EFFECT OF DIETARY SUPPLEMENTATION OF TURMERIC (*Curcuma longa*) ON PRODUCTION PERFORMANCE OF BROILER CHICKEN

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Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

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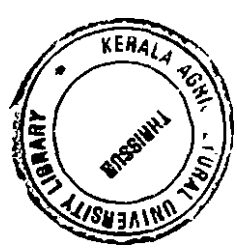

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DECLARATION

I hereby declare that this thesis, entitled **"EFFECT OF DIETARY SUPPLEMENTATION OF TURMERIC (*Curcuma longa)* ON PRODUCTION PERFORMANCE OF BROILER CHICKEN"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"EFFECT OF DIETARY SUPPLEMENTATION OF TURMERIC (*Curcuma longa)* ON PRODUCTION PERFORMANCE OF BROILER CHICKEN"** is a record of research work done independently by **SIMI G,** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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"I shall offer to Thee the sacrifice of thanks giving and call upon the name of the LORD"

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Dedicated to

ACHAN & AMMA

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Introduction

1. INTRODUCTION

The poultry industry in India has registered a growth rate of 15 to 20 per cent during the last two decades and has developed rapidly from small-scale backyard rearing to highly specialized, intensive production. It is estimated that 25 per cent of the world's meat supply is derived from poultry and the proportion is increasing steadily. This trend has been more noticeable in developing countries in recent years. Poultry production is one of the fastest growing food production sectors in India and broiler industry that gained spectacular progress has transformed into imperative industrial status. Chicken meat production in India has increased from 1.08 to 1.60 million metric tones during the period from 2000 to 2004 (FAO, 2005).

Poultry provides a considerable supply of food for the world's population. The low-fat, low-calorie, high protein, cost effective broiler meat now finds ready acceptance, not only among urban consumers but also in rural households. The accomplishment in the industrial sector is attributed to scientific breeding, management, nutritional and technological practices ordained through tenacious research. Profitability in poultry production involves assessment of demand and supply, planning the size of activity, integration measures to bring down the cost of production, prudent assessment of cost benefits and the rate of returns in the productivity. Poultry farming has to meet the new demands of cost effective means of production for the sustained survival in the global market.

Improvement in productive performance and economizing feeding have drawn considerable attention of poultry scientists. Nutritional manipulations for promotion of growth are essential because feed forms a major share of the input cost. The quest for growth promoting feed additives began in the wake of negative effects from potential residual hazards of the anabolic steroids and antibiotics. Feed additives have become essential components of feeds and various potential sources are under investigation. Herbal growth promoters are

new biotechnological concept for achieving efficient broiler production. Inclusion of herbal growth promoters in broiler ration gives beneficial effects as they are more innocuous alternatives and are safe to the consumers and environment.

Turmeric (*Curcuma longa*) is a tropical herb of Zingiberaceae family, commonly used in Indian cuisine as a spice, food coloring agent and is also used extensively in Ayurveda for various ailments. The rhizome is the portion of the plant, popularly used in indigenous medicine in Asia. The active ingredients of turmeric are curcumin, tetrahydrocurcuminoids, turmerin, demethoxycurcumin and bisdemethoxycurcumin. The main active substance is curcumin. Turmeric extracts have immunomodulatory, antimutagenic, antinematodal, anti-inflammatory and antimicrobial effects apart from antifungal, hypolipidaemic, hypocholesterolaemic, and antioxidative activities. The pharmacological properties of turmeric make it effective against endoparasites and external or internal injuries. Soni *et al.* (1992) proposed the protective effect of turmeric in aflatoxin- induced mutagenicity and hepatocarcinogenecity.

The antimicrobial effect of turmeric in the digestive tract of broiler chicken improves the performance in terms of growth and feed efficiency. There is paucity of studies on use of turmeric as growth promoting feed additive in poultry rations. The present study involving the dietary supplementation of turmeric in broiler chicken was undertaken with the following objectives.

1) To assess the effects on growth, overall production performance and economics of incorporation of turmeric powder in experimental diets of broiler chicken.

