Proc. 3rd All Africa Conf. Anim. Agric. & 11th Conf. Egyptian Soc. Anim. Prod., Alexandria, Egypt, 6-9 November 2000: 571-577

THE RESPONSE OF BROILER CHICKS TO L-THREONINE SUPPLEMENTATION IN LOW PROTEIN CORN-SOYBEAN DIETS

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SUMMARY

Two experiments were conducted using 460 Hubbard chicks, one-day-old to investigate: 1) The response of broiler chicks to threonine (Thr) supplementation in low protein corn-soy diets; and 2) Whether the low protein diets (19% and 17% CP) supplemented with methionine (Met), lysine (Lys) and Thr produce performance equal to that obtained from the NRC recommended diets (23% CP from 0 to 3 weeks of age and 20% CP from 4 to 6 weeks of age). In Experiment 1, six graded levels of Thr (0.00, 0.05, 0.10, 0.15, 0.20, and 0.25%) were supplemented to a 19% CP diet fortified with adequate amount of Met and Lys and compared with a 23% CP diet as recommended by NRC (1994) for broilers 0-3 weeks of age. In Experiment 2, a 17% CP diet contained adequate amount of Met and Lys was supplemented with the same levels of Thr used in Experiment 1 and compared with a 20% CP diet as recommended by NRC (1994) for broilers 4-6 weeks of age.

In both experiments, body weights increased numerically and feed conversion improved significantly when low protein diets were supplemented with Thr. The maximal body weight and feed conversion were achieved at 0.78% total Thr (0.69% digestible Thr) from 0 to 3 weeks of age. However, from 4 to 6 weeks of age, body weight and feed conversion were maximized at 0.72 % total Thr (0.64% digestible Thr). Chicks fed the 19% CP diet supplemented with Met, Lys, and Thr had growth rate and feed efficiency equal to those of the 23% CP, NRC diet. Similarly, performance of chicks fed the 17% CP supplemented with Met, Lys and Thr was equal to that obtained from the 20% CP, NRC diet. The low protein diets supplemented with amino acids were economical and had no negative impacts on carcass characteristics or mortality rate.

Keywords: Broiler performance, low-protein diets, threonine requirement, amino acids

INTRODUCTION

Corn and soybean meals are the most common ingredients used in poultry diets worldwide. The order of limiting amino acids in corn-soybean diets is Met, Lys, Thr, Val and Arg (Han *et al.*, 1992; Fernandez, 1994). Therefore, Thr is the third limiting amino acid in reduced CP corn-soy diet and now produced commercially for animal use. The requirements of total Thr is estimated to be 0.80, 0.74 and 0.68% for broiler chicks 0 to 3, 3 to 6 and 6 to 8 weeks of age, respectively (NRC, 1994). However, Webel *et al.* (1996) found that Thr requirement was 0.61% as digestible Thr for broiler chicks 3 to 6 weeks of age. Kidd *et al.* (1999) and Dozier *et al.* (1999) reported that Thr requirement of male broiler chicks from 6 to 8 weeks of age is 0.67% as total Thr (0.60% digestible Thr).

Recently, there is a tendency to feed poultry corn-soybean meal diets low in crude protein and supplemented with essential amino acids. This is not only because they are safe and profitable diets but also to reduce nitrogen pollution related to poultry manure since nitrates, phosphorous and pathogens adversely affect both surface and ground water (Barton, 1996). Therefore, providing birds with diets low in crude protein and supplemented with adequate amounts of essential amino acids will reduce nitrogen execration by the bird and consequently reduce nitrogen pollution related to poultry manure. There are great discrepancies, however, in attempts that have been made to feed broiler chicks low protein diets supplemented with amino acids. Bornstein and Lipstein (1975) compared a 19.7% CP diet (supplemented with Met and Lys) to a 23.1% CP diet supplemented with Met and found that chick growth and feed efficiency were equal for these two diets. Waldroup *et al.* (1976) reported that maximal growth of young chicks could be obtained with a 19% CP diet supplemented with crystalline amino acids. Moreover, Parr and Summers (1991); and Han *et al.* (1992) reported that chicks fed low protein diets (ranged from 21 to 16.5% CP) supplemented with essential amino acids had similar growth rate and feed efficiency as those fed a 23% CP diet. Conversely, Edmonds *et al.* (1985) and Colnago *et al.* (1991) concluded that optimal performance of starter and grower could not be achieved with low protein diets supplemented with crystalline amino acids.

