 g/kg Coban 60, and 2.0 g/kg sodium bicarbonate. Amount of vitamins and trace minerals provided is shown in Table 1. Coban 60 is a product of Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. [2]All diets calculated to contain 3200 ME kcal/kg. Calculated © values from NRC (1994). Analyzed values from Ajinomoto Heartland Lysine LLC, Chicago IL.

Table 4: Calculated and analyzed nutrient content of diets where amino acids were added to basal diet to provide various levels of Lys and Arg

%Lys		% Arg		% CP[1]		% Met		%TSAA		%Added Lys		% Added Met	
C[2]	A[3]	C	A	C	A	C	A	C	A	C	A	C	A
1.1	1.18	1.25	1.23	19.49	21.1	0.55	0.58	0.85	0.94	0.21	0.22	0.18	0.17
1.1	nd[4]	1.35	nd	19.69	20.8	0.55	nd	0.85	nd	0.21	0.19	0.18	0.18
1.1	nd	1.45	nd	19.89	21.2	0.55	nd	0.85	nd	0.21	0.23	0.18	0.21
1.1	nd	1.55	nd	20.09	22.0	0.55	nd	0.85	nd	0.21	0.21	0.18	0.20
1.1	nd	1.65	nd	20.29	21.6	0.55	nd	0.85	nd	0.21	0.24	0.18	0.17
1.2	nd	1.25	nd	19.58	21.0	0.55	nd	0.85	nd	0.31	0.32	0.18	0.24
1.2	nd	1.35	nd	19.78	21.0	0.55	nd	0.85	nd	0.31	0.29	0.18	0.17
1.2	nd	1.45	nd	19.98	21.8	0.55	nd	0.85	nd	0.31	0.33	0.18	0.19
1.2	nd	1.55	nd	20.18	21.8	0.55	nd	0.85	nd	0.31	0.33	0.18	0.25
1.2	nd	1.65	nd	20.38	21.5	0.55	nd	0.85	nd	0.31	0.31	0.18	0.23
1.3	nd	1.25	nd	19.67	21.4	0.55	nd	0.85	nd	0.41	0.40	0.18	0.20
1.3	nd	1.35	nd	19.87	21.7	0.55	nd	0.85	nd	0.41	0.42	0.18	0.23
1.3	nd	1.45	nd	20.07	21.5	0.55	nd	0.85	nd	0.41	0.38	0.18	0.23
1.3	nd	1.55	nd	20.27	21.6	0.55	nd	0.85	nd	0.41	0.42	0.18	0.21
1.3	nd	1.65	nd	20.47	21.6	0.55	nd	0.85	nd	0.41	0.40	0.18	0.19
1.4	nd	1.25	nd	19.76	22.1	0.55	nd	0.85	nd	0.51	0.51	0.18	0.16
1.4	nd	1.35	nd	19.96	21.5	0.55	nd	0.85	nd	0.51	0.52	0.18	0.16
1.4	nd	1.45	nd	20.16	23.3	0.55	nd	0.85	nd	0.51	0.51	0.18	0.22
1.4	nd	1.55	nd	20.36	22.5	0.55	nd	0.85	nd	0.51	0.53	0.18	0.19
1.4	1.42	1.65	1.68	20.56	22.3	0.55	0.58	0.85	0.95	0.51	0.50	0.18	0.18

[1]Includes crude protein equivalency of Lys and Arg supplements (NRC, 1994). [2]Calculated from NRC (1994) adjusted to crude protein and moisture content of ingredients used. [3]Analyzed by Ajinomoto Heartland Lysine LLC, Chicago IL. [4]Not determined.

interaction of Lys and Arg on BW. Much of the deleterious effect of low levels of Lys or Arg could be associated with higher dietary levels of CGM in the INTACT diets. In a companion study where the level of CGM was increased from 0 to 30% a consistent reduction in BW was observed as the level of CGM increased, related

Table 5: Calculated (C) and analyzed (A) nutrient content of diets where amount of dietary ingredients was adjusted to provide various levels of Lys and Arg

