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Effect of increasing levels of dietary tryptophan on growth performance, meat yields and cost benefit of commercial broiler chickens

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ABSTRACT

The experiment was carried out to determine the optimum levels of dietary tryptophan (Trp) to investigate the growth performance, meat yields and cost effectiveness of commercial broiler chickens. A total number of 576 day-old Cobb 500 straight run broiler chicks were used in this trial. Four dietary treatments were considered for comparison and each treatment had eight replications with 18 birds per replication. A corn-soya based basal diet was formulated. Diets were provided into two different phases: starter and grower phase. Starter diet was fed up to 21 days and grower diet was provided for 22-35 days. First group of chicks fed basal diet considered as control diet (Trp 100%), the other experimental treatments (T_2 to T_4) were supplemented with increasing levels of tryptophan (Trp) at 115%, 130% and 145% respectively where recommendation is 100%. Birds were kept under identical conditions of management throughout the experimental period (0-35 d). Performance parameters were recorded on a weekly basis and the meat yield traits were measured at the end of the experimental period. Trp supplementation at increasing levels significantly ($P<0.05$) improved body weight, feed intake and lower FCR compared to the control. Increasing levels of dietary Trp significantly ($P<0.01$) improved thigh, drumstick and gizzard weight. Birds receiving highest level of supplementation (145% Trp) attained slightly higher profit over control group. Increasing level (145% Trp) of supplemental Trp may be used for enhancing growth performance, feed efficiency, higher meat yield and profitable production of commercial broiler chickens.

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Introduction

Amino acids are very essential components in poultry diets. These are the building blocks of protein and play a vital role in structural and protective tissues in the body. Amino acids are also important to improve enzyme and tissue functions (NRC, 1994). Animals need 22 amino acids for their growth and production. There are 10 essential amino acids, which poultry cannot synthesize in the body, and therefore must be supplied by diet (Ravindran *et al.,* 1999). These essential amino acids for poultry are: Methionine, Lysine, Threonine, Tryptophan, Valine, Leucine, Isoleucine, Phenylalanine, Arginine and Histamine (McDonlad, 1958). Formulating diets based on digestible amino acid (AA) basis has gained significant momentum among animal producers because of their effects to improve nutrient retention and reduce wastage of costly nutrients (Elizabeth, 2010).

The critical amino acids are those amino acids which are found mostly deficient or marginally present in natural sources. Trp is the fourth among critical amino acids. Other critical amino acids are Methionine, Lysine and Threonine. Trp is an aromatic AA and isolated from the pancreatic digesta of casein. It is produced by a patented fermentation process using modern biotechnology and specially selected high-performing microorganisms. Actually, Trp acts as a precursor for the synthesis of serotonin and melatonin (Emadi *et al.*, 2010). Dietary Trp has shown to maximize feed intake, growth and carcass traits of broiler chickens and increasing levels of Trp influenced the behavior of birds (Rosa *et al.,* 2001). Trp has a sedative effect because of its influence on levels of the neurotransmitter serotonin (Shea-Moore *et al.,* 1990; Newberry *et al.,* 1993). Moehn *et al*. (2012) reported that, deviation of Trp level either higher or lower than the requirement had detrimental effects on feed intake and growth performance.

Since the demand of poultry meat is increasing day by day in developing countries, particularly for poultry meat in Bangladesh, attempts are needed to augment production in a cost-effective manner. But the major problem of modern poultry industry is feed cost as feed comprises approximately 70% of the total production cost in Bangladesh. Among different nutrients, protein is

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one of the major cost components (Kamran *et al.,* 2004) when formulating broiler chicken diets. It is very much troublesome to meet up protein requirement of broiler chickens as compared to that of other nutrients. During ration formulation, protein supplying ingredients incur comparatively more price which maximizes the feed cost (Ojano-Dirain and Waldroup, 2002). Broiler birds require higher CP (Crude protein). So, dietary protein has major effects on growth performance and overall cost of finished product but the major emphasis remains on AA.