2) To evaluate the hematological and biochemical parameters including cholesterol levels in serum and thigh meat of broilers.

Review of Literature

2. REVIEW OF LITERATURE

2.1 BIOLOGICAL FUNCTIONS OF TURMERIC

Curcumin (diferuloylmethane), the main yellow bioactive component of turmeric posseses a wide spectrum of biological actions. The antibacterial, antifungal, immunomodulatory, hypolipidaemic, hepatoprotectant and hypocholesterolaemic activities of turmeric are reviewed in this chapter. Safety evaluation studies indicate that both turmeric and curcumin are well tolerated at a very high level dose without any toxic effects.

2.1.1 Antibacterial Action

Elsamma *et al.* (1996) investigated the antibacterial activity of ether and ethyl acetate extracts of *Curcuma longa* against gram negative and gram positive bacteria and suggested that extracts of *Curcuma longa* had significant effects on *Staphylococcus aureus* and *Klebsiella pnuemoniae.*

Negi *et al.* (1999) extracted the oil from *Curcuma longa* and tested the fractions of the hexane extract for antibacterial activity and found that fraction II was the most effective against *Bacillus cereus, B. coagulans, B. subtilis, Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeuruginosa.*

Rath *et al.* (2002) investigated the antimicrobial activities of six essential oils against certain gram positive and gram negative organisms and reported that turmeric was effective against *Escherichia coli, Salmonella typhimurium, Shigella boydic, Bacillus cereus* and *Pseudomonas aeuroginosa.*

Thakarae (2004) investigated the effect of dietary supplementation of different spices in broiler diets and reported that inclusion of turmeric extract at 0.29 per cent in the diet produced an antimicrobial effect.

Kim *et al.* (2005) investigated the antimicrobial activity of ethyl acetate, methanol and water extracts of *Curcuma longa* against Methicillin – resistant *Staphylococcus aureus* (MRSA) and concluded that MRSA intracellular invasion was significantly decreased in the presence of 0.125-2mg/ml of water extract of *Curcuma longa.*

2.1.2 Antifungal Action

Apisariyakul *et al.* (1995) studied the effect of turmeric oil in *Trichophyton rubrum* induced dermatophytosis in guinea pigs. The results showed that 15 isolates of the dermatophytes could be inhibited by turmeric oil.

Anu and Kapoor (1997) studied the antifungal activities of fresh juice and aqueous extracts of turmeric and ginger rhizomes against *Aspergillus niger* and *Penicillium digitatus in vitro.* The results suggested that the tested extracts arrested the growth of the fungi and that juices showed a better antifungal activity.

Lee *et al.* (2001) studied the effects of naturally occurring compounds from plants on biotransformation of aflatoxin B_1. It was shown that the formation of the aflatoxin B_1 reductase product, aflatoxicol by chicken liver cytosols was strongly inhibited by curcumin.

Perumal *et al.* (2004) studied the antifungal activity of nine traditional medicinal plants against *Aspergillus flavus, Aspergillus terreus* and *Mucor sp.* It was seen that *Curcuma longa* was the most effective against Mucor species and exhibited significant activity against *Aspergillus flavus.*

2.1.3 Immunomodulatory Action

Yoshimasa *et al.* (1998) investigated the inhibitory effects of curcumin and tetrahydro curcuminoids on tumor promoter induced oxidative stress in vitro and in vivo studies. It was observed that curcumin and tetrahydrocurcuminoids

exhibited significant inhibitory effects on Tissue Plasminogen Activator (TPA) induced O_2- generation in differentiated Hela–60 cells. It was thus concluded that curcuminoids significantly suppress TPA – induced oxidative stress via both interference with infiltration of leukocytes into the inflammatory regions and inhibition of their activation.

Antony *et al.* (1999) studied the immunomodulatory activity of curcumin administered at the rate of 200 μg/ kg in mice and observed that curcumin increased the circulating antibody titre, plaque – forming cells in the spleen, bone marrow cellularity and α–esterase positive cells. A significant increase in macrophage phagocytic activity indicated the immunostimulatory activity of curcumin.