The present study was conducted to investigate: 1) The response of broiler chicks to threonine (Thr) supplementation in low protein corn-soy diets; and 2) Whether the low protein diets (19% and 17% CP) supplemented with methionine (Met), lysine (Lys) and Thr produce performance equal to that obtained form the NRC recommended diets (23% CP from 0-3 weeks of age and 20% CP from 4-6 weeks of age).

MATERIALS AND METHODS

Two experiments were carried out at Al-Kanater Al-Khairia Poultry Farm, Horticulture Service Unit, Agricultural Research Center, Egypt. A total of 460 Hubbard chicks, one-day-old, were used in both experiments. The chicks were wing-banded and reared in battery chicks that located in an open-sided house with natural ventilation. Feed and water were provided *adlibitum*, and a 24 hour constant artificial light was maintained. Chicks were kept under similar conditions of management throughout the experimental periods. The experimental diets were analyzed for crude protein (AOAC, 1990). Amino acids analyses were performed at the laboratory of Degussa Huels Co., Germany, following 24 hour hydrolysis in 6 N HCL at 110 C (Spackman *et al.*, 1958). Methionine and Cys were analyzed separately following performic acid oxidation. Met as methionine sulfone and Cys as cysteic acid (Moore, 1963).

Experiment 1

Two-hundreds and ten one-day-old broiler chicks were weighed and randomly assigned into 7 treatments. Each treatment included three replicate pens with 10 chicks per pen. A 19% CP corn-soy diet fortified with adequate amount of Met and Lys (Table 1) was supplemented with six graded levels of L-Thr (0.0, 0.05, 0.10, 0.15, 0.20, and 0.25%) and compared with a 23% CP diet as recommended by NRC, 1994 (control diet). The diets were fed from 0 to 3 weeks of age. Live body weight, body weight gain and feed consumption were recorded weekly and mortality rate was recorded daily. Feed conversion (g feed: g gain) was calculated. Also, the economical evaluation was calculated to compare the low protein diets with the NRC diet (control diet).

Experiment 2

A total of 250 chicks, one-day-old, were used in this experiment. All chicks were fed a 23% CP starter diet as recommended by NRC, 1994 from 0 to 3 weeks of age. At the end of the third week, chicks were weighed and 210 chicks were chosen and assigned into replicate pens in a manner that ensured that each pen has almost the same average body weight and weight range. Seven treatments were used (three replicates of 10 chicks per treatment). A 17% CP corn-soy diet fortified with Met and Lys was supplemented with the same six graded levels of L-Thr that had been used in Experiment 1 and compared with a 20% CP corn-soy diet as recommended by NRC, 1994 for broiler chicks 4-6 weeks of age (control diet, Table 1). Parameters of live body weight, body weight gain, feed consumption, feed conversion, mortality rate, and economical comparison were determined with the same procedures used in Experiment 1. At the end of the six week of age, 6 chicks per treatment (3 males and 3 females) were chosen within treatment's mean and slaughtered for carcass evaluation. The chicks were weighed, slaughtered, plucked, eviscerated, and re-weighed to determine the carcass yield. Giblets (heart, liver, and gizzard) and abdominal fat were also weighed. The data were presented as percentage of live body weight.