Determining the optimal levels of dietary tryptophan for an increase in feed intake and enhancing growth performance of broiler chicken has become a subject of interest. In addition, it seemed worthwhile to examine the effects of feeding low protein diet than the current industry diet on productive performance of broiler chickens. With this view, the current study was designed to determine the optimal levels of dietary Trp for increasing growth performance, meat yield parameters and cost effectiveness of commercial broilers under the environmental conditions of Bangladesh. Although tryptophan plays a key role in efficient poultry production, but there is no specific or exact dose of Trp to be fed and the duration of feeding. Although early studies (Hsia *et al*., 2005; Emadi *et al.,* 2010) were relevant to growth performance, meat yields and blood parameters of broiler chickens, economics of using increasing levels of Trp in the diet is not definitely known. Moreover, the effect of feeding Trp to enhance growth performance as well as its cost effectiveness in broiler production is completely a new approach in Bangladesh poultry sector. The aim of the current study was to examine the performance and cost effectiveness of broilers fed increased levels of dietary tryptophan at 115%, 130%, and 145% relative to the current practice (100% recommendations).

Materials and Methods

Experimental Site

The experiment was conducted in a gable type open sided house at Bangladesh Agricultural University (BAU) Poultry Farm, Mymensingh.

Diet

Completely vegetable based basal diets were formulated to meet the nutrient requirements of birds. Chicks were allocated into four dietary treatments with eight replicates per treatment and 18 birds per replicate. Control diet (T_1) was supplemented with Trp (100%) and for T_2 (115%), T_3 (130%), T_4 (145%) respectively. The ingredient and nutrient composition of the basal diet is presented in Table 1.

Table 1. Ingredient and nutrient composition of starter and grower diet (kg/100kg)

Ingredients/nutrient composition	Starter diet (0-21d)				Grower diet (22-35d)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Ingredients								
Corn	48.01	58.48	58.48	58.48	59.91	67.83	67.83	67.83
Soybean meal, 44% CP	42.41	32.92	32.92	32.92	31.48	24.36	24.36	24.36
MBM, 44 % CP	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybean oil	2.35	0.52	0.52	0.52	1.84	0.44	0.44	0.44
Limestone	0.07	0.13	0.13	0.13	0.00	0.00	0.00	0.00
Dicalcium phosphate	1.26	1.26	1.26	1.26	0.89	0.89	0.89	0.89
Salt (NaCl)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Sodium bicarbonate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Vitamin mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Met AMINO®	0.0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.04	0.04	0.04	0.04	0.07	0.07	0.07	0.07
Thre AMINO®	0.0.15	0.15	0.15	0.15	0.12	0.12	0.12	0.12
Val AMINO (L-Valine)	0.00	0.14	0.14	0.14	0.00	0.10	0.10	0.10
L-Isoleucine	0.00	0.11	0.11	0.11	0.00	0.11	0.11	0.11
Tryp AMINO®	0.00	0.02	0.05	0.08	0.00	0.0.03	0.05	0.08
Nutrient composition								
Dry matter	89.73	89.72	89.72	89.72	90.00	89.74	89.74	89.74
ME (kcal/kg)	3000	3000	3000	3000	3100	3100	3100	3100
Crude protein	25.05	22.30	22.30	22.30	21.19	19.13	19.13	19.13
Sodium Chloride	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Calcium	1.05	1.05	1.05	1.05	0.89	0.87	0.87	0.87
Available Phosphorus	0.50	0.50	0.50	0.50	0.42	0.42	0.42	0.42

T_1=control (100% Trp), T_2=115% Trp, T_3=130%; Trp, T_4=145% Trp, MBM=meat & bone meal, ME= metabolizable energy, kcal=kilo calorie, kg=kilogram

