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Ideal Dietary Threonine Requirements for Commercial Broilers to Optimize Economic and Production Performance

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ABSTRACT

Background: 250 commercial broiler birds (Ven Cobb) were used in the present research to evaluate the graded concentration of digestible threonine (100, 75, 70, 65 and 60% of the digestible lysine) in order to optimize the threonine requirements for improving the productive performance in commercial broiler diets.

Methods: The chicks were divided into five treatments, each containing ten replicates and each with five chicks, owing to a completely random design (CRD). During the experiment, a corn-soy based diet was prepared and supplemented with digestible threonine at decreasing concentration of digestible Lysine.

Result: The concentration of digestible threonine in broiler diet did not influence the weekly body weight gain and feed intake during experimental period. However, FCR was significantly ($P<0.05$) affected during 1st and 2nd weeks with better FCR recorded in control group (100% Cobb recommended threonine), whereas in 4th week, comparable better FCR was also recorded in 60% of the digestible threonine (T5) supplemented group. The dietary variation in threonine did not influence the slaughter parameters (dressing percentage, ready-to-cook yield and thigh weight), serum biochemical parameters (total protein), antioxidant enzymes activity (lipid peroxidation) and livability. Among all groups the highest net revenue over the feed cost (Rs.71.09/bird) was generated in 60% of the digestible threonine supplemented group. Therefore, the findings of the present study, concludes that digestible threonine concentrations during the pre-starter, starter and finisher phases at 60% of the digestible lysine (0.708, 0.630 and 0.570%, respectively) are optimum for getting good economic returns without having negative impact on growth performance, slaughter parameters, serum biochemical parameters and livability in commercial broilers.

Key words: Broilers, Carcass traits, Economic efficacy, Lipid peroxidation, Threonine.

INTRODUCTION

Over the past 50 years, the world's chicken production has grown significantly to meet the rising demand for poultry products. Typically, broiler chicks are fed diets high in protein or AA and grow quickly (ERS, USDA, 2001). By using the digestible amino acids (DAA) principle, it may be possible to maintain optimal chicken performance while lowering the dietary protein concentration. The DAA concept has several benefits, including lowering environmental pollution, lowering feed costs, lowering the dietary requirements of the limiting amino acid (AA) and diverting a larger percentage of dietary amino acids (AA) for protein synthesis. Corn and soybean meal (SBM) are used in the formulation of the majority of broiler chicken diets. In order for the fast-growing broilers of today to exhibit their full genetic potential, the AA contents of such diets are inadequate. The amino acid requirements are thus met by supplementing the corn-SBM based meals with crystalline amino acids. High levels of well-balanced nutrients are necessary for the fast growth of broiler chickens, particularly amino acids for early marketing. These amino acids are crucial for the body's defensive and structural building as well as for the activities of enzymes and tissues (NRC, 1994). Dietary Threonine is the third limiting amino acid in low crude protein (CP) poultry diets based on corn-soybean meal (Fernandez *et al.,* 1994). This amino acid plays an important role in the maintenance of intestinal mucosal integrity, nutrient digestion and absorption (Dozier *et al.,* 2001; Mao *et al.,* 2011; Wang *et al.,* 2009). Dietary threonine requirements for maximum productivity reduced as birds grew older (Jones *et al.,* 2019). White leghorn layers performed well on low protein diets (*i.e.*, 13.46% CP) supplemented with optimal doses of lysine (0.65%) and thronine (66% lysine) without affecting intestinal morphology (Nagaraja *et al.,* 2021). In ovo supplementation with five amino acids (Lys, Met, Thr, Arg, Glu) with or without

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minerals, or a combination of four amino acids (Lys, Thr, Arg and Glu) with Lys, lowered hatchability. The combination of four amino acids (Met, Thr, Arg and Glu) without Lys at lower concentrations (1x) resulted in high hatchability (86.6%) (Saravanakumar *et al.,* 2024). However, it is currently uncertain how much dietary protein can be replaced by digestible threonine supplementation without affecting broiler performance. The current biological investigation was aimed to carry out to assess the performance, slaughter characteristics and economics of commercial broiler diets supplemented varied concentration of digestible threonine in commercial broiler diets.

