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## Effect of dietary supplementation of L-threonine on performance of commercial broiler chicken

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### Abstract

The study evaluated the impact of reducing dietary crude protein (CP) levels with supplemental L-threonine on the growth performance, feed efficiency, carcass characteristics, and economic returns of commercial broiler chickens. A total of 224 day-old Vencobb broiler chicks were allotted to seven dietary treatments with varying CP levels and L-threonine supplementation. Results showed that broilers fed diets containing 10% additional L-threonine with 1.5% reduced CP (T<sub>4</sub>) achieved significantly higher final body weights and weight gain. Feed intake and feed conversion ratio (FCR) were also positively influenced by threonine supplementation. Economic analysis revealed that the highest return over feed cost (ROFC) was obtained in birds fed the diet containing 15% additional L-threonine with 0.5% reduced CP (T<sub>5</sub>). The study concludes that reduced-CP diets supplemented with L-threonine can enhance growth performance and economic efficiency in broilers.

**Keywords:** Broiler chickens, crude protein reduction, L-threonine supplementation

### 1. Introduction

The poultry sector in India has emerged as one of the most dynamic components of the agro-animal industry, exhibiting remarkable growth in recent decades. Annual growth rates of 16% in poultry population, 8.5% in egg production, and 7.8% in broiler output surpass the agricultural sector's overall growth rate of 2.5%. India currently ranks as the third-largest producer of eggs and the fourth-largest producer of chicken meat globally (BAHFS, 2019) [2]. However, the per capita availability of eggs (79/year) and chicken meat (3.11 kg/year) remains below the Indian Council of Medical Research (ICMR) recommendations of 180 eggs and 11 kg meat annually, indicating substantial scope for improvement in production efficiency.

Feed constitutes more than 70% of the total cost of poultry production, with protein being the most expensive component. Excessive dietary crude protein (CP) not only increases costs but also contributes to environmental pollution through elevated nitrogen excretion. Recent advancements highlight that crystalline amino acid supplementation—particularly essential amino acids (EAAs)—enables formulation of low-CP diets without compromising growth, feed efficiency, or nutrient balance (Chamba *et al.*, 2014) [3].

L-Threonine is the third limiting amino acid in broiler diets after methionine and lysine. It plays a vital role in protein synthesis, immune competence, feathering, and gastrointestinal mucin production (Lemme, 2003) [5]. As an indispensable amino acid, threonine must be supplied in adequate dietary amounts. Deficiency results in reduced growth, poor feed efficiency, and impaired carcass traits, whereas optimal supplementation improves performance and nitrogen utilization (Azzam *et al.*, 2015) [1].

In this context, the present study was conducted to evaluate the effect of dietary L-threonine supplementation in reduced-CP diets on growth performance, feed utilization, carcass characteristics, and economic efficiency of commercial broilers.

### 2. Materials and Methods

**Experimental Design** A total of 224 straight-run commercial day-old broiler chicks of Vencobb strain were randomly distributed to seven dietary treatments (T<sub>1</sub> to T<sub>7</sub>) of varying levels of CP and L-Threonine.

Each treatment consisted of four replicates containing eight chicks per replicate. The seven treatments were: T<sub>1</sub> diet kept as basal diet with 23, 22 and 20% CP and 0.86, 0.80 and 0.77% of L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>2</sub> diet with 22.5, 21.5, 19.5% CP and 0.946, 0.880 and 0.847% of L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>3</sub> diet with 22, 21, 19% CP and 0.946, 0.880 and 0.847% of L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>4</sub> diet with 21.5, 20.5, 18.5% CP and 0.946, 0.880 and 0.847% L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>5</sub> diet with 22.5, 21.5 and 19.5% CP and 0.989, 0.920 and 0.885% L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>6</sub> diet with 22, 21, 19% CP and 0.989, 0.920 and 0.885% L-Threonine in pre-starter, starter and finisher mash, respectively. T<sub>7</sub> diet with 21.5, 20.5 and 18.5% CP and 0.989, 0.920 and 0.885% L-Threonine in pre-starter, starter and finisher mash, respectively. Birds were reared in deep litter system using standard management and health care practices.