Statistical Analysis

Data were subjected to the ANOVA using procedure of the General Linear Models (GLM) of SAS® software (SAS Institute, 1990). One way analysis of variance was used in both experiments using model:

$Y_{ij} = \mu + T_i + e_{ij}$ where: Y_{ij} = the observation of the parameter measured, μ = overall means, T_i = the effect of the treatment, e_{ij} = the random error term. Differences with probability of ≤ 0.5 were considered significant. Means were separated by Duncan's multiple range test (Duncan, 1955). Regression analysis using non-linear functions was used to develop equations to allow for calculation of body weight gain or feed conversion (Y) at any level used of % Thr supplementation (x) using the following model: $Y = b_0 + b_1 x + b_2 x^2$

Table 1. Composition of the experimental diets

Ingredients	Starter (0-3 weeks)		Grower (4-6 weeks)		
	Control 23% CP	19% CP	Control 20% CP	17% CP	Price (L.E) /ton
Yellow corn	458.00	602.60	560.70	670.50	480
Soy bean meal 44%	431.80	307.60	345.20	250.60	1100
Vegetable oil	73.10	48.40	62.10	43.10	1700
Limestone	13.90	14.20	14.50	14.80	50
Di-Ca-P	15.40	16.40	10.70	11.50	1050
Salt	3.00	3.00	3.00	3.00	150
Premix [1]	3.00	3.00	3.00	3.00	7000
L-Lys HCL 78%	-----	1.40	----	1.90	8000
DL-Methionine 99%	1.80	2.90	.80	1.60	15000
L-Threonine 99%[2]	-----	-----	-----	-----	14000
Total	1000.00	1000.00	1000.00	1000.00	
Price (L.E) /Ton[3]	884	808	800	744	
Calculated (%); CP	23.00	19.00	20.00	17.00	
ME, Kcal/Kg	3150	3150	3200	3200	
Ca	1.00	1.00	.90	.90	
P, available	.45	.45	.35	.35	
Try	.35	.26	.29	.23	
Determined (%); CP	23.13	19.00	20.04	16.94	
Met	.52	.58	.38	.41	
Met + Cys	.90	.89	.72	.71	
Lys	1.35	1.20	1.14	1.05	
Thr	.90	.68	.77	.62	
Val	1.13	.91	.98	.82	
Arg	1.66	1.28	1.40	1.11	
His	.63	.51	.55	.46	
Iso-Leu	1.04	.81	.88	.71	
Leu	2.00	1.68	1.78	1.55	
Phy-Al	1.18	.95	1.02	.85	

[1] Supplied per Kg of diet; Vit. A, 12,000 IU; Vit D3, 2,000 IU; Vit E, 40 mg; Vit. K3, 4 mg; Vit. B1, 3 mg; Vit. B2, 6 mg; Vit. B6, 4 mg; Vit. B12, 30 micro g; Niacin, 30 mg; Folic Acid, 1.5 mg; Biotin, 80 micro g; Pantothenic Acid, 13.2 mg; Choline Chloride, 700 mg; Iron, 40 mg; Manganese, 60 mg; Copper, 10 mg; Zinc, 70 mg; Selenium. 0.2 mg; Iodine, 1.5 mg; Cobalt, 0.25 mg.

[2] Six levels of L-Thr (0.0, 0.05, 0.1, 0.15, 0.2, 0.25%) were added to the 19 and 17% CP diets.