MATERIALS AND METHODS

The study was carried out in commercial broilers using 250 day-old male broiler chicks (Ven Cobb-400) in a completely randomized design (CRD). After obtaining the chicks, they were all weighed and had their wings banded. They were then randomly assigned to five treatments, each with 10 replicates and five chicks in each. In electrically heated battery brooders, the chicks were raised in optimum brooding conditions throughout the experimental period six weeks. The biological experiment under report was conducted at the Poultry Experimental Station, Department of Poultry Science, College of Veterinary Science, PVNRTGVU, Rajendranagar, Hyderabad,Telangana State, India.

The experiment was conducted from August-2021 to January-2022.

Experimental diets

According to Cobb breeder's recommendations, a corn-soya based control diet was formulated and other experimental diets were formulated by reducing crude protein levels by 2, 1 and 1% during pre-starter, starter and finisher phases respectively, with graded concentrations of threonine 75, 70, 65 and 60% of digestible Lysine during pre-starter (0-14 d); (0.885, 0.826, 0.767 and 0.708), starter (15-28 d); (0.787, 0.735, 0.682 and 0.630) and finisher period (29-42 d); (0.712, 0.665, 0.617 and 0.570) (Table 1).

Collection of data

The body weight was recorded on individual bird basis at weekly intervals up to six weeks of age and feed intake was calculated on replicate-wise at weekly intervals. The feed conversion ratio (FCR) was calculated as feed intake per unit bodyweight gain from 0-6 weeks of age at weekly intervals. At the end of 6th week of each experiment, blood from one bird per replicate was collected for serum biochemical parameters by using diagnostic test kits (Arkray Healthcare Pvt. Limited, Sachin (Surat), India).

Table 1: Nutrient composition threonine supplemented diets in commercial broilers.

Nutrient	T_1 (Cobb std. 100%)	T_2 (75%)	T_3 (70%)	T_4 (65%)	T_5 (60%)
Pre starter phase (0-14 days)					
ME (k cal/kg)	3035	3035	3035	3035	3035
CP (%)	22.00	20.00	20.00	20.00	20.00
Ca (%)	0.90	0.90	0.90	0.90	0.90
Avl. phosphorus (%)	0.449	0.449	0.449	0.449	0.45
Lysine (%)	1.18	1.18	1.18	1.18	1.18
M+C (TSAA) (%)	0.88	0.88	0.88	0.88	0.88
Threonine (%)	0.770	0.885	0.826	0.767	0.708
Valine (%)	0.89	0.89	0.89	0.89	0.89
Starter phase (15-28 days)					
ME (k cal/kg)	3108	3108	3108	3108	3108
CP (%)	20.0	19.0	19.0	19.0	19.0
Ca (%)	0.84	0.84	0.84	0.84	0.84
Avl. phosphorus (%)	0.42	0.42	0.42	0.42	0.42
Lysine (%)	1.05	1.05	1.05	1.05	1.05
M+C (TSAA) (%)	0.80	0.80	0.80	0.80	0.80
Threonine (%)	0.690	0.787	0.735	0.682	0.630
Valine (%)	0.84	0.81	0.81	0.81	0.81
Finisher phase (29-42 days)					
ME (k cal/kg)	3180	3180	3180	3180	3180
CP (%)	19.0	18.0	18.0	18.0	18.0
Ca (%)	0.76	0.76	0.76	0.76	0.76
Avl. phosphorus (%)	0.38	0.38	0.38	0.38	0.38
Lysine (%)	0.95	0.95	0.95	0.95	0.95
M+C (TSAA) (%)	0.740	0.666	0.666	0.666	0.666
Threonine (%)	0.650	0.712	0.665	0.617	0.570
Valine (%)	0.80	0.76	0.76	0.76	0.76

The lipid peroxidation levels in the serum were estimated and expressed in nano mol Malondialdehyde (MDA)/mg protein (Ohkawa *et al.,* 1979). The protein concentration was determined by the method of Lowry *et al*. (1951). At the end of experimental period (6 weeks), ten birds from each dietary group were sacrificed to evaluate the effect of supplementing synthetic amino acids to the corn soybean meal based diets on carcass parameters (dressing percentage, thigh weight and ready to cook meat) which were expressed as gram per kg live body weight. The mortality among the birds as per replicate/treatment wise is recorded throughout the experimental period and dead birds were subjected to necropsy examination to determine the cause of death. Body weight of dead bird was recorded and used to calculate the feed efficiency.