## 2.1 Parameters Studied

- Body weight (BW): recorded weekly (day-old to 6 weeks).
- Body weight gain (BWG): calculated for pre-starter (0-2 weeks), starter (3-4 weeks), finisher (5-6 weeks), and overall periods (0-6 weeks).
- Feed consumption (FC): recorded for each phase and overall.
- Feed conversion ratio (FCR): calculated weekly and cumulatively.
- Carcass characteristics: recorded at the end of the trial.
- Economics: return over feed cost (ROFC) based on feed cost and income from live weight sale.

## 3. Statistical Analysis

The data were analysed using completely randomized design as per Snedecor and Cochran (1994) [12]. Means of replicates under each treatment was considered for analysis.

## 4. Results and Discussion

### 4.1 Body Weight and Body Weight Gain

The data on mean body weight (BW) of broilers at day-old age and then at weekly interval is presented in Table 1. At the end of 6th week, dietary treatment T<sub>4</sub> showed significantly ( $p < 0.05$ ) higher in body weight as compared to control and other dietary treatments. The results of the present study showed that the body weight of broilers from treatment T<sub>4</sub> supplemented with addition of 10% L-Threonine than basal level and with reduction of 1.5% CP% improved body weight by 203.30 and 225.27 g at the end of 5th and 6th week of age, respectively as compared to control. The present findings were in accordance with the results of Neto *et al.*, (2012) [8] and Azzam *et al.*, (2015) [11] who found that broiler chicken fed diets supplemented with L-Threonine had significantly ( $p < 0.05$ ) higher body weight at 42 days of age as compared to birds fed with basal diet. The BWG during pre-starter, starter, finisher phases and overall experimental period is given in Table 2. Results of the study indicated that mean body weight gain of birds fed with T<sub>2</sub> to T<sub>4</sub> diet with 10% additional L-Threonine with 0.5-1.5% reduced CP% was significantly ( $p < 0.05$ ) higher than the birds fed with T<sub>6</sub>, T<sub>5</sub> and T<sub>1</sub>, diet. Perusal of the data recorded in the study indicated significantly higher weight gain was noticed in broilers offered diet containing 10% additional L-Threonine with 1.5% reduced CP%. The present findings were in accordance with the findings of Roy (2013) [10], Shirzadegan *et al.*, (2015) [11].

**Table 1:** Mean & SE of weekly body weight (g) of broilers fed with different treatment diets.

| Traits | Treatment       |                 |                 |                |                 |                |                | SEm   | CD at 5% | CV % |
|--------|-----------------|-----------------|-----------------|----------------|-----------------|----------------|----------------|-------|----------|------|
|        | T <sub>1</sub>  | T <sub>2</sub>  | T <sub>3</sub>  | T <sub>4</sub> | T <sub>5</sub>  | T <sub>6</sub> | T <sub>7</sub> |       |          |      |
| BW0    | 46.80±0.17      | 46.15±1.09      | 46.62±0.11      | 46.59±0.14     | 47.00±.12       | 46.65±.15      | 46.14±.26      | .44   | NS       | 1.89 |
| BW1    | 176.81±5.48     | 183.87±2.96     | 181.25±4.69     | 190.44±4.95    | 166.87±5.02     | 180.06±3.77    | 181.59±5.89    | 4.77  | NS       | 5.30 |
| BW2    | 402.93±7.00     | 422.84±12.69    | 431.43±10.46    | 430.25±4.04    | 443.06±4.44     | 421.93±9.37    | 423.60±4.94    | 8.17  | NS       | 3.84 |
| BW3    | 901.12±25.21    | 860.53±11.04    | 883.75±17.94    | 913.47±13.57   | 792.40±31.13    | 851.62±34.86   | 851.78±60.44   | 31.85 | NS       | 7.36 |
| BW4    | 1549.84±15.92   | 1410.53±35.31   | 1433.37±26.56   | 1536.40±40.27  | 1365.34±53.05   | 1406.90±89.69  | 1410.33±97.49  | 58.79 | NS       | 8.13 |
| BW5    | 1939.20b±36.42  | 1960.73b±77.18  | 1991.03b±12.70  | 2142.50a±45.56 | 1901.18b±25.84  | 1844.45b±25.65 | 1991.93b±84.02 | 50.57 | NS       | 5.14 |
| BW6    | 2563.20bc±31.03 | 2674.54ab±28.09 | 2665.42ab±50.01 | 2788.47a±52.72 | 2597.72bc±41.23 | 2464.31c±38.36 | 2641.33b±74.64 | 47.47 | NS       | 3.61 |

