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Effect of different levels of dietary crude protein on the growth performance and carcass characteristics of commercial broilers at different phases of growth

T. Srilatha*, V. Ravinder Reddy, V. Chinni Preetam, S.V. Rama Rao[1] and Y. Ramana Reddy[2]

Department of Poultry Science, College of Veterinary Science,
P.V. Narasimha Rao Telangana Veterinary University, Rajendranagar, Hyderabad-500 030, Telangana, India.
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ABSTRACT

An experiment was conducted to find out the effect of different levels of crude protein in broiler diets during different phases. *i.e.*, pre starter (0-11d), starter (12-21d) and finisher (22-42d). 360 day-old broilers (Vencobb) were procured from a commercial hatchery and fed either high or low dietary CP diets during pre-starter (23 and 21%) , starter (21 and 19%) and high, moderate or low CP diets during finisher (18.5, 17.5 and 16.5%) phases, for a total of 12 possible treatment combinations at d 42. The results showed that the broilers fed low levels of CP (21 and 19 %) had significantly($P<0.05$) higher body weight gain (BWG) and feed intake (FI), and better feed efficiency over the diets with high levels of CP during pre-starter and starter phases (23 and 21%, respectively). The higher (18.5%) level of protein in the finisher phase showed higher BWG and best FCR compared to the lower levels (17.5 and 16.5%). Carcass characters were not influenced by the variation in dietary CP level tested except the abdominal fat weight which was significantly higher in broiler fed low CP diet compared to those fed higher levels of CP during all three phases. The results indicated that the broilers fed low CP diets supplemented with critical amino acids (21 and 19%) had beneficial effect on the growth performance during pre-starter and starter phase. The broilers showed an ability to respond to increase in dietary CP levels during finisher phase.

Key words: Body weight gain, Broilers, : Crude protein, Feed efficiency.

INTRODUCTION

Nutrient management is of major concern for today's modern poultry enterprise because feed represents the greatest single expenditure associated with poultry production. Major emphasis is given to precision feeding to reduce cost of feeding and maximize economic efficiency of poultry farming. While formulating a broiler's diet, the importance is given for utilizing the correct amount of balanced dietary protein and amino acids (AA) because it is one of the major cost components of the poultry diets second to energy and has major effect on growth performance.

Practically, broiler diets based on maize-soybean meal are deficit in methionine (Met), lysine (Lys), threonine (Thr) and tryptohan (Try) to meet the requirement of modern broilers. Therefore, it became essential to supplement these critical AA in broiler diet to achieve the desired performance. Supplementation of the first two critical amino acids (Met and Lys) in broiler diets is known to increase the possibility of reducing the dietary CP level to a point without adversely affecting the broiler performance (Waldroup *et al.*, 1976; Uzu, 1982; Jensen and Colnago, 1991). On meeting the levels of the first two limiting AA (Met and Lys), supplementation of subsequent two limiting AA (Thr and Try) would facilitate to further reduce the dietary CP. In the recent times, Thr and Try are being synthesized and are available for commercial exploitation in poultry / livestock feeding. Experiments were conducted with other critical amino acids (arginine, Thr and Try) besides Met and Lys (Aletor *et al.*, 2000; Sohail *et al.*, 2003; Corzo *et al.*, 2005a,b; Waldroup *et al.*, 2005a,b; Yamazaki *et al.*, 2006) to optimize the dietary CP levels in broiler diet.

Developing feeding programs that utilize concepts such as ideal protein, formulation programs that calculate the ingredient combinations that will closely meet the bird's nutritional requirements at the least possible cost (Pesti and Miller, 1992) and digestible AA values also allowed the poultry industry to reduce dietary CP to the optimum level and reduce the cost of rations (Kidd *et al.,* 1996).