[3] Prices per Egyptian pound (L.E) where 1 US $ = 3.42 L.E

RESULTS AND DISCUSSION

Chick performance

Body weight gain decreased numerically and feed conversion impaired significantly when chicks 0-3 weeks of age fed the 19% CP diet supplemented with Met and Lys but no Thr supplementation compared with those resulted from the 23% CP diet fortified with Met as recommended by NRC, 1994 (Table 2). Supplementing Thr to the 19% CP diet restored the same body weight and feed conversion obtained from the 23% CP, NRC diet. The maximal body weight and feed conversion were achieved from the 19% CP diet when supplemented with 0.10% Thr (0.78% total Thr in the diet or 0.68% digestible Thr). The higher levels of Thr supplementation did not give any further improvement in body weight or feed conversion. This was due the fact that bird takes its requirement from the Thr at this level. Similarly, in Experiment 2, (4-6 weeks of age) body weight increased numerically and feed conversion improved significantly with Thr supplementation to the 17% CP diet (Table 3). Also, body weight gain and feed conversion of chicks fed the 17% CP diet were maximized at 0.10% Thr supplementation (0.72% total Thr or 0.64% digestible Thr) and were equal to those obtained from the 20% CP, NRC diet. Mortality rate during 0 to 3 weeks of age (Experiment 1) or 4 to 6 weeks of age (Experiment 2) was normal and was not due to dietary treatments.

Table 2. Performance of broiler chicks (3 weeks of age) fed low protein diet supplemented with different levels of threonine (Thr), Experiment 1

Treatment	% total Thr	% digestible Thr [2]	Live body weight (g)	Body weight gain (g)	Feed intake (g)	Feed conversion (g/g)	% mortality
Control 23 %CP	0.90	0.78	676	636	928	1.46[b]	6.67 (2/30)
			% Thr supplementation to 19% CP				
0.00	0.68	0.59	652	612	943	1.54[a]	3.33 (1/30)
0.05	0.73	0.64	661	619	920	1.49[b]	3.33 (1/30)
0.10	0.78	0.69	678	636	932	1.46[b]	3.33 (1/30)
0.15	0.83	0.74	679	637	936	1.47[b]	10.0 (3/30)
0.20	0.88	0.79	690	648	944	1.46[b]	0.00 (0/30)
0.25	0.93	0.84	680	638	935	1.47[b]	0.00 (0/30)
Pooled SEM			13	13	21	0.02	
P ≤			0.477	0.484	0.952	0.009	

[a,b] Means with different superscript letters differ significantly (P ≤ .05).

[1] Initial live body weight at 0 week of age was 41 ± 0.8 (SEM) distributed randomly among the treatments.

[2] Assuming that Thr digestibility in the corn-soy bean diet is 87% (NRC, 1994) and in the Thr supplementation is 100% (Chung and Baker, 1992).

Body weight gain = 609 + 326 x - 800 x^2 (R^2 = 0.92).

Feed conversion = 1.536 - 0.92 x + 2.62 x^2 (R^2 = 0.92) where x = % Thr supplementation.

Table 3. Performance of broiler chicks (6 weeks of age) fed low protein diet supplemented with different levels of threonine (Thr), Experiment 2

Treatment	% total Thr	% digestible Thr[2]	Live body weight (g)[1]	Body weight gain (g)	Feed intake (g)	Feed conversion (g/g)	% mortality
Control 20% CP	0.77	0.67	1987	1316	2589	1.97[c]	0.00 (0/30)
			% Thr supplementation to 17% CP				
0.00	0.62	0.54	1933	1261	2637	2.09[a]	0.00 (0/30)
0.05	0.67	0.59	1979	1309	2657	2.03[b]	0.00 (0/30)
0.10	0.72	0.64	1990	1320	2615	1.98[c]	0.00 (0/30)
0.15	0.77	0.69	1981	1314	2584	1.97[c]	10.0 (3/30)
0.20	0.82	0.74	1991	1321	2601	1.97[c]	0.00 (0/30)
0.25	0.87	0.79	1987	1319	2585	1.96[c]	0.00 (0/30)
Pooled SEM			13	30	62	0.02	
P ≤			0.477	0.648	0.948	0.009	

[a,b,c] Means with different superscript letters differ significantly (P ≤ .05).

[1] Initial live body weight at 3 weeks of age was 670 ± 10 (SEM) assigned equally among the experimental units.