**Table 2:** Mean & SE of weekly body weight gain (g) of broilers fed with different treatment diets

| Traits | Treatment       |                 |                 |                |                 |                |                | SEm   | CD at 5% | CV %  |
|--------|-----------------|-----------------|-----------------|----------------|-----------------|----------------|----------------|-------|----------|-------|
|        | T <sub>1</sub>  | T <sub>2</sub>  | T <sub>3</sub>  | T <sub>4</sub> | T <sub>5</sub>  | T <sub>6</sub> | T <sub>7</sub> |       |          |       |
| BWG0-1 | 130.00±5.48     | 137.73±2.04     | 134.63±4.64     | 143.85±4.82    | 119.87±4.94     | 131.41±3.64    | 135.45±5.82    | 4.64  | NS       | 6.94  |
| BWG1-2 | 226.12b±12.00   | 238.97b±14.41   | 250.18ab±11.0   | 239.81b±2.27   | 276.18a±3.20    | 241.87b±7.36   | 242.01b±9.95   | 9.58  | 28.38    | 7.82  |
| BWG2-3 | 498.17±31.02    | 437.68±18.02    | 452.31±26.39    | 483.22±11.72   | 349.34±27.69    | 429.69±31.91   | 428.18±63.14   | 33.58 | NS       | 15.27 |
| BWG3-4 | 648.72±35.29    | 550.00±40.90    | 549.62±20.17    | 622.96±27.84   | 572.93±26.05    | 555.27±83.30   | 558.55±42.80   | 44.00 | NS       | 15.17 |
| BWG4-5 | 389.36c±49.62   | 550.19ab±51.21  | 557.65ab±34.48  | 606.06a±16.45  | 535.84ab±32.58  | 437.55bc±72.76 | 581.59a±27.15  | 44.14 | 130.69   | 16.89 |
| BWG5-6 | 624.00±19.93    | 713.80±74.06    | 674.38±61.20    | 645.97±20.96   | 696.54±42.04    | 619.88±28.79   | 649.39±43.47   | 45.60 | NS       | 13.80 |
| BWG0-2 | 356.13±6.99     | 376.70±13.08    | 384.81±10.52    | 383.66±3.94    | 396.05±4.43     | 375.28±9.25    | 377.46±4.92    | 8.24  | NS       | 4.35  |
| BWG2-4 | 1146.90±10.87   | 987.68±33.11    | 1001.94±36.82   | 1106.19±38.44  | 922.28±49.41    | 984.96±80.77   | 986.73±99.69   | 57.26 | NS       | 11.23 |
| BWG4-6 | 1013.36b±43.05  | 1264.00a±34.00a | 1232.04a±30.13  | 1252.03a±12.57 | 1232.37a±71.40  | 1057.43b±53.84 | 1230.99a±33.75 | 43.44 | 128.64   | 7.34  |
| BWG0-6 | 2516.40bc±31.15 | 2628.39ab±28.44 | 2618.80ab±49.93 | 2741.88a±52.72 | 2550.72bc±41.35 | 2417.68c±38.27 | 2595.19b±74.44 | 47.46 | 140.53   | 3.67  |

## 4.2 Feed Consumption

The data on feed intake (g/bird) recorded at a weekly interval as well as pre-starter, starter, finisher phase and overall experimental period is shown in Table 3. The mean feed consumption of birds fed with T<sub>4</sub> diet was significantly ( $p < 0.05$ ) higher than the birds fed with T<sub>5</sub> and T<sub>6</sub> diets but

did not differ significantly from T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>7</sub>, diets. The lowest feed consumption was observed in T<sub>5</sub> Minimum and significantly ( $P < 0.05$ ) lower feed intake was observed in broilers assigned all except T<sub>2</sub> and T<sub>5</sub> (0.5% CP reduction than basal diet with addition of 15% L-Threonine) diet among the other groups. Maximum and significantly

( $P < 0.05$ ) higher feed intake was observed in broilers assigned  $T_2$  and  $T_4$  (0.5-1.5% CP reduction than basal diet with addition of 10% L-Threonine) diet, among the other L-Threonine supplemented groups. Present results were

similar to the results reported by Estalkhizir *et al.*, (2013) [4] who observed that the birds fed with additional L-Threonine showed significantly higher feed intake as compared to other groups.