Majority of the studies available in the literature were conducted in temperate climate, where the birds are reared in environmental controlled houses with the required parameters to keep the bird in the best possible environment. Besides the dietary variation in energy, the genetic potential of the broilers available in our country is different from that of other parts of the World. Therefore, it is more prudent to establish the optimum levels of protein with appropriate

*Corresponding author's e-mail: Srilatha.mangalam@gmail.com
[1]Directorate of Poultry Research, Hyderabad 500 030, Telangana, India.
[2]Department of Animal Nutrition, College of Veterinary Science, S.V.V.U, 516360, Andhra pradesh, India.

concentrations of the first 4 critical AA (Lys, Met, Thr and Try). Therefore, present aim of the study was to determine the effect of different dietary crude protein levels supplemented with critical amino acids at different phases of growth of commercial broilers.

MATERIALS AND METHODS

Experimental birds: At day one, a total of 360 day–old chicks were randomly distributed in to 72 battery brooder pens (5 chicks/Pen) , placed in open sided poultry shed. Feed and water were offered *ad libitum* throughout the experimental period. Three phase feeding program (Pre starter from 1 to 11 d, Starter from 12 to 21 d and finisher from 22 to 42 d) was followed. All the birds were raised under uniform management conditions. Birds were immunized against Newcastle disease (ND) at 7th (primary) and 28th (booster) d of age with *Lasota* vaccine and Infectious bursal disease with IBD (Intermediate-Georgia strain) vaccine at 14th day of age.

Experimental diets: Broilers were fed least-cost formulated diets that were primarily composed of maize, soybean meal, Maize gluten meal, de oiled rice bran and vegetable oil. All the feed ingredients were analysed for proximate principles (AOAC, 1995) and total amino acids (Llames and Fontaine, 1994) before formulating the diets. Analyzed values (CP and total amino acids) for each feed ingredient were put in to the formulation matrix and experimental diets were formulated. Digestibility coefficients (AminoDat® 4.0, Evonik Industries, Mumbai) for individual amino acids of the feed ingredients were considered while formulating the experimental diets with various digestible amino acids. During pre-starter phase, 2 levels of dietary treatments were formulated to contain either a high (H) or low (L) levels of CP (23 and 21%) and were fed to the chicks from 1-11 d of age. At 12 d of age, the birds were sub divided and each group was fed either H (21%) or L (19%) level CP in the starter phase, which resulted in 4 treatment combinations (H-H, H-L, L-H and L-L). At 22 d of age, each group was further sub divided in to three, which were fed with 3 different levels of CP (high -H, moderate-M and low-L; 18.5, 17.5 and 16.5%, respectively), which resulted in 12 treatments. The digestible Lys content of the diets was maintained at 5.65% of the CP. The concentrations of Lys, Thr and Try were maintained at the same ratio considering the ideal AA values suggested by Baker (1996), except Met which was maintained at 45, 45 and 38% of Lys during PS, S and F phases, respectively. All diets are iso-caloric and the concentrations of other nutrients were uniform across the treatments in each phase. Ingredient and nutrient composition of experimental diets are given in Table 1.