Housing and management

Five hundred and seventy six Cobb 500 one day-old mixed sex broiler chicks procured from a local hatchery were raised by following the instructions of Cobb 500 commercial broiler management guide to meet the nutrient requirement of birds. Similar management condition was provided to all birds throughout the experimental period. The room was divided into 32 pens of equal size by using wire net and bamboo materials. Area of each pen was 21 square feet (7 feet x 3 feet). After arrival of chicks, they were provided with glucovet powder (a mixture of 490g glucose and 10g vitamin C in 500g powder, manufactured by the ACME Laboratories Ltd, Bangladesh) to overcome stress. For the first few days, feeds were supplied four hours interval and then from 4 to 13 days three times daily and finally twice daily. First 2-3 days feeds were given on newspaper along with one plastic round drinker. After that two large round tube feeders and one large round drinker (8 litres capacity) were allotted for the birds of each pen until the end of trial. Fresh and clean drinking water was supplied three times daily (morning, noon and evening). Feed and water was supplied *ad libitum* basis. Every day (morning and evening) drinkers were washed but feeders were cleaned in the evening only. The birds were exposed to 23 hours of lighting and a dark period of 1 hour daily throughout the experimental period. Strict biosecurity was maintained by using foot bath at the gate of the shed where bleaching powder and glutaraldehyde and ammonium chloride containing TH4+ disinfectant (Manufactured by THESEO, France and Marketed by Century Agro Limited, Bangladesh) solution were used alternatively. Dried rice husks were used as litter materials. Infectious Bronchitis (IB) and Newcastle Disease (ND) by MA5 + Clone 30 live vaccine were administered to birds on day 5. Infectious Bursal Disease (IBD) by 228E live vaccines were provided on day 10 and booster dose on day 17. According to the manufacturer recommendations ND booster dose was administered on day 21.

Live birds processing

At the end of feeding trial, two birds from each alternative pen having body weight close to pen average was considered for measuring carcass parameters. A total of eight birds (four male and four female) from 4 replicates per treatments were randomly selected for measuring carcass yield. To facilitate processing of broilers, feed was withdrawn 12 hours before slaughtering with uninterrupted access to water. The birds were slaughtered (Followed by the rule of Animal Welfare and Ethical Committee, Bangladesh Agricultural University) and allowed to bleed for 5 minutes. Slaughtered birds were further immersed in hot water (51-55^{0}C) for 120 seconds in order to lose the feathers as described by Yalcin *et al.* (1999). The feathers were removed by hand pinning. Dressed broilers were cut into different parts such as breast, thigh, drumstick, wing and back. The cut up parts were weighed and recorded separately for male and female broilers. Finally, dressing yield was calculated by combining male and female data.

Methods of cost benefit analysis

Cost of production was calculated based on some specific items such as chicks, feed, vaccine, test ingredients and casual labor. Some of these cost heads were varied widely during the trial period due to fluctuating market price. The total production cost per bird and per kg broiler was calculated. The additional cost incurred for test ingredients (tryptophan) was also taken into account in analyzing the cost benefit. The profit or loss was calculated by deducting the production cost per kg broiler chicken from market price of per kg broiler chicken.

Data collection and record keeping

All growth performance data including body weight (BW), feed intake (FI), feed conversion ratio (FCR) and survivability were recorded on days 7, 14, 21, 28 and 35. Data on carcass measurements were also collected at the end of the trial.

Data analysis

Data of BW, BW gain, FI, FCR, survivability and edible meat characteristics of broilers in different dietary groups were subjected to analysis of variance in a Completely Randomized Design (CRD) employing SAS (2009) statistical computer package programme (version 9.1). Duncan Multiple Range Test (DMRT) was computed to compare the differences in mean values.