[2] Assuming that Thr digestibility in the corn-soybean diet is 87% (NRC, 1994) and in the Thr supplementation is 100% (Chung and Baker, 1992).

Body weight gain = 1270 + 663 x - 1948 x^2 (R^2 = 0.92).

Feed conversion = 2.086 - 1.30 x + 3.32 x^2 (R^2 = 0.92) where x = % Thr supplementation

The finding that low protein diets supplemented with amino acids gave performance equal to that of NRC recommended diets agreed with previous reports by Bornstein and Lipstein (1975) and Waldroup *et al.* (1976). Also, Han *et al.* (1992) found that performance of low-protein corn-soy diets (19% CP from 0-3 weeks of age and 16% CP from 3-6 weeks of age) supplemented with Met, Lys, Thr, Val, and Arg was similar to that of 23 and 20% CP, control diets. In the experiments herein the 19% or 17% CP diet was supplemented with only Met, Lys, and Thr, the most limiting amino acids for broilers. Valine and Arg were expected to have a minimal effect on chick performance since they have already met the chick's requirements recommended by NRC for the 23 or 20% CP diet. On the contrary, these results disagreed with Edmonds *et al.* (1985); Pinchasov *et al.* (1990) and Colnago *et al.* (1991) who reported that optimal performance of chicks could not be achieved with the low protein diets supplemented with crystalline amino acids.

The maximal body weight and feed conversion of chicks were achieved at 0.78% total Thr (0.69% digestible Thr) from 0-3 weeks of age and at 0.72% total Thr (0.64% digestible Thr) from 4-6 weeks of age. These figures were somewhat lower than the requirements suggested by the NRC, 1994 and higher than those determined by Webel *et al.* (1996). They found that the requirement of Thr was 0.61% as digestible Thr for broiler chicks 3-6 weeks of age and reported that NRC requirement of Thr is too high. The NRC (1994) estimate of the total Thr requirement for broiler chicks is 0.80% from 0 to 3 weeks of age and 0.74% from 3 to 6 weeks of age. Recently, there is interest to study the ideal amino acid profile for broiler chicks using Lys as a reference while other amino acids can be expressed as a ratio of Lys (Baker and Han, 1994). In the present experiment, body weight gain and feed conversion were maximized at 64% Thr:Lys ratio from 0-3 weeks of age and at 68.5% Thr:Lys ratio from 4-6 weeks of age which are in a good agreement with the ideal Thr:Lys ratio reported by Edwards *et al.* (1999).

Carcass characteristics

Carcass characteristics as percentage of live body weight of chicks fed low protein diet supplemented with different levels of Thr (Experiment 2) are presented in Table 4. Reducing CP in the diet from 20 to 17% CP had no significant effect on dressing weight or abdominal fat. Even though the differences were not statistically significant, chicks fed the 17% CP with no Thr supplementation had lower dressing weight and higher abdominal fat compared with those fed the 17% CP supplemented with Thr or those fed the 20% CP diet. Nevertheless, chicks fed the 17% CP supplemented with Thr had % abdominal fat similar to that obtained from the 20% CP diet. Higher body fat associated with feeding low protein diets was observed earlier by Han *et al.* (1992). They found that body fat concentration was significantly higher for chicks fed the 19% CP diet but when this diet was supplemented with amino acids, body fat concentration was equal to that obtained from the 23% CP diet. Moreover, Kidd and Keer (1997) reported that increasing Thr from 0.55 to 0.75% for broilers during 30 to 42 days significantly improved carcass yield, percentage of breast meat yield and decreased the percentage of abdominal fat.