Table 1: Ingredient and nutrient composition of diets

Ingredient	Pre starter,0-11d		Starter,12-21d		Finisher21d-42d		
	H	L	H	L	H	M	L
CP, %	23	21	21	19	18.5	17.5	16.5
Maize	606.12	628.64	645.27	705.38	706.52	720.86	766.00
Soybean meal	278.66	226.89	232.4	184.26	168.83	161.00	124.93
Maize gluten 60%	66.89	62.23	65.31	62.2	62.29	61.86	59.45
de oiled rice bran	0.75	34.42	0.00	0.00	0.00	0.00	0.00
Oil (vegetable)	0.00	0.00	9.29	0.24	18.58	12.30	5.40
Salt	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Sodium bicorbonate	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	19.33	19.48	19.67	19.93	16.99	17.18	17.37
Shell grit	8.24	8.67	8.48	8.77	7.81	8.02	8.24
DL-Methionine	2.63	2.34	2.41	2.04	1.34	1.16	1.00
L-lysine HCl	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Tryptophan	0.13	0.17	0.19	0.24	0.33	0.37	0.40
Threonine	1.9	1.8	0.17	1.6	2.01	1.9	1.78
Constants#	5.35	5.35	5.35	5.35	5.35	5.35	5.35
Nutrient composition (Analyzed)							
ME (kcal/kg)##	2950	2950	3050	3050	3150	3150	3150
Protein (%)	23	21	21	19	18.5	17.5	16.5
Calcium (%)	0.90	0.90	0.90	0.90	0.80	0.80	0.80
NPP (%)	0.45	0.45	0.45	0.45	0.40	0.40	0.40
Lysine (%)	1.300	1.187	1.187	1.074	1.102	1.017	0.932
Methionine (%)	0.585	0.534	0.541	0.483	0.419	0.386	0.354
Met+cyst, %	0.88	0.8139	0.821	0.744	0.684	0.636	0.589
Threonine (%)	0.872	0.796	0.796	0.715	0.771	0.712	0.652
Tryptophan (%)	0.208	0.190	0.191	0.172	0.187	0.173	0.158

Constants# provided (mg/kg diet): thiamin 1; pyridoxine, 2; cyanocobalamine, 0.01; niacin, 15; pantothenic acid, 10; α tocopherol, 10; riboflavin, 10; biotin, 0.08; menadione, 2; retinol acetate, 2.75; cholecalciferol, 0.03; choline, 650; copper, 8; iron, 45; manganese, 80; zinc, 60; selenium, 0.18; monensin sodium, 100; and hydrated sodium calcium alumino silicates, 800

Calculated based on published ME values.

Response criteria: Body weight gain (BWG) was calculated on individual bird basis and replicate feed intake was recorded at weekly intervals. The feed conversion ratio (FCR) was calculated as feed intake per unit body weight gain from 0-6 weeks of age at weekly intervals. At the end of biological trial (42 d of age), 6 birds/ treatment were slaughtered. The bird weighing nearer to the mean body weight of the respective treatment was selected, fasted overnight and slaughtered by cervical dislocation to study ready-to-cook without skin (RTC) yield, relative weights of liver, abdominal fat, breast, heart, gizzard, bursa, spleen and which were expressed in relation to the pre-slaughter live weight of the bird.

Statistical analysis: A completely randomized design with 36, 18 and 6 replications at the end of pre starter, starter and finisher phases respectively, was used to test the effect of different dietary CP levels. The data were analyzed with one way analysis of variance by using statistical package for social sciences (SPSS 15th version) and means were compared using Duncans multiple range test (Duncan's ,1955) and significance was considered at p<0.05.

RESULTS AND DISCUSSION

Growth performance of broilers: The birds fed low levels of CP (21 and 19%) showed significantly (P<0.005) higher BWG and better FCR as compared to the diets with high levels of CP (23 and 21%) , birds fed high levels of CP had lower FI during pre-starter and starter phase (Table 2 and 3).

Table 2: Growth performance at 11 d of age of broilers fed different levels of crude protein

Treatment	Weight gain	Feed intake	FCR
H	174.5^{b}	214.6^{b}	1.24^{b}
L	220.2^{a}	248.0^{a}	1.13^{a}
SEM	3.35	2.82	0.011
n	36	36	36
p-value	0.001	0.001	0.002

$^{a-b}$ means within the same column not having similar superscripts are significantly different (P<0.05).