Results

Growth performance

Growth performance data are presented in Table 2. At the end of the experiment, the highest BW was observed where supplemental Trp level was increased to 145% (T_4) and lowest BW was found in control group (T_1). Final BW and BW gain were significantly increased ($P< 0.01$) in all dietary treatments compared to control treatment. There was no significant difference in BW between T_2 (115% Trp) and T_3 (130% Trp) groups but they exhibited significant difference from the control (T_1) and T_4 (145% Trp) group. In Fig. 1, all dietary groups showed similar BW up to 2nd week. After 2nd week, some variation was observed whereas, 115% (T_2) Trp and 130% Trp (T_3) treated group gained better weight and it continued up to 4th week of age. After 4th weeks to end of trial, 145% Trp fed group obtained maximum weight among the dietary treatments. The highest FI was observed in higher 145% Trp supplemented group (T_4) and lowest FI was found in control group (T_1). There were no significant differences in FI among T_2, T_3 and T_4 but they significantly differed ($P<0.05$) from the control (T_1). In Fig. 2, weekly feed intake data revealed that birds of all groups consumed similar amount of feed up to 3rd weeks of age.

At 4th weeks of age, feed consumption was slightly decreased but at 5th weeks of age feed intake was increased normally. At the end of the feeding trial, bird's on 145% Trp (T_4) level consumed highest amount of feed as compared to other groups. Birds on Trp supplemented groups showed better FCR as compared to control group. Trp supplementation at 145% (T_4) exerted lowest FCR whereas, control group (T_1) showed highest FCR value. Dietary treatments T_2, T_3 and T_4 did not show any significant difference among themselves in terms of FCR but data significantly ($P<0.01$) differed from the control (Table 2). Feed conversion data indicated that (Fig. 3), there were no significant differences among the dietary groups up to 3rd week of age. In 4th week, FCR was higher in T_4 and lowest in control group. At 5th week, tremendous improvement was found in 145% Trp fed group and highest feed conversion ratio appeared in control group. The survivability was above 99.6% for all groups (Table 2).

Table 2. Effect of feeding different levels of tryptophan on growth performances of broiler (0-35 days)

Parameters	Different dietary treatments				P-value
	T_1	T_2	T_3	T_4	
ILW (g/b)	45.5± 0.14	45.4± 0.11	45.6± 0.06	45.4± 0.15	0.61
FLW (g/b)	1410.6^c± 9.26	1530.4^b± 4.99	1542.6^b± 6.58	1578.8^a±2.93	0.01
LWG (g/b)	1365.1^c±9.29	1485.0^b± 4.91	1497.0^b±6.58	1533.4^a±2.98	0.01
FI (g/b)	2347.9^b±20.69	2400.5^{ab}±22.33	2414.6^a±21.28	2440.5^a±21.79	0.05
FCR	1.72^a±0.02	1.62^b± 0.01	1.61^b±0.01	1.59^b±0.01	0.01
Sur. (%)	99.6±0.13	99.6± 0.19	99.7±0.18	99.8±0.11	0.84

T_1=control (100% Trp), T_2= 115% Trp, T_3= 130%; Trp, T_4= 145% Trp, ILW=initial live weight, FLW=final live weight, LWG=live weight gain, FI=feed intake, FCR=feed conversion ratio, Sur.=survivability; a, b, c=superscript, means bearing superscript in a row not in common differ significantly at the stated level of probability. (±) indicates standard error of mean (SEM).

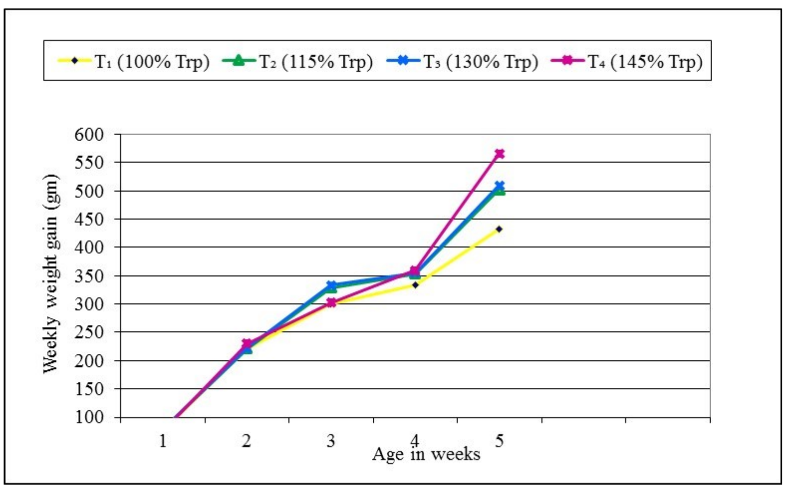

Fig. 1. Weekly weight gain patterns of broiler chicks containing different levels of Trp