Kurkure *et al.* (2000) investigated the protective effect of turmeric at the rate of 0.5 g / kg feed in induced aflatoxicosis in cockerels. It was observed that humoral immune status adjudged by HI titre against Newcastle disease virus and cell mediated immune response assessed by contact sensitivity test proved the potential of turmeric to moderately reduce immune toxicity due to dietary aflatoxin B_1 and concluded that population of lymphocytes in lymphoid organs were slightly restored by turmeric.

Bansal *et al.* (2001) conducted a study to determine the cytoprotective and immunomodulatory properties of Geriforte, a herbomineral compound containing *Curcuma longa* in rats. It was observed that Geriforte supplementation reduced cytotoxicity and apoptosis induced by tert – BHP. It relieved the inhibitory effect of tert – BHP on lymphocyte proliferation and decreased DNA fragmentation appreciably.

Xiaohua *et al.* (2004) investigated the effect of curcumin on the mitogen/ antigen induced proliferation of spleenic lymphocytes, induction of cytotoxic T lymphocytes, lymphokine activated killer cells and production of cytokines. It was observed that alloantigen induced proliferation of spleenic lymphocytes and

development of cytotoxic T lymphocytes was significantly suppressed at 12.5 – 30 µmol/L curcumin. The results indicated that curcumin inhibits cells proliferation, cell mediated cytotoxicity and cytokine production by inhibitory target genes involved in induction of the immune response.

Jindamongkon *et al.* (2005) studied the effects of extract of *Curcuma longa, Paederia tomentosa* and *Tinospora crispa* on stress and immunity of broilers. Groups T_3, T_4 and T_5 were fed 0.01, 0.03 and 0.05 per cent of *C. longa.* The broilers supplemented with 0.5 per cent turmeric had higher anti-ND titre when compared to the control group. It was suggested that supplementation of turmeric in broilers reduce stress while enhancing humoral immune response.

2.2 BODY WEIGHT AND BODY WEIGHT GAIN

Soni *et al.* (1992) studied the effect of turmeric, garlic and asafoetida in reversing the aflatoxin induced liver damage in ducklings. Groups of ten ducklings were used for each set of experiment and each received 5 micrograms aflatoxin per day for fourteen days. Turmeric was supplemented to the third group at the rate of 50 mg per day per bird and fourth group was supplemented with curcumin at the rate of 10 mg per day per bird for 14 days and observed that there was significant difference in body weight gain of birds supplemented with turmeric and curcumin.

Allen *et al.* (1998) studied the effect of one per cent turmeric in diet of chicken infected with *Eimeria maxima* for three weeks of age. It was observed that turmeric had a protective effect on weight gain in *Eimeria maxima* infected chicken and reduced lesion scores and oocyst output.

Kurkure *et al.* (2001) conducted an experiment in White Leghorn cockerels to study the protective effect of turmeric on aflatoxin induced toxicity. The chicks were divided into three groups of which group A served as aflatoxin negative control and were given plain feed. The chicks of group B served as

aflatoxin positive control. The chicks from group C were given aflatoxin and turmeric powder at the rate of 0.5 per cent up to 28th day of age. It was observed that mean gain in body weight was numerically higher in the group C than the aflatoxin fed group.

Mohan *et al.* (2001) investigated the efficacy of turmeric, curcumin and chitosan in reversing the aflatoxin induced liver damage in broilers for a period of eight weeks. Broiler chicks of three days of age were divided into five groups of 10 chicks each. Group II was fed 50 mg aflatoxin containing feed and 10 mg curcumin per day per bird. The body weight gain of group II and group III birds were higher than the control group.

Sarma *et al.* (2001) conducted an experiment in one hundred and twenty broiler chicks to evaluate the effect of dietary supplementation of Spirulina and a herbal product AV/LTG/26B that contained turmeric as an active ingredient. The control group was fed with normal basal diet. In the treatment groups, the basal diet was supplemented with Spirulina, herbal product and the combination of herbal product plus Spirulina. At sixth week, all supplemented groups showed higher body weight ($P \leq 0.01$) than the control group and significant differences existed between T_1, T_2 and T_3.