Table 3: Growth performance at 21 d of age of broilers fed different levels of CP

Treatment	Weight gain	Feed intake	FCR
H-H	488.9^{d}	731.4^{d}	1.50^{b}
H-L	607.1^{b}	851.3^{b}	1.40^{a}
L-H	549.6^{c}	801.9^{c}	1.46^{b}
L-L	680.6^{a}	956.4^{a}	1.41^{a}
SEM	9.51	11.47	0.008
n	18	18	18
p-value	0.001	0.001	0.001

$^{a-c}$ means within the same column not having similar superscripts are significantly different (P<0.05). * Pre-starter-starter phases, H-High, L-low

Thus the data suggested levels of 21 and 19% CP appear to be adequate for commercial broilers during the pre-starter and Starter phases, respectively. These results are in agreement with those of Maksoud *et al.* (2011), who reported significantly higher growth in broiler fed 21% CP supplemented with crystalline EAA compared to those fed 23% protein diet. Several workers have confirmed that broiler chicks fed low protein diets supplemented with EAA performed similar to those fed higher CP diets [Han *et al.*, 1992 (19% *vs* 23%); Moran *et al.*, 1992 (23% *vs* 20%); Aletor *et al.,* 2001 (23% *vs* 18%); Ciftci and Ceylan. 2004(21.30% vs19.13%) Namroud *et al.*, 2008 (23% *vs* 21%)].Increased efficiency of dietary CP at their lower concentrations might have increased the protein availability, which in turn supported the growth in broilers fed lower levels of CP in diet. Increased protein retention efficiency with reduction in dietary CP level (28, 23, 18%) was also reported by Noy and Sklan (2002). The present results showed that the chicks fed higher CP had lower feed intake compared to those fed a low-CP diet. The results were also previously confirmed by several studies (Aletor *et al.*, 2000, Sklan and Plavnik, 2002). The decreased feed intake with increases in CP may be due to depressing effect of CP / amino acids in excess of dietary requirement. Similar to these observations Aletor *et al.* (2000) also found protein appetite (reduction in FI) in broiler fed higher CP levels in diet. Fancher and Jensen (1989a) suggested specific amino acids rather than CP *per se* are instrumental in influencing the feed intake by chicken. In contrast, other studies (Bregendahl *et al.*, 2002; Si *et al.*, 2004; Jiang *et al.*, 2005; Waldroup *et al.*, 2005a; Farkhoy *et al.,*2012) reported impaired weight gain and feed efficiency when broilers were fed low protein (20% to 16%) diets supplemented with AA compared to the control diet (23 %).

In contrast to that of initial two phases, the birds fed on higher (18.5%) level of protein in the finisher phase (Table 4) showed higher body weight gain (L-L-H) and best FCR (H-H-H) compared to the lower levels (16.5% and 17.5%). Feeding lower protein levels in the finisher phases reduced the feed efficiency. This is in partial agreement with the results of Corzo *et al.* (2010), who reported improved body weight gain when broilers fed on high protein (23, 21 and 20%) diets throughout the life but best FCR was observed in broilers fed on low CP diets (20, 21 and 20%, in PS, S and F, respectively) in early phase and high CP during finisher phase. In contrast Abbasi *et al.* (2014) reported that the dietary CP level can be reduced up to 10 %(18.89 vs17 %) without any adverse effect on growth performance during finisher phase (25- 42 d age).

Table 4: Growth performance at 42 d of age of broilers fed different levels of crude protein

Treatment*	Weight gain	Feed intake	FCR
H-H-H	1899 ^{def}	3047^{g}	1.60^{a}
H-H-M	1886 ^{def}	3102^{def}	1.65 ^{ab}
H-H-L	1793 ^{ef}	3003^{e}	1.67 ^{b}
H-L-H	2066^{abc}	3315^{abc}	1.61 ^{a}
H-L-M	2057^{abc}	3390^{abc}	1.65 ^{ab}
H-L-L	1958^{cd}	3429^{cd}	1.75 ^{c}
L-H-H	1970^{bcd}	3223^{bcd}	1.64 ^{ab}
L-H-M	1912de	3176de	1.66 ^{ab}
L-H-L	1801^{ef}	3235^{ef}	1.79 ^{c}
L-L-H	2102^{a}	3453^{ab}	1.64 ^{ab}
L-L-M	2027^{abc}	3542^{abc}	1.74 ^{c}
L-L-L	2075^{ab}	3642^{ab}	1.75 ^{c}
SEM	15.42	27.24	0.009
n	6	6	6
p-value	0.001	0.001	0.001

$^{a-c}$ means within the same column not having similar superscripts are significantly different (P<0.05).