**Table 3:** Mean & SE of feed consumption (g/bird) of broiler fed with different treatment diets

| Traits | Treatment       |                 |                 |                |                |                 |                 | SEm    | CD at 5% | CV %  |
|--------|-----------------|-----------------|-----------------|----------------|----------------|-----------------|-----------------|--------|----------|-------|
|        | T <sub>1</sub>  | T <sub>2</sub>  | T <sub>3</sub>  | T <sub>4</sub> | T <sub>5</sub> | T <sub>6</sub>  | T <sub>7</sub>  |        |          |       |
| FC1    | 177.56±3.43     | 179.34±1.92     | 179.25±0.51     | 182.69±0.72    | 173.37±2.95    | 176.66±2.16     | 172.91±6.87     | 3.31   | NS       | 3.73  |
| FC2    | 399.81ab±7.79   | 404.75a±4.36    | 392.37abc±3.76  | 398.09ab±2.23  | 373.00c±10.78  | 379.06bc±8.62   | 381.59bc±9.57   | 7.38   | 21.69    | 3.78  |
| FC3    | 767.53±30.19    | 775.65±16.95    | 749.28±16.05    | 804.26±40.47   | 704.62±22.82   | 726.74±25.20    | 756.72±40.82    | 29.07  | NS       | 7.70  |
| FC4    | 726.82cd±53.99  | 823.65±17.36    | 735.64±6.46     | 859.12±24.65   | 642.47±51.00   | 695.24±75.62    | 740.56±80.85    | 51.72  | NS       | 13.86 |
| FC5    | 1226.03±40.97   | 1207.68±62.82   | 1128.38±40.35   | 1275.09±108.87 | 1097.83±17.07  | 1161.69±63.11   | 1159.58±26.91   | 58.68  | NS       | 9.96  |
| FC6    | 1255.12bc±68.21 | 1476.40a±49.50  | 1313.40bc±74.45 | 1503.29a±45.23 | 1271.41b±53.67 | 1199.22c±48.34  | 1362.32ab±48.17 | 53.66  | 158.89   | 8.00  |
| TFC0-2 | 577.37ab±8.69   | 5584.09a±5.69   | 571.62ab±3.85   | 580.78a±2.79   | 546.37c±12.97  | 555.72bc±10.70  | 554.50bc±8.71   | 8.36   | 24.59    | 2.95  |
| TFC3-4 | 1102.09±18.70   | 1599.31±26.41   | 1484.92±18.50   | 1663.38±46.21  | 1347.09±73.53  | 1421.97±100.43  | 1497.28±119.20  | 73.78  | NS       | 9.82  |
| TFC5-6 | 2481.15BC±92.72 | 2684.08AB±76.09 | 2441.78C±60.23  | 2778.38a±85.85 | 2369.25c±55.59 | 2360.91c±95.13  | 2521.90bc±56.30 | 76.24  | 225.75   | 6.05  |
| TFC0-6 | 4552.88bc±137.2 | 4867.48ab±95.1  | 4498.32c±66.28  | 5022.54a±68.00 | 4262.70c±89.04 | 4338.59c±152.31 | 4573.68bc±149.3 | 113.62 | 336.40   | 4.95  |

### 4.3 Feed Conversion Ratio

The data on average weekly FCR is depicted in Table 4. Supplementation of L-Threonine in the diet of broilers improved FCR. Minimum FCR was noted in broilers assigned  $T_5$  diet with 0.5% CP reduction than basal diet with addition of 15% L-Threonine during 5th week and 6th week. While, maximum FCR was observed in those assigned  $T_2$  diets (0.5% CP reduction than basal diet with addition of

10% L-Threonine). Thus, supplementation of diet with 0.5% CP reduction than basal diet with addition of 15% L-Threonine to broilers caused significant ( $P < 0.05$ ) improvement in FCR. Present results were in accordance with the results of Ashok *et al.*, (2017) [6] who found that lowest feed conversion ratio was observed in the groups fed diet with reduced excess L-Threonine level compared to basal diet.