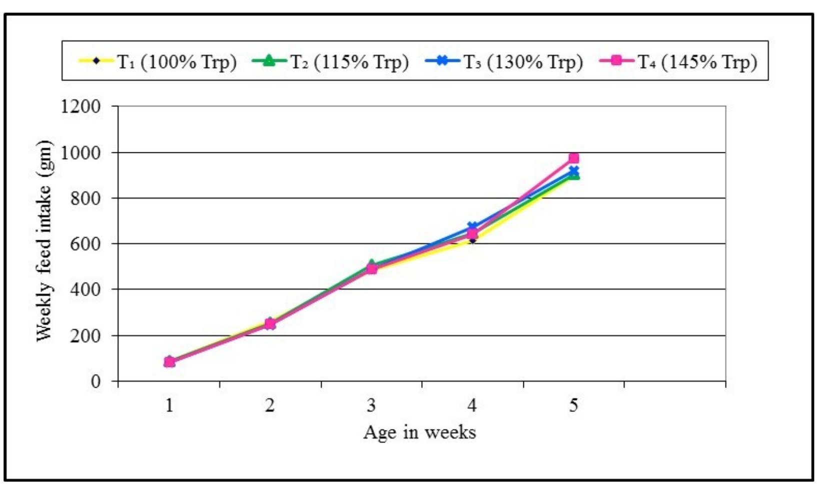

Fig. 2. Weekly feed intake trend of broiler chicks receiving different levels of Trp

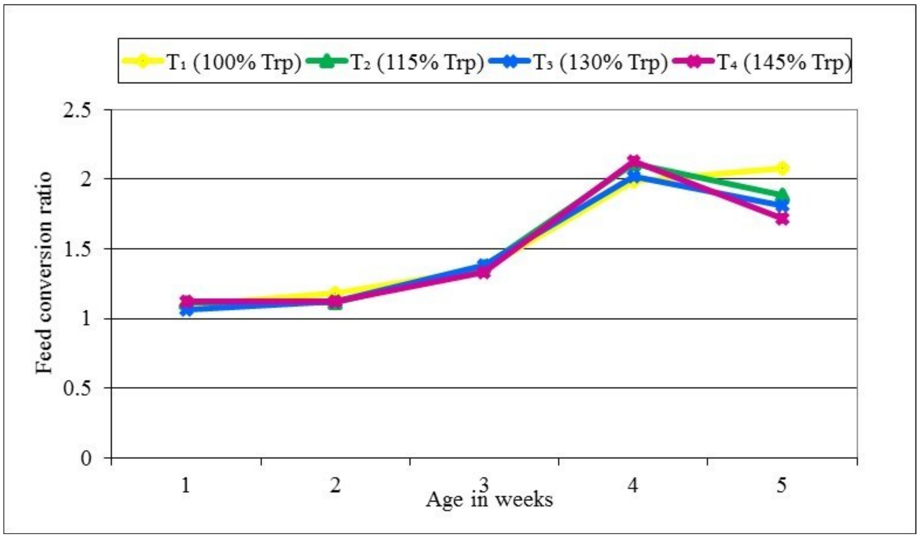

Fig. 3. Weekly feed conversion ratio of broilers receiving diets containing different levels of Trp