The feed cost was arrived for pre-starter, starter and finisher broiler diets separately on the ration formulated and the prevailing market price of the major and minor feed ingredients. The phase wise (pre-starter, starter and finisher) cost of production of broilers was calculated for all the treatment groups by multiplying feed intake with feed cost. The cost of production per kg live weight was calculated by multiplying cost of total feed intake and feed conversion ratio for all treatment groups. The total cost of production was subtracted from the sale amount of broilers for each treatment group was calculated to arrive the profitability. The 15th version of the Statistical Package for Social Sciences (SPSS) one-way ANOVA was used to analyze the data. The difference between the treatment means was analyzed using Duncan's multiple range test (Duncan, 1955) at P<0.05.

RESULTS AND DISCUSSION

Performance

Supplementation of digestible threonine at decreasing concentration of (75, 70, 65 and 60% of Lysine) did not influence (P>0.05) body weight gain (BWG) at different weeks. Contrary to the present study, Mehri *et al*. (2012); Corzo *et al*. (2009); Kidd *et al*. (1999) who reported that, threonine (%) 0.78, 0.73 and 0.66 respectively increased the body weight gain significantly (P<0.05) in commercial broilers. The feed intake was significantly (P<0.05) increased in groups fed 65% of d Lysin concentration during 3rd week of age in commercial broilers. However, the feed intake values during the corresponding week in 75% threonine group are comparable to control group. The feed intake during third week in 70% threonine supplemented group showed a significant (P>0.05) reduction in feed intake compared to T_4 and T_5. Contrary to the findings of the present study, Star *et al.* (2010) who reported that a higher level of dietary Thr:Lys ratio (0.70) in treatment group significantly (P<0.05) increased feed intake compared to a threonine to lysin ratio of 0.65 in broilers. The inclusion level of digestible threonine 100% of the Cobb recommendation (0.77%) in dietary group (T_1) significantly (P<0.05) improved the weekly FCR during first

Table 2: Effect of digestible threonine supplementation on weekly body weight gain, feed intake and FCR in commercial broilers.

Treatment	Weekly body weight gain (g/bird)						Feed intake (g/bird)						Feed conversion ratio (feed/gain)					
	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6
T_1	114	222	274	425	439	393	121	271	426^{ab}	669	800	844	1.059^{b}	1.223^{b}	1.552	1.577^{b}	1.827	2.176
T_2	112	217	274	411	463	407	124	271	429^{ab}	650	814	822	1.105^{a}	1.251^{ab}	1.562	1.582^{b}	1.759	2.028
T_3	109	215	259	395	445	410	123	273	400^{b}	629	782	828	1.127^{a}	1.271^{a}	1.549	1.596^{b}	1.759	2.027
T_4	112	221	285	390	454	409	124	280	444^{a}	638	824	846	1.102^{a}	1.268^{a}	1.561	1.637^{a}	1.816	2.101
T_5	112	220	284	417	420	456	125	281	438^{a}	662	765	916	1.111^{a}	1.275^{a}	1.544	1.589^{b}	1.830	2.002
SEM	0.849	1.783	3.353	4.596	5.476	8.061	0.820	1.986	4.659	5.887	7.315	12.61	0.006	0.006	0.006	0.006	0.011	0.026
N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
P-Value	0.479	0.691	0.096	0.075	0.126	0.126	0.709	0.302	0.025	0.184	0.069	0.126	0.001	0.047	0.870	0.018	0.052	0.214

^{abcde}Mean bearing at least one common superscript in a column do not differ significantly (P <0.05).

Table 3: Effect of digestible threonine supplementation on slaughter characteristics, antioxidants and serum biochemical profile of commercial broilers.