* pre-starter-starter-finisher phases, H-High, M- Moderate, L-low

Carcass Traits: Carcass characters were not influenced by the variation in dietary CP level tested in the study (Table 5), which implies that the lower levels of CP (21, 19 and 16.5% CP, in pre-starter, starter and finisher phases, respectively) and amino acids used at various phases are adequate for optimum RTC and breast yields. Also the two critical amino acids like Lys and Met in these diets supported the carcass yields. Similar to the present observation Fancher and Jensen (1989a) did not find any difference in breast meat, when female broilers were given various levels of CP (15.9% to 18.3%) during the finisher phase (3 to 6 wks).

Deposition of fat in abdominal area significantly increased in broiler fed low CP diet either all through 1 to 42 d of age or the lower levels of CP during starter and finisher phases compared to those fed higher levels of CP during all three phases. Increased fat deposition could be due to wider ratio of ME and CP in low protein diets compared to the high CP diets. Widening the energy and protein ratio was reported to predispose fat deposition in chicken (Bartov *et al.*, 1974; Summers and Leeson, 1979) due to excess intake of energy per unit intake of CP. Broilers alter feed intake to meet the requirement of CP / AA in diets containing adequate levels of energy. This hypothesis may be supported by the results of Aletor *et al*. (2000) who demonstrated that wider energy and protein ratios in low-CP diets increases consumption of dietary energy, which might have deposited as fat after meeting the energy requirement. In the present study, the energy: protein ratio in lowest CP (16.5%) finisher was higher compared to the high CP (18.5%) diet (191 *vs* 170). These results are in agreement with Corzo *et al*. (2010) who reported increased abdominal fat deposition in broilers fed lower levels of CP (17.29%) in finishing phase.

CONCLUSION

Based on the data, it is concluded that the broilers fed low CP levels with optimum essential amino acids (21 and 19%) improved growth performance compared to the diets with high levels of CP (23 and 21%) during pre-starter (0-11d) and starter (12-21 d) phases. The broilers were benefitted from being fed with high dietary CP levels (18.5%) during finisher phase (22-42 d).

Table 5: Effect of different levels of crude protein during various phases of growth on the slaughter variables (% of pre-slaughter live weight) in commercial broilers.

Treatment	RTC	Abdominal fat	Breast weight	Visceral organs		
				Liver	Heart	Gizzard
H-H-H	65.26	1.586^{c}	20.58	1.837	0.477	1.652
H-H-M	65.56	2.110^{ab}	20.50	1.907	0.521	1.714
H-H-L	64.78	2.179^{ab}	20.12	2.143	0.490	1.738
H-L-H	66.53	1.875^{bc}	21.86	1.901	0.519	1.785
H-L-M	65.94	2.368^{a}	21.11	2.044	0.598	2.006
H-L-L	64.31	2.467^{a}	21.51	2.001	0.505	1.616
L-H-H	66.04	2.170^{ab}	20.69	1.931	0.568	1.690
L-H-M	64.93	2.004^{abc}	20.78	1.962	0.546	1.746
L-H-L	62.72	2.089^{ab}	18.76	1.897	0.533	1.718
L-L-H	65.60	1.800^{bc}	21.07	1.911	0.524	1.681
L-L-M	64.97	2.162^{ab}	21.35	1.731	0.477	1.700
L-L-L	66.23	2.200^{ab}	20.90	2.185	0.504	1.559
SEM	0.249	0.047	0.204	0.040	0.010	0.025
n	6	6	6	6	6	6
p-value	0.144	0.005	0.244	0.669	0.432	0.084

$^{a-c}$ means within the same column not having similar superscripts are significantly different (P<0.05).

* pre-starter-starter-finisher phases

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