% Lys		% Arg		% CP		% Met		% TSAA		% Added Lys		% Added Met	
C[1]	A[2]	C	A	C	A	C	A	C	A	C	A	C	A
1.1	1.18	1.25	1.24	19.50	21.4	0.55	0.58	0.85	0.95	0.21	0.27	0.18	0.21
1.1	nd[3]	1.35	nd	18.77	20.8	0.55	nd	0.86	nd	0.09	0.04	0.25	0.32
1.1	nd	1.45	nd	19.81	22.0	0.55	nd	0.85	nd	0.01	0.01	0.23	0.24
1.1	nd	1.55	nd	26.73	29.8	0.59	nd	1.03	nd	0.00	0.01	0.00	0.01
1.1	nd	1.65	nd	34.03	36.1	0.87	nd	1.45	nd	0.00	0.01	0.00	0.01
1.2	nd	1.25	nd	19.26	21.5	0.55	nd	0.85	nd	0.31	0.24	0.18	0.25
1.2	nd	1.35	nd	18.89	20.2	0.55	nd	0.83	nd	0.19	0.38	0.25	0.30
1.2	nd	1.45	nd	19.93	21.7	0.55	nd	0.85	nd	0.10	0.09	0.23	0.23
1.2	nd	1.55	nd	20.98	21.8	0.55	nd	0.87	nd	0.01	0.02	0.21	0.25
1.2	nd	1.65	nd	27.37	29.1	0.59	nd	1.03	nd	0.00	0.01	0.00	0.01
1.3	nd	1.25	nd	19.74	22.1	0.55	nd	0.85	nd	0.41	0.39	0.18	0.22
1.3	nd	1.35	nd	19.01	20.4	0.55	nd	0.83	nd	0.29	0.28	0.25	0.32
1.3	nd	1.45	nd	20.04	22.5	0.55	nd	0.85	nd	0.20	0.22	0.23	0.27
1.3	nd	1.55	nd	21.01	22.2	0.55	nd	0.87	nd	0.11	0.10	0.21	0.21
1.3	nd	1.65	nd	22.18	23.6	0.55	nd	0.89	nd	0.02	0.01	0.19	0.26
1.4	nd	1.25	nd	19.86	21.9	0.55	nd	0.85	nd	0.51	0.65	0.18	0.16
1.4	nd	1.35	nd	19.12	21.4	0.55	nd	0.83	nd	0.39	0.28	0.25	0.32
1.4	nd	1.45	nd	20.15	22.3	0.55	nd	0.85	nd	0.30	0.43	0.23	0.30
1.4	nd	1.55	nd	21.21	22.4	0.55	nd	0.87	nd	0.21	0.27	0.21	0.21
1.4	1.39	1.65	1.55	22.09	22.3	0.55	0.55	0.89	0.92	0.12	0.15	0.19	0.25

[1]Calculated from NRC (1994) adjusted to crude protein and moisture content of ingredients used. [2]Analyzed by Ajinomoto Heartland Lysine LLC, Chicago IL. [3]Not determined.

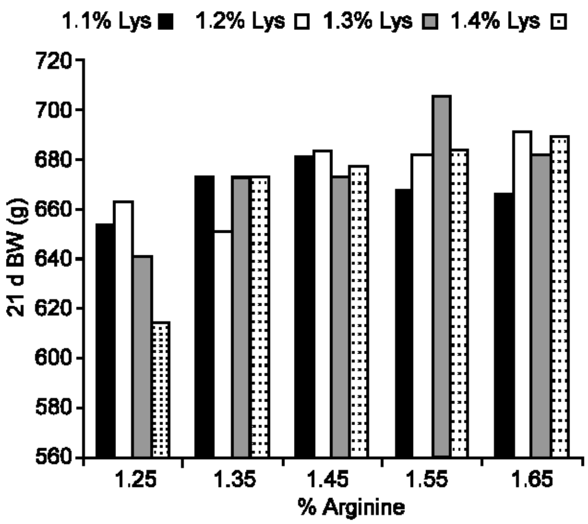

Fig. 1: Body weight of male broilers fed diets with different levels of arginine and lysine

primarily to a reduction in feed intake (Table 8). The FCR remained relatively equal over all levels of dietary CGM, suggesting the primary effect was on feed intake.