**Table 4:** Mean & SE of feed conversion ratio of broilers fed with different treatment diets

| Traits | Treatment      |                |                |                |                |                |                | SEm  | CD at 5% | CV % |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------|----------|------|
|        | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub> | T <sub>5</sub> | T <sub>6</sub> | T <sub>7</sub> |      |          |      |
| FCR0-1 | 1.00±0.01      | 0.97±0.02      | 0.99±0.02      | 0.96±0.02      | 1.04±0.1       | 0.98±0.01      | 0.96±0.06      | 0.03 | NS       | 5.99 |
| FCR0-2 | 1.43a±0.04     | 1.38ab±0.04    | 1.33b±0.03     | 1.34b±0.01     | 1.23c±0.01     | 1.31b±0.01     | 1.31bc±0.03    | 0.03 | 0.09     | 4.53 |
| FCR0-3 | 1.49±0.01      | 1.58±0.03      | 1.49±0.01      | 1.51±0.3       | 1.58±0.01      | 1.51±0.04      | 1.55±0.05      | 0.03 | NS       | 4.48 |
| FCR0-4 | 1.34c±0.05     | 1.55a±0.02     | 1.43bc±0.02    | 1.46ab±0.04    | 1.38bc±0.02    | 1.41bc±0.06    | 1.46ab±0.01    | 0.04 | 0.11     | 5.31 |
| FCR0-5 | 1.70ab±0.02    | 1.73a±0.05     | 1.60cd±0.02    | 1.64abc±0.02   | 1.57d±0.01     | 1.70abc±0.04   | 1.61bcd±0.03   | 0.04 | 0.10     | 4.20 |
| FCR0-6 | 1.77ab±0.04    | 1.82a±0.02     | 1.69bc±0.04    | 1.80a±0.01     | 1.64c±0.05     | 1.75ab±0.03    | 1.73abc±0.01   | 0.04 | 0.10     | 4.00 |

### 4.4 Economics

The return over feed cost (ROFC) can be derived by subtracting the feed cost from income of selling of birds on live weight basis. It clearly expresses the profitability of broiler production. The return over feed cost (Rs./bird) for Economics was calculated in terms of return over feed cost (ROFC). ROFC (Rs./bird) for birds fed with  $T_1$ ,  $T_2$ ,  $T_3$ ,  $T_4$ ,  $T_5$ ,  $T_6$  and  $T_7$  diets was 7.96, 7.97, 26.67, 17.98, 30.47, 18.72, 23.17, respectively. The highest ROC was found in the birds fed with  $T_5$  diet followed by  $T_3$ ,  $T_7$ ,  $T_6$ ,  $T_4$ ,  $T_2$  and  $T_1$  groups. The ROFC of birds fed with different treatment diets differed among each other. Treatment means indicated that cost of feed/bird was lowest in  $T_5$  group (0.5% CP

reduction than basal diet with addition of 15% L-Threonine) and was highest in the control group.

Treatment means of the data clearly indicated that the net return over feed cost/bird was influenced due to reduction of CP% and supplementation of L-Threonine in the diet. It was lowest in broilers assigned control diet containing L-Threonine as per NRC requirement. reduction of CP% from 0.5 to 1.5% with addition of 10 to 15% L-Threonine than NRC level in the broiler diet caused a increase in the net return over feed cost as compared to control group. However, diet group supplemented with 15% additional L-Threonine level with 0.5% reduced CP% recorded better ROFC than rest of the L-Threonine supplemented diets.

**Table 5:** Return Over Feed Cost (Rs./bird) of different treatment diets

| Traits                                   | Treatment      |                |                |                |                |                |                |
|------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                                          | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub> | T <sub>5</sub> | T <sub>6</sub> | T <sub>7</sub> |
| Income from selling of birds (RS./birds) | 0179.2         | 186.9          | 186.2          | 195.3          | 182.00         | 172.2          | 184.8          |
| Cost of feed (RS/bird)                   | 171.24         | 178.93         | 159.53         | 177.32         | 151.53         | 153.48         | 161.63         |
| ROFC(RS/BIRD)                            | 7.96           | 7.97           | 26.67          | 17.98          | 30.47          | 18.72          | 23.17          |

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