Dressing yields

The carcass characteristics of the experimental broiler chickens are shown in Table 3. Dressing percentage did not significantly differ from each other. The birds that received 145% Trp showed significantly higher thigh meat yield compared to control treatment (P<0.01). There was no statistical difference among T_1, T_2 and T_2, T_3 group whereas, 145% Trp (T_4) supplemented group significantly increased (P<0.01) highest thigh meat as compared to control group (T_1). Drumstick meat yield showed significant difference among the dietary groups and highest drumstick meat yield was observed in 145% Trp fed group. There was no significant difference in drumstick meat yield among T_2, T_3, and T_4 group but they differed significantly from control group (P<0.01). Breast meat yield was shown to be better in 115% Trp fed group (T_2) than control with no significant difference among the treatment groups. Highest level of Trp supplemented fed group showed significantly more gizzard weight compared to control group (P<0.01) with no difference among other treatment groups for heart, liver or giblet weight. Highest wing weight was observed for the highest level of Trp supplementation group (T_4) and the lowest wing weight (5.23%) was found in control group (T_1) with no significant difference.

Cost benefits analysis

The economics of feeding different levels of Trp is shown in Table 4. Highest and lowest feed cost was calculated in 145% Trp (T_4) and control group (T_1) respectively. The additional costs incurred for Trp over the control were BDT (Bangladeshi Taka) 0.60 for 115% Trp, BDT 1.21 for 130% Trp and BDT 1.95 for 145% Trp supplemented groups. The total cost of production was maximum in control group (T_1) and minimum in 145% Trp (T_4) supplemented group as would be expected. The profit was highest in 145% Trp (T_4) supplemented group and lowest in control group (T_1). It was therefore clear that supplementation of 145% Trp fed group was more profitable over the control group.

Table 3. Effect of feeding different levels of tryptophan on meat yield of broiler (0-35 days)

Variables (%)	Different dietary groups				P-value
	T_1	T_2	T_3	T_4	
DP	66.6±0.41	67.3±0.32	68.2±1.14	69.5±1.21	0.15
Thigh	10.3^{c}±0.04	10.57^{bc}±0.08	10.80^{ab}±0.13	10.99^{a}±0.11	0.01
Drumstick	6.58^{b}± 0.05	7.13^{a}±0.15	7.34^{a}±0.29	7.48^{a}±0.11	0.01
Breast	34.74±0.17	35.55±0.27	35.48±1.11	35.39±0.81	0.83
Wing	5.23± 0.0	5.25±0.12	5.35±0.08	5.88±0.33	0.08
Heart	0. 64±0.08	0.66±0.04	0.65±0.05	0.71±0.03	0.76
Liver	3.20± 0.13	3.54±0.22	3.62±0.09	3.64±0.08	0.16
Gizzard	2.61^{b}±0.07	2.74^{b}± 0.09	2.75^{ab}±0.06	3.09^{a}±0.14	0.01
Giblet	6.84±0.17	7.21±0.32	6.84±0.25	6.84±0.39	0.76

T_1=control (100% Trp), T_2=115% Trp, T_3=130%; Trp, T_4=145% Trp, DP=Dressing percentage; a, b, c=superscript, means bearing superscript in a row not in common differ significantly at the stated level of probability. (±) indicates standard error of mean (SEM).

Table 4. Cost benefit analysis and cost of production in different dietary treatments

Parameters	T_1	T_2	T_3	T_4
Feed intake (kg/broiler)	2.35	2.40	2.41	2.44
Final weight (kg/broiler)	1.41	1.53	1.54	1.58
Feed price (Tk./kg)	35.50	34.59	34.54	34.52
Trp (Tk. 1200/kg)	0.00	0.60	1.21	1.95
Feed cost (Tk./kg)	35.50	35.19	35.75	36.47
Feed cost (Tk./bird)	83.43	84.46	86.16	88.99
Others (Chicks, vaccines, litter, disinfectants, transport, labor etc.)	68.00	68.00	68.00	68.00
Total cost production (Tk./broiler)	151.43	152.46	154.16	156.99
Total cost of production (Tk./kg)	107.40	99.65	100.10	99.36
Sale price (130 (this selling price is not quiet regular) Tk./kg live broiler)	183.30	198.90	200.20	205.40
Profit (Tk./bird)	31.87	46.44	46.04	48.41
Profit (Tk./kg)	22.60	30.35	29.90	30.64
Profit (Tk./kg) (over control)	0.00	7.75	7.30	8.04

T_1=control (100% Trp), T_2=115% Trp, T_3=130%; Trp, T_4=145% Trp, kg=kilogram; Tk.= taka.