Although CGM is a common feed ingredient, it is seldom used at high levels in commercial broiler diets. The fine powdery texture of this ingredient per se may inhibit feed intake. Peter *et al.* (2000) observed a 5.6% reduction in body weight gain and a 6% reduction in feed intake when the diets were formulated with CGM. Even though these differences were not statistically significant, there was a clear evidence of poor utilization of these diets high in CGM content. This indicates that researchers should take care in considering the ingredient composition of their test diets. As early as 1957, Krautmann *et al.* had pointed out a marked difference in the Arg requirement of chicks depending on the ingredients used. Based on the results of the present experiment, it can be concluded that differences in results could be due not only to the Lys and Arg levels in the diets but to ingredients utilized in the diets. Using the basal diets fortified with amino acids, it was concluded that the NRC level of lysine was adequate for both body weight and feed conversion. An Arg level of approximately 1.3% to 1.45% was necessary to obtain adequate body weight and FCR at 21 days (Fig. 1 and Fig. 2). Labadan *et al.* (2001) determined requirements of Lys and Arg by broken-line regression analysis of response to six or seven dietary levels of each amino acid at the time. These authors estimated a Lys requirement of 1.28 ± 0.05 and 1.21 ± 0.02 for BW gain and FCR in the period of 0 to 2 wks of age and 1.13 in the period of 2 to 4 wks. The Arg requirement was estimated in 1.24 ± 0.02 and 1.28 ± 0.04 in the two periods. However, in the present research it was demonstrated that above 1.15% Lys and 1.38% Arg (Fig. 1), there is no further benefits in performance when dietary Lys content is increased. Ueno and Ishibashi (1998) also concluded from a factorial experiment, that the maximum BW gain was achieved at 1.1% Lys and 1.36% Arg for chickens between 8 and 18 days of age.

In the basal diet supplemented with amino acids, there

Table 6: Effects of different levels of lysine and arginine obtained by supplementing a basal diet with crystalline amino acids on body weight and feed conversion (mean of six pens of five male broilers)

Lys	Arg	21-d Body wt (g)	0-21d Feed Conversion (g/g)
---------------- (%)---------------			
1.1	...	668	1.299
1.2	...	674	1.303
1.3	...	675	1.293
1.4	...	668	1.301
...	1.25	643^{b}	1.343^{a}
...	1.35	667^{a}	1.309^{b}
...	1.45	678^{a}	1.292^{bc}
...	1.55	684^{a}	1.280^{c}
...	1.65	682^{a}	1.270^{c}
1.1	1.25	653	1.318
1.1	1.35	673	1.302
1.1	1.45	681	1.284
1.1	1.55	667	1.295
1.1	1.65	666	1.295
1.2	1.25	663	1.366
1.2	1.35	651	1.312
1.2	1.45	683	1.283
1.2	1.55	682	1.286
1.2	1.65	691	1.268
1.3	1.25	641	1.329
1.3	1.35	673	1.305
1.3	1.45	673	1.312
1.3	1.55	705	1.256
1.3	1.65	682	1.265
1.4	1.25	614	1.360
1.4	1.35	673	1.319
1.4	1.45	677	1.289
1.4	1.55	684	1.285
1.4	1.65	689	1.254
Statistical analysis		Probability > F	
Arg		0.01	0.01
Lys		0.80	0.87
Arg x Lys		0.39	0.64

$^{a-c}$Means in comparisons with common superscripts do not differ significantly (P ≤ 0.05).

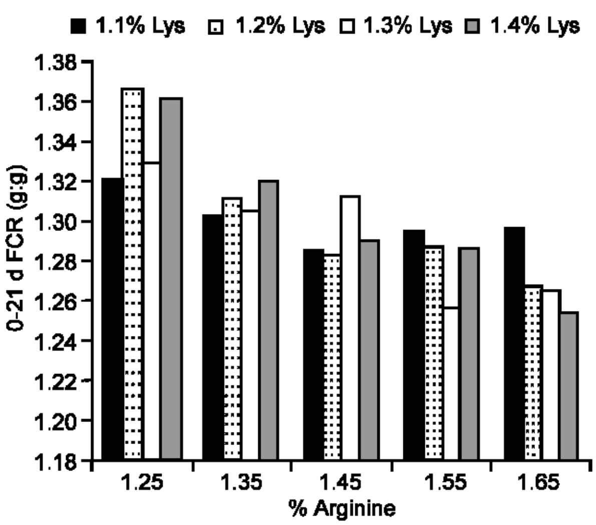

Fig. 2: Feed conversion by broilers fed diets with different levels of arginine and lysine.

Table 7: Effects of different levels of lysine and arginine obtained by varying the amounts of intact ingredients body weight and feed conversion (mean of six pens of five male broilers)

Lys	Arg	CGM[1]	21 d Body wt (g)	0-21 d Feed Conversion (g/g)
-------------------- (%) --------------------				
1.1	...	10.89	612^{c}	1.313^{a}
1.2	...	3.97	639^{b}	1.278^{b}
1.3	...	1.02	667^{a}	1.265^{b}
1.4	...	1.03	652^{ab}	1.288^{b}
...	1.25	5.11	648^{ab}	1.333^{a}
...	1.35	0.06	647^{ab}	1.304^{b}
...	1.45	0.00	662^{a}	1.274^{c}
...	1.55	4.06	634^{bc}	1.257^{c}
...	1.65	11.93	622^{c}	1.265^{c}
1.1	1.25	5.10	658^{abcd}	1.341
1.1	1.35	0.05	652^{abcd}	1.314
1.1	1.45	0.00	644^{abcd}	1.278
1.1	1.55	16.25	568^{fg}	1.305
1.1	1.65	33.04	540^{g}	1.329
1.2	1.25	5.11	655^{abcd}	1.308
1.2	1.35	0.06	651^{abcd}	1.292
1.2	1.45	0.00	671^{abc}	1.274
1.2	1.55	0.00	619^{def}	1.253
1.2	1.65	14.69	597^{ef}	1.265
1.3	1.25	5.12	653^{abcd}	1.330
1.3	1.35	0.07	647^{abcd}	1.278
1.3	1.45	0.00	667^{abc}	1.275
1.3	1.55	0.00	684^{a}	1.216
1.3	1.65	0.00	682^{ab}	1.227
1.4	1.25	5.12	626^{cde}	1.351
1.4	1.35	0.08	637^{bcde}	1.331
1.4	1.45	0.00	665^{abc}	1.268
1.4	1.55	0.00	664^{abcd}	1.252
1.4	1.65	0.00	668^{abc}	1.239
Statistical analysis			Probability > F	
Arg			0.0132	0.0001
Lys			0.0001	0.0017
Lys * Arg			0.0001	0.1390

$^{a-g}$Means in comparisons with common superscripts do not differ significantly (P ≤ 0.05). [1]Corn gluten meal.

was no significant interaction between Lys and Arg for body weight gain; although it does appear that there was a reduction in performance with low levels of Arg and high levels of Lys. Similar results have been found at this lab in previous experiments (Mendes *et al*., 1997; Waldroup *et al*., 1998) or by other authors (Wang *et al*., 1999). These low levels of Arg are highly unlikely to occur in practical formulation, so it is not necessary to fix a specific ratio between the two amino acids in formulating feeds. The response to Arg and Lys in diets based on intact ingredients was confounded by use of diets with high levels of corn gluten meal.

In conclusion, the results of the present study demonstrate that differences in diet type may influence the response to Arg and Lys due to factors other than amino acid levels *per se*. Use of diets differing in levels of ingredients known to have reduced digestibility, amino acid imbalance, poor palatability, or various antinutritive

Table 8: Effects of level of corn gluten meal (CGM) in diets formulated to provide a minimum of 110% of NRC (1994) recommended amino acid levels

CGM %	21 d BW (g)	0-21 d Feed intake (g/bird)	0-21 d Feed: Gain ratio
0	690[a]	884[a]	1.281
5	678[ab]	860[ab]	1.268
10	652[abc]	828[b]	1.270
15	646[bc]	816[b]	1.263
20	664[abc]	864[ab]	1.301
25	625[c]	821[b]	1.313
30	644[bc]	814[b]	1.263
Prob > F	0.037	0.028	0.551
SEM	0.016	0.020	0.015

abcMeans in column with common superscripts do not differ significantly (P<0.05).

factors may confound the results and make it difficult to determine whether the final results were due to amino acid levels *per se* or to the types of diets or ingredients used.

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