Table 4. Carcass charachteristics (as percentge of live body weight) of broiler chicks fed low protein diets supplemented with threonine, Experiment 2

Treatments	Live body weight (g)[1]	Dressing weight (%)	Giblets (%)[2]	Total edible parts (%)[3]	Abdominal fat (%)
Control 23/20% CP[2]	1987	66.9	5.1	71.9	1.95
	% Thr supplementation to 23/17% CP				
0.00	1933	65.8	4.9	70.8	2.22
0.05	1979	68.0	5.1	73.1	2.25
0.10	1990	68.4	4.7	73.1	1.85
0.15	1981	67.7	5.2	72.9	1.90
0.20	1991	67.3	4.9	72.2	1.87
0.25	1987	68.5	4.8	73.2	2.06
Pooled SEM	13	2.5	.26	2.7	.21
P ≤	.477	.169	.347	.190	.829

[1] Chicks were fed 23% CP (control diet) from 0 - 3 weeks of age, live body weight at 3 weeks of age was 670 ± 10 (SEM) assigned equally among the experimental treatments.
[1] Giblets = heart + liver + gizared.
[2] Total edible parts = dressing weight + giblets.

Economical evaluation

Economical evaluation of using low protein diets supplemented with amino acids was summarized in Table 5. During 0 to 3 weeks of age (Experiment 1), feed cost/Kg weight gain for chicks fed the 19% CP diet either with or without Thr supplementation was lower when compared with that of the 23% CP diet. Supplementing Thr to the 19% CP diet at level of 0.10% gave the lowest feed cost/Kg weight gain (93.4% of the value of 23% CP diet). Similarly, during 4 to 6 weeks of age (Experiment 2), feed cost/Kg weight gain decreased with feeding the 17% CP diet with no Thr supplementation (98.9% of the value of the control diet). However, further decrease in feed cost/Kg weight gain was achieved with supplementing Thr to the 17% CP diet and the lowest value was obtained at 0.10% supplemental Thr (95.4% of the value of the control). Generally speaking, economical evaluation should be re-evaluated when considerable changes occur in the prices of corn, soybean meal, and supplemented amino acids.

Table 5. Economical studies for broiler chicks fed low protein diets supplemented with different levels of threonine (Thr), Experiment 1 and 2.

Treatment	Body weight gain (Kg)[1]	Feed Intake (Kg)[2]	Price of Feed/Kg (L.E)[3]	Cost of feed Intake (LE)[4]	Cost of feed / Kg weight gain (L.E)[5]	Cost of feed as % of control
Broiler chicks at 3 weeks of age, Experiment 1						
Control CP%	23 0.636	0.928	0.884	0.820	1.289	100
% Thr supplementation to 19% CP						
0.00	0.612	0.943	0.808	0.762	1.245	96.6
0.05	0.619	0.920	0.815	0.750	1.212	94.0
0.10	0.636	0.932	0.822	0.766	1.204	93.4
0.15	0.637	0.936	0.829	0.776	1.218	94.5
0.20	0.648	0.944	0.836	0.789	1.218	94.5
0.25	0.638	0.935	0.843	0.788	1.235	95.8
Broiler chicks at 6 weeks of age, Experiment 2						
Control CP	20% 1.316	2.589	0.800	2.071	1.574	100
% Thr supplementation to 17% CP						
0.00	1.261	2.637	0.744	1.962	1.556	98.9
0.05	1.309	2.657	0.751	1.995	1.524	96.8
0.10	1.320	2.615	0.758	1.982	1.502	95.4
0.15	1.314	2.584	0.765	1.977	1.505	95.6
0.20	1.321	2.601	0.772	2.008	1.520	96.6
0.25	1.319	2.585	0.779	2.014	1.527	97.0

[1] Initial live body weight at 3 weeks of age was 670 ± 10 (SEM) for experiment 2 assigned equally among the experimental units.
[3] Prices per Egyptian pound (L.E) where 1 US $ = 3.42 L.E according to Egyptian market, June, 2000.
[4] = 3 x 2.
[5] = 4 / 1.

ACKNOWLEDGMENT

The authors wish to acknowledge S. Bootwalla and J. Fickler, Feed Additives Division, Degussa Huels Co., for providing and analyzing the amino acids used in this study.

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