Discussion

The highest BW was found in 145% Trp treated group and the lowest was found in control group as shown in Table 2. The BW obtained for different groups in this study did not meet Cobb 500 standards. This was because the birds were fed experimental mash feed and reared in an open-sided house where temperature and relative humidity (RH) became too high during the experimental period (temp 35º C and RH 80%). In spite of this fact, it has shown that increasing levels of Trp increased the BW gain of birds. Lindseth *et al.* (2015) mentioned that Trp is the precursor of serotonin, which attributes to regulate appetite and proper utilization of nutrients and facilitating better growth in Trp treated birds.

The result of increased body weight as obtained in the present study coincided with the previous findings of Emadi *et al.* (2010) who reported that BW gain enhanced linearly with increasing dietary level of Trp and they observed the highest BW with an increasing level of Trp. Our trend of results with straight run flock was also in agreement with a study of Corzo *et al.* (2005a) who found that male Ross 308 broilers acquired highest BW gain at 0.24 % level of Trp. Wang *et al.* (2014) observed that BW gain was improved at high levels of dietary Trp (0.27%). The highest amount of feed was consumed by 145% Trp fed T_4 group and the lowest amount by control group. The higher feed intake found in Trp treated groups as observed in this study could be hypothesized to increased serotonin production with increasing levels of Trp supplementation. It is well established that serotonin, which is formed in the brain influences feed consumption of animals (Shea-Moore *et al*., 1996; Peganova and Eder, 2003; Xi *et al.,* 2009). On the other hand, Trp plays a vital role in nutrition and physiology, specially feed intake, and neurological function (Li *et al.,* 2007). Melatonin is another precursor of Trp, which provides signal for the synchronization of feeding and digestion process (Koide and Ishibashi 1995; Harms and Russell, 2000; Peganova and Eder, 2003). Results of the present study also agreed with Wang *et al.* (2015) where feed intake of male broiler chickens showed a quadratic response to the increasing level of Trp. Corzo (2012) observed that highest feed consumption was achieved by broiler chickens that fed 0.24% dietary Trp compared to the lowest feed consumption at 0.12% level of Trp.

The result is in agreement with the present trial since the highest FI was found with an increasing level of Trp. In this research, 145% Trp fed group (T_4) showed lowest FCR value as compared to control group where the higher levels of Trp supplementation improved feed conversion ratio. Birds fed diet containing standard level of Trp (control group) revealed abnormal behavior and most of them showed a tendency of feed scrubbing from the feeder. Consequently, feed wastage was high in this group. Due to improper feed consumption, nutrient intake for desired growth obviously declined resulting in improper growth. Such an abnormal behavior was previously reported by Corzo *et al.* (2005b). The improvement in FCR with increasing levels of Trp in our study also got support from Wang *et al.* (2014) where feed conversion decreased with increasing levels of Trp. The results were quite in agreement with the results of Rogers and Pesti (1990); Han *et al.* (1991); Emadi *et al.* (2010).

In this trial, higher levels of Trp supplementation showed mixed responses with improved thigh and gizzard weight percentages with no difference in other dressing parameters. This finding was partly in agreement with Hsia *et al.* (2005); Corzo *et al.* (2005a); Xi *et al*. (2009). The profit was maximum in 145% Trp supplemented group (T_4). It was observed that total cost of production reduced in 145% Trp fed group (T_4) due to increased body weight and reduced FCR. Consequently, profit was maximized indicating that increasing level of Trp increased profit.

Conclusion

Based on findings of this study, it may be concluded that increasing level of dietary Trp had positive impact on the growth performance, dressing yields and profitability of broiler chickens. Supplementation of increasing level of Trp could be a nutritional strategy to improve broiler growth performance in a cost-effective manner. Therefore, increasing levels of tryptophan supplementation in the diet may be considered as a nutritional tool for profitable broiler production.

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