Al-Sultan (2003) studied the effect of turmeric on overall performance of broiler chicken. The chicks were divided into four groups and birds in group I were fed basal diet, while groups II , III and IV were fed basal diet supplemented with 0.25, 0.5 and 1.0 per cent turmeric respectively during five-weeks experimental period. It was found that the higher body weight gain occurred in birds fed diet containing turmeric at level of 0.5 per cent followed by birds that received 1 per cent turmeric.

Kumar *et al.* (2005) conducted an experiment in two-hundred and forty Cobb broilers to study the effect of supplemental prebiotic, probiotic and turmeric in diets during summer for a period of 42 days. Chicks were distributed

into groups of 15 each. Five treatments consisted of basal diet and turmeric powder at 1 g/ kg feed. A significantly higher weight gain was noticed in chicks supplemented with turmeric in diet over those of control chicks.

Samarasinghe *et al.* (2003) conducted two bioassays to evaluate turmeric root powder and Mannan oligo-saccharides (MOS) as alternatives to feed antibiotics in broiler birds. In the first trial, one hundred and eighty, 19-day old broilers assigned to groups of 10 birds each were housed in wire meshed battery cages during four weeks. The diets included a basal feed without additives and with either virginiamycin, MOS or turmeric at 0.1, 0.2 and 0.3 per cent levels. The highest initial body weight was for the group fed turmeric at 0.3 per cent of feed, followed by those fed 0.2 per cent and 0.1 per cent .In the second trial, one hundred and forty four 21-days old broilers arranged on 16 groups were fed on the first four diets with four replicates for a similar period. Virginiamycin, MOS and turmeric increased the weight gain significantly by 8.8, 8 and 15 per cent respectively.

Durrani *et al.* (2006) investigated the effect of turmeric at 0.25, 0.5 and 1.0 per cent levels on the overall performance of broiler chicken and reported that the body weight of broilers fed 0.5 per cent turmeric was significantly higher than the control group in starter phase. In finisher phase, higher body weight was obtained in birds fed with 0.5 per cent turmeric followed by those fed 0.25 and 1 per cent respectively.

Emadi and Kermanshahi (2006) studied the effect of turmeric rhizome powder on performance and carcass characteristics of broiler chicken and observed that weight gain was not significantly affected by adding 0.25, 0.50 and 0.75 per cent turmeric in the diets.

Mekala *et al.* (2006) conducted an experiment to assess the usefulness of curcumin and Silymarin on aflatoxicosis in broiler chicken. One hundred and forty four Vencobb day old broiler birds were divided into 8 treatment groups.

Turmeric was fed at the rate of 10 mg/ bird/ day for group III from 15th day to 42nd day. Only numerical increase in body weight gain was recorded in the group at the end of fourth week and in the subsequent weeks.

2.3 FEED INTAKE

Sarma *et al.* (2001) evaluated the effect of dietary supplementation of Spirulina and a herbal product AV/LTG/26 B that contained *Curcuma longa* in 120, day-old broiler chicks, distributed randomly into four groups of 30 each in two replicates. They were offered control diet (T_1) Spirulina (T_2), AV/LTG/26 B (T_2) and their combinations (T_3) at the rate of 0.05 per cent in diets. It was observed that feed consumption in broilers did not differ among groups.

Al-Sultan (2003) studied the effect of turmeric in a basal diet supplemented with 0.25, 0.5 and 1.0 per cent levels in broiler chicken during a five weeks experimental period. Feed intake among the treatment groups differed significantly ($P \leq 0.05$) and the highest feed intake was noticed in the group fed 1.0 per cent turmeric, followed by those fed 0.25 and 0.5 per cent levels.

Samarasinghe *et al.* (2003) conducted two bioassays to evaluate turmeric root powder and MOS as alternatives to feed antibiotics for broilers. In one trial, the diets consisted of a basal feed without additives and with Virginiamycin, MOS or turmeric at 0.1, 0.2 and 0.3 per cent levels respectively. Among the turmeric supplemented dietary groups, higher daily feed intakes were observed in the groups that received turmeric at 0.1 and 0.3 per cent levels. In the second trial, there was significant difference in daily feed intake of birds fed turmeric at the rate of 1.0 per cent when compared to those fed MOS.

Durrani *et al.* (2006) while investigating the effect of supplementation of 0.25, 0.5 and 1.0 per cent turmeric on overall performance of broiler chicken observed that in the starter phase the feed consumption in birds fed 0.5 per cent

turmeric was significantly lower when compared to the other groups. In the finisher phase also, the feed consumption was significantly lower in the same group.

Kumar *et al.* (2005) conducted an experiment in 240 Cobb broilers to study the effect of supplemental prebiotic, probiotic and turmeric in diet on the performance during summer for 42 days. Results on feed intake of chicks in different dietary groups revealed only numerical difference in the groups fed 1 per cent turmeric, thereby indicating practically no influence of the three additives in diet on feed consumption by chicks.

Emadi and Kermanshahi (2006) after investigating the effect of turmeric rhizome powder on performance of broiler chicken reported that feed intake in broilers was not affected significantly by the addition of 0.25, 0.50 and 0.75 per cent turmeric to the experimental diets.

Mekala *et al.* (2006) conducted an experiment to assess the usefulness of curcumin and Silymarin in aflatoxicosis in broiler chicken. One-hundred and forty four Vencobb day - old broiler birds were divided into eight treatment groups. Curcumin was fed at the rate of 10 mg/ bird/ day for group III. It was found that the curcumin supplemented birds showed normal feed intake when compared to decreased feed consumption of aflatoxin fed birds.

2.4 FEED EFFICIENCY

Sarma *et al.* (2001) evaluated the effect of dietary supplementation of Spirulina and turmeric containing herbal product (AV/LTG/26 B) in broiler chicken. It was observed that feed conversion efficiency did not differ significantly among the various dietary groups.

Al-Sultan (2003) studied the effect of supplementation of turmeric at different levels (0.25, 0.5 and 1.0 per cent) in broiler chicken for a period of five

weeks and reported that the feed conversion efficiency of birds received 0.5 per cent turmeric in diet was superior than the other groups.

Samarasinghe *et al.* (2003) conducted two bioassays to evaluate turmeric root powder and MOS as alternatives to feed antibiotics for 19 – day old broilers during four weeks. The diets consisted of a basal feed without additives and with virginiamycin, MOS or turmeric at 0.1, 0. 2 and 0.3 g / kg respectively. It was observed that feed conversion ratio was not significantly influenced by additives. In the second trial, feed conversion ratio of birds reduced by 15.1, 12.5 and 10.5 per cent when they were fed on diets supplemented with turmeric (1g/ kg), MOS and virginiamycin respectively.

Kumar *et al.* (2005) conducted an experiment in 240 Cobb broilers to study the effect of supplemental prebiotic, probiotic and turmeric in diet on the performance during summer for 42 days. Chicks were distributed to 16 groups and fourth to eighth treatments consisted of basal diet and turmeric powder at 1 g/kg feed. A higher feed efficiency was reported in birds fed with feed additives.

Durrani *et al.* (2006) after studying the effect of supplementation of turmeric powder at 0.25, 0.50 and 1.0 per cent levels in broiler chicks reported that better feed efficiency was noted in the birds fed 0.5 per cent turmeric in both starter and finisher phases.

Mekala *et al.* (2006) conducted an experiment to assess the usefulness of curcumin and Silymarin on aflatoxicosis of broiler chicken. Curcumin was fed at the rate of 10 mg/ bird/ day for group III and 20 mg/bird/ day for group IV along with aflatoxin. For group VII, curcumin was fed at 10 mg/ bird/ day along with curcumin and Silymarin. Results indicated that groups fed with curcumin recorded better feed conversion efficiency value.

Emadi and Kermanshahi (2006) studied the effect of turmeric rhizome powder on performance of broiler chicken and observed that a positive trend in

feed conversion ratio occurred as the turmeric level in the diet (0.25, 0.50 and 0.75 per cent) increased. But no significant effect was noted on feed conversion ratio.

2.5 WEIGHT OF LYