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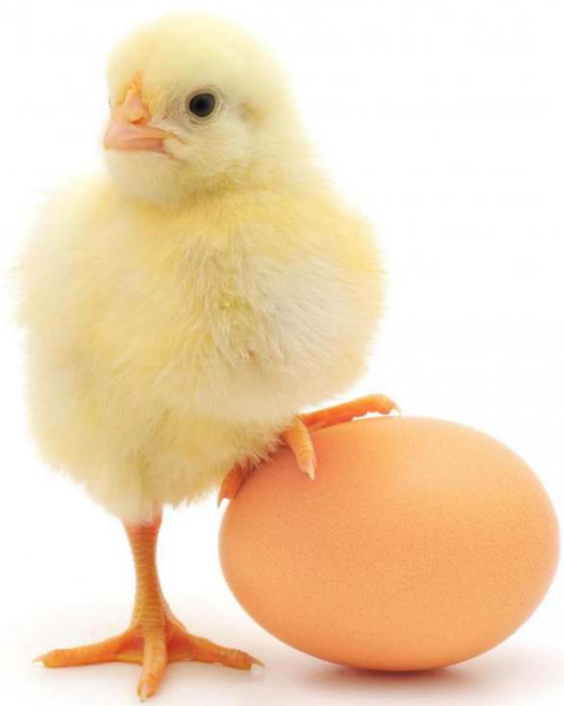

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Influence of *Ad libitum* or Control Feeding on the Performance of Broilers Fed Diets Low in Crude Protein[1]

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Abstract: Reduction of dietary crude protein (CP) with amino acid supplementation has been effective in reducing the cost of poultry feed. However, the performance of broilers declines when CP levels reaches a point and can not be totally restored with amino acid supplementation. This study was conducted to determine if differences in feed intake were responsible for the reduced performance at low protein levels. Diets were formulated to meet 100% of NRC (1994) recommendations for indispensable amino acids (Lys at 110%) with CP levels of 16%, 18%, 20%, 22% or 24% with the CP and metabolic energy (ME) equivalency values of amino acids considered in the diet formulation. A minimum dietary electrolyte balance of 200 meq/kg was maintained. There were two feeding regimes including *ad libitum* feeding and control feeding with a total of ten treatments. All birds were provided a complete 24% CP diet *ad libitum* from one to 7 d. At 7 d chicks were weighed and placed on test diets containing the various levels of CP. One group remained on *ad libitum* feeding while the other group was control fed. Feeding diets with less than 20% CP resulted in the loss of BW and impaired feed conversion ratio (FCR) regardless of feeding regimes. There was no significant difference in feed intake and mortality among different dietary treatments in both feeding regimes. Reduction in feed intake does not appear to be the cause of reduced performance on diets low in CP.

Key words: Broilers, feed intake, crude protein, amino acids

Introduction

Feeding strategies in poultry production have been given a new perception with the advent of environmental problems related to the pollution of nitrogen from the animal manure by large animal production units. In the past, dietary formulations were aimed at maximizing the broiler performance at least cost without special concern for nutrient oversupply. The recent concerns about the environment and the high cost of protein supplements may force nutritionists to decrease CP levels in diets while sustaining the performance. In practical poultry diets based on corn and soybean meal, Met is considered as the first limiting amino acid followed by Lys. Therefore, supplementation of Met and Lys in crystalline form to practical poultry diets provides a means to increase the efficiency of protein utilization and reduce the CP level in diets. However, the performance of broilers often declines when the CP level is further reduced even though all known indispensable amino acid requirements are satisfied (Edmonds *et al.*, 1985; Fancher and Jensen, 1989 a,b; Bregendahl *et al.*, 2002; Si *et al.*, 2004a; Jiang *et al.*, 2005).

The fact that the dietary feed intake is a key factor in a successful broiler nutrition program is well accepted. High levels of voluntary intake are required for rapid and efficient gains. There are numerous factors that influence the feed intake and it is generally considered that feed intake is controlled by a series of negative feedback signals from the digestive tract, liver and other organs in response to the presence of nutrients. Some researchers indicate that the feed intake was depressed when the protein content of the diet was very low or very high and when the diet is deficient or excess in one or more of the essential amino acids (Frazier *et al.* 1947; Mackay *et al.* 1941; Meyer, 1958; Meyer and Hargus, 1959; Harper *et al.* 1970). Feed intake is also depressed when the proportions of amino acids in the diet deviate greatly from the proportional amino acid requirements of the organism. Glista (1951) found that chicks force-fed a free amino acid diet grew at a rate quite comparable to that observed with diets containing intact protein and suggested that the major obstacle in using free amino acid diets was insufficient feed intake. Waldroup *et al.* (1976) demonstrated that the growth potential of chicks was largely controlled by the feed intake and feed intake should increase in diets limited in excess amino acids as the birds eat to meet their requirement. Lipstein *et al.* (1975) also pointed out that the total feed intake increased for chicks fed low CP diets to provide amounts of limiting essential amino acids required for the maximum growth. Our assumption is that the feed intake of broilers is influenced by the desire to obtain limiting amino acids; imbalance among amino acids or high synthetic amino acid content in low CP diets may adversely influence the feed intake of broilers. Thus, it is possible that some factors in diets low in CP may result in the reduced feed intake, which then impairs the performance of broilers.

Table 1: Composition (g/kg) of diets with different levels of crude protein and amino acid levels for broilers from 0 to 21 d

Ingredient	Crude protein (%)				
	24	22	20	18	16
Yellow Corn	455.29	518.68	584.13	650.54	727.08
Soybean meal (47%)	424.80	370.99	314.48	254.21	175.11
Dicalcium phosphate	17.30	17.67	18.06	18.49	19.10
Poultry oil	78.43	67.88	56.75	45.49	32.21
Ground limestone	12.10	12.16	12.22	12.27	12.32
Salt	3.57	3.50	3.42	3.34	3.26
Sodium bicarbonate	2.00	2.00	2.00	2.00	2.00
Potassium sulfate	0.00	0.00	0.00	0.88	5.55
L-Lysine HCl	0.00	0.00	1.17	3.40	6.36
DL-Methionine	1.51	2.12	2.77	3.46	4.41
L-Arginine	0.00	0.00	0.00	0.00	2.43
L-Threonine	0.00	0.00	0.00	0.92	2.24
L-Valine	0.00	0.00	0.00	0.00	1.47
L-Phenylalanine	0.00	0.00	0.00	0.00	0.11
L-Isoleucine	0.00	0.00	0.00	0.00	1.00
L-Tryptophan	0.00	0.00	0.00	0.00	0.35
Choline 60%[1]	2.00	2.00	2.00	2.00	2.00
Vitamin Premix[2]	2.00	2.00	2.00	2.00	2.00
Trace mineral mix[3]	1.00	1.00	1.00	1.00	1.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00

[1]Provides 1040 mg/kg supplemental choline. [2]Provides per kg of diet: Vitamin A 7714 IU; cholecalciferol 2204 IU; vitamin E 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione 1.5 mg; folic acid 0.9mg; thiamin 1.54 mg; pyridoxine 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg. [3]Provides per kg of diet: Mn 100 mg; Zn 100 mg; Fe 50 mg; Cu 10mg; I 1 mg.

The first objective of present study was to compare the performance of chicks fed amino acid supplemented diets varying in CP levels. The second objective was to compare the performance of broilers fed either *ad libitum* or on a controlled basis to determine if differences in feed intake are responsible for the reduced performance on diets low in CP.

Materials and Methods

Diet formulation: Diets were formulated using corn and soybean meal as the intact protein sources. Both of these ingredients are considered to have good amino acid digestibility (NRC, 1994). The crude protein content of the corn and soybean was determined prior to the formulation and their nutrient content was adjusted accordingly. Supplemental amino acids (L-Lysine HCl, DL- Methionine, L-Arginine, L-Threonine, L-Valine, L-Phenylalanine, L-Isoleucine and L-Tryptophan) were used to meet the minimum needs for these amino acids and to minimize excess levels of amino acids according to NRC (1994) recommendations. The crude protein and metabolizable energy contributions of amino acids (NRC, 1994) were considered in the diet formulation. All diets were calculated to contain 3200 ME kcal/kg. Essential amino acids other than lysine were stipulated at a minimum of 100% of the NRC (1994) recommendations for the 0 to 21 d broiler; lysine was added at 110% of the NRC (1994) recommended level. The minimum dietary electrolyte balance [(Na + K) – Cl] was fixed at a minimum of 200 meq/kg with 0.25% sodium and a minimum of 0.2% sodium bicarbonate. The corn and soybean meal used were analyzed for CP using Association of Official Agricultural Chemists (AOAC, 1970) procedures. Five primary diets were formulated to contain 24, 22, 20, 18, and 16% CP. Diets were supplemented with complete vitamin and trace mineral mixes obtained from a commercial integrator. All diets were analyzed for crude protein and total amino acid content by a major producer of amino acids. The composition of the five basal diets is shown in Table 1 with the calculated and analyzed nutrient values provided in Table 2. Diets were provided in mash form.

Feeding regimes: Two feeding regimes were utilized in this experiment. In the *ad libitum* regime the experimental diets and tap water were available at all times to broilers. In the control feeding regime the amount of feed was weighed each morning to broilers fed diets containing various CP levels, based on an amount consumed the previous day by an *ad libitum*-fed control group fed the diet with the lowest level of CP.
From 1 to 7 d of age all broilers in both feeding regimes

Table 2: Nutrient analysis of diets with different levels of crude protein and amino acid levels for chicks from 0 to 21d

Nutrient[1]	Basis[2]	Crude protein (%)				
		24.00	22.00	20.00	18.00	16.00
Crude protein (%)	C	24.00	22.00	20.00	18.00	16.00
	A	24.00	21.50	20.48	17.77	15.53
Methionine (%)	C	0.54	0.57	0.60	0.63	0.68
	A	0.55	0.62	0.64	0.67	0.65
Lysine (%)	C	1.43	1.27	1.20	1.20	1.20
	A	1.47	1.26	1.22	1.22	1.21
Tryptophan (%)	C	0.29	0.26	0.24	0.21	0.20
	A	0.26	0.23	0.22	0.19	0.17
Threonine (%)	C	0.98	0.90	0.81	0.80	0.80
	A	1.00	0.90	0.82	0.83	0.82
Isoleucine (%)	C	1.24	1.13	1.01	0.88	0.80
	A	1.28	1.10	0.92	0.85	0.80
Histidine (%)	C	0.62	0.57	0.51	0.45	0.36
	A	0.68	0.61	0.54	0.47	0.40
Valine (%)	C	1.31	1.19	1.07	0.94	0.90
	A	1.27	1.17	1.01	0.96	0.94
Leucine (%)	C	2.01	1.88	1.74	1.58	1.36
	A	2.08	1.85	1.68	1.51	1.28
Arginine (%)	C	1.81	1.64	1.47	1.28	1.25
	A	1.79	1.52	1.50	1.34	1.29
Proline (%)	C	1.39	1.31	1.22	1.12	0.98
	A	1.39	1.25	1.17	1.05	0.82
TSAA (%)	C	0.90	0.90	0.90	0.90	0.90
	A	1.06	0.99	0.98	0.96	0.87
Phe + Tyr (%)	C	2.28	2.08	1.88	1.65	1.35
	A	1.97	1.74	1.47	1.51	1.36
Gly + Ser (%)	C	2.29	2.08	1.87	1.64	1.32
	A	2.35	2.03	1.83	1.56	1.36
Total EAA (%)[3]	C	15.16	13.89	12.61	11.42	10.34
EAA as % of CP	C	63.17	63.13	63.05	63.44	64.63
Calcium (%)	C	0.90	0.90	0.90	0.90	0.90
Nonphytate P (%)	C	0.45	0.45	0.45	0.45	0.45
Chloride (%)	C	0.27	0.27	0.26	0.30	0.20
Sodium (%)	C	0.25	0.25	0.25	0.25	0.25
Potassium (%)	C	0.95	0.86	0.78	0.69	0.58
(Na+K)-Cl (meq/kg)	C	273.55	253.61	233.66	200.16	200.01

[1]All diets were calculated to contain 3,200 ME kcal/kg. [2]C = calculated; A = analyzed. [3] Sum of all essential amino acids including Cys and Tyr.

were fed a common 24% CP basal diet. Birds that were to be the baseline group for the control feeding treatments were fed the common 24% CP diet from 1 to 6 d and placed on the 16% CP diet at 6 d. The function of this group, consisting of twelve pens of six male chicks per pen, was to determine the feed consumption for broilers in the control feeding regime. On day 7 chicks on the *ad libitum* feeding regime were changed to diets containing the varying CP levels and continued to receive the test diets on an *ad libitum* basis. For the control feeding regime, the average feed consumption of baseline chicks fed the 16% CP diet on the previous day was determined. The feed for each chick fed various CP levels in the control feeding regime was based on 90% of this value. Adjustments were made daily for mortality within each individual pen. This procedure was followed each day until the end of the study at 21 d.

Chicks and housing: Male chicks of a commercial broiler strain[2] 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.

Six chicks were placed in each of sixty compartments. At 7 d chicks were weighed and assigned to pens to provide approximately equal starting weight. Continuous

Table 3: Effects of *ad libitum* and controlled feeding on performance of male broilers fed diets with reduced crude protein levels fortified with indispensable amino acids (means of six pens with five chicks each)

% Crude Protein	Feeding system	7-21 d BW gain (g)	7-21 d Feed/bird (g)	7-21 d CP/bird (g)	7-21 d PER (Gain/CP)	7-21 d FCR (feed/gain)	7-21 d mortality (dead/total)
24	*Ad libitum*	608^{a}	816^{ab}	195.84	3.10	1.342^{e}	0/30
22	*Ad libitum*	603^{a}	858^{a}	188.76	3.19	1.423^{de}	1/30
20	*Ad libitum*	574^{b}	811^{b}	162.20	3.53	1.414^{de}	2/30
18	*Ad libitum*	539^{c}	841^{ab}	151.38	3.56	1.560^{b}	0/30
16	*Ad libitum*	475^{d}	824^{ab}	131.84	3.60	1.738^{a}	0/30
24	Controlled	465^{de}	678^{c}	162.72	2.85	1.461^{cd}	1/30
22	Controlled	444^{e}	680^{c}	149.60	2.97	1.528^{bc}	1/30
20	Controlled	442^{e}	686^{c}	137.20	3.22	1.549^{b}	0/30
18	Controlled	397^{f}	679^{c}	122.22	3.24	1.712^{a}	1/30
16	Controlled	371^{f}	666^{c}	106.56	3.48	1.792^{a}	1/30

[abcdef]Means within column with no common superscripts differ significantly ($P < 0.05$).

24 hr fluorescent lighting was provided. Care of birds followed recommended guidelines (FASS, 1999).

Measurements: Birds were group weighted by pen at 7 and 21 d and body weight gain from 7 to 21 d calculated. Feed consumption during the period was determined by weighing the feed container at the start and the end of the study for the *ad libitum* feeding regime. Feed consumption for the control feeding regime was obtained by adding the daily feed allocation, subtracting an residual feed that remained in the trough at the conclusion of the study. Mortality was checked twice daily; birds that died were weighed with the weight used to adjust the feed conversion [FCR = total feed consumed ÷ (weight of live birds + weight of dead birds)]. Protein consumption (grams/bird) was calculated from feed consumption data and the Protein Efficiency Ratio (PER; grams of gain per gram of protein consumed) calculated.

Data analysis: Pen means served as the experimental unit. Data were subjected to the analysis of variance (SAS Institute, 1991) as a single factor arrangement using the General Linear Models procedure. The 7 d body weight served as a covariate for analysis of 7 to 21 d BW gain. Mortality data were transformed to $\sqrt{n+1}$ prior to analysis. The means for treatments showing significant difference in the analysis of variance were compared using the least significant difference procedure. All statements of significance are based on the 5% level of probability.

Results and Discussion

Analyzed CP values and amino acids for the experimental diets were in close agreement with calculated values (Table 2). Although the overall level of essential amino acids declined as the dietary crude protein content decreased, the ratio between dietary essential and nonessential amino acids stayed virtually the same. This indicates that there is an almost equal reduction in both dietary essential and nonessential amino acids as the crude protein level is reduced.

The reduction of CP level in diets had a significant influence on the live performance of male broilers (Table 3). A reduction in the dietary crude protein to a level lower than 22% in *ad libitum* fed birds or lower than 20% in control fed birds resulted in a significant reduction in BW gain during the test period. Birds fed the diets on a controlled intake basis had significantly lower BW gain than their cohorts on *ad libitum* fed diets with the same protein level.

The feed intake of birds on the *ad libitum* series was not markedly influenced by the dietary protein level. Although there were some fluctuations in feed intake among the different treatment groups, none of them differed significantly from that of those fed the diet with 24% CP. As the birds on the control fed diets were given a daily allocation of feed, overall intake was similar among protein levels.

Crude protein intake declined as the dietary protein in the diet declined, for both the *ad libitum* and control fed birds. However, the PER was improved as dietary protein levels declined. Therefore, efficiency of protein use is not necessarily a desirable goal in terms of economic poultry production.

Feed conversion worsened as the dietary protein level declined, for both *ad libitum* and control fed birds. Birds fed the diets on a controlled basis tended to have worse feed conversion than their cohorts fed the same protein levels on an *ad libitum* basis, but this was not consistent. Overall mortality was rather low with no consistent trend noted related to dietary protein level or feeding system.

These results indicate that the problems encountered in diets with low levels of CP do not appear to be totally related to the feed intake. We have previously examined in our laboratory the influence of various factors including electrolyte balance, ratio of Met to Cys, ratio of

Lys to other EAA, ratio of Trp to large neutral amino acids, and ratio of EAA to nonessential amino acids on the performance of chicks fed low CP diets (Waldroup *et al.*, 2002; Si *et al.*, 2001; 2004a, 2004 b, 2004c, 2004d). None of these approaches improved the performance of broilers fed low crude protein diets comparable to that of positive control diets with typical CP levels.

Although the total level of essential amino acids in the diets declined as the CP level was reduced, the ratio of essential to nonessential amino acids remained relatively the same. The ratio of essential to nonessential amino acids has been studied with rats (Heger, 1990), pigs (Wang and Fuller, 1989), turkeys (Bedford and Summers, 1988), broilers (Stucki and Harper, 1961; Bedford and Summers, 1985), and kittens (Rodgers *et al.*, 1998). Except for kittens, results of the other studies have shown optimal growth rates when the dietary EAA/NEAA ratio ranged from 40:60 to 65:35. Values in the present study lie within these ranges. It is probable that reduction in overall nitrogen pool associated with reduction in both essential and nonessential amino acids may be a primary factor related to reduced performance on diets low in crude protein.

Minimal research has been conducted on requirements for some of the essential amino acids that are not typically marginal or deficient in corn-soybean diets. It is highly likely that these may become deficient as the dietary crude protein declines. Jiang *et al.* (2005) noted that supplementation of low CP diets with Gly in excess of NRC (1994) recommendations significantly improved performance of chicks fed low CP diets but did not reach that of chicks fed diets with 22 or 24% CP. This is in agreement with studies of Heger and Pack (1996) and Schutte *et al.* (1997) who recommended higher levels of Gly+Ser in low CP diets fortified with amino acids. More research needs to be conducted on other amino acids that may also become lacking as the dietary CP declines.

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[2]Cobb 500, Cobb-Vantress Inc. Siloam Springs AR 72761