Treatment	Dressing (%)	RTC meat (carcass weight g/kg live weight)	Thigh weight (g)	Lipid peroxidation (n mol MDA/mg protein)	Total Protein (g / dL)
T_1	72.19	741.9	219.5	2.996	3.864
T_2	73.35	743.5	223.5	3.361	3.782
T_3	72.00	750.0	221.1	3.307	3.779
T_4	73.49	734.9	216.9	2.960	4.191
T_5	73.89	748.9	221.9	2.463	3.979
SEM	0.292	2.920	1.677	0.174	0.098
N	10	10	10	10	10
P-Value	0.499	0.499	0.785	0.507	0.668

[ab]Mean bearing at least one common superscript in a column do not differ significantly (P<0.05).

Table 4: Influence of digestible threonine concentration on cost economics of commercial broilers.

Treatment	Cost of the diet (Rs./kg)			Feed intake (g/bird)			Cost of feeding (Rs./bird)			Cost for cumulative feed intake (Rs./bird) (0-6 wks)	Body wt at 6 wks (g)	Revenue generated (Rs./bird)	Net revent overfeed cost (Rs. / bird)
	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher				
T_1	22.20	21.70	21.20	393	1096	1644	8.72	23.78	34.85	67.36	1912	133.84	66.48
T_2	22.20	21.75	20.80	395	1079	1637	8.77	23.47	34.05	66.29	1929	135.03	68.74
T_3	21.80	20.95	20.70	397	1030	1610	8.65	21.58	33.33	63.56	1877	131.39	67.83
T_4	21.40	20.70	20.60	404	1084	1671	8.65	22.44	34.42	65.51	1916	134.12	68.61
T_5	21.00	20.60	20.50	406	1101	1682	8.53	22.68	34.48	65.69	1954	136.78	71.09

* sale price was considened as Rs- 70/- per kg log live weight.

and second weeks of age. However, poor FCR was significantly ($P<0.05$) recorded in dietary group T_4 during 4th week of age. This is in agreement with the findings of the Corzo *et al.* (2009) who reported that threonine (replaced (0.76%) significantly affected the FCR of male broilers during 14-28 days age (Table 2).

Supplementation of varied concentrations of digestible threonine in broilers diets did not influence the slaughter parameters (dressing percentage, ready-to-cook yield and thigh weight), serum biochemical parameters (total protein) and oxidation activity (lipid peroxidation). These results are contrary with the findings of Min *et al.* (2017) who reported that concentrations of total protein (TP) increased quadratically with increasing threonine level and the highest concentrations of TP were obtained at the 125% threonine level (Table 3).

Livability

Supplementation of crystalline threonine in graded concentrations at 75 to 60% of the digestible lysine did not influence the livability of broilers during 0-42 days. The livability on the varied levels of threonine in the diets ranged from 94 to 98% during overall experimental period. These results are in concurrence with the results of Awad *et al.* (2014) who reported that mortality rate was considerably low in reduced dietary crude protein (CP) level and dietary treatments fortified with crystalline amino acids to meet the ideal AA ratios concept in broiler diets.

Cost economics

The cumulative feed cost (Rs/bird) for 0-6 weeks age was decreased in gradient manner with decreasing concentration of dig threonine in the experimental diets. However no significant difference was recorded in weekly body weight gains. Hence the net revenue over the feed cost (Rs) increased with the reduction digestible threonine concentrations in the experimental diets. Among all groups the highest net revenue over the feed cost (Rs.71.09/bird) was generated in 0.708, 0.630 and 0.570% dig. Threonine (60% of the digestible lysine) during pre-starter, starter and finisher phases respectively. These results are in agreement with those of Burnham (1992) who reported that replacing intact protein, soybean meal with crystalline amino acids, L-Threonine, L-Lysine and DL-Methionine to balance essential amino acid levels in practical broiler diets resulted in increased live weight performance and gave a financial advantage (Table 4).

CONCLUSION

Based on findings of the present study, it is concluded that digestible threonine concentrations during the pre-starter, starter and finisher phases at 60% of the digestible lysine (0.708, 0.630 and 0.570%, respectively) are optimum for getting good economic returns without having negative impact on growth performance, slaughter parameters, serum biochemical parameters and livability in commercial broilers.

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Conflict of interest

The authors declare that they have no conflict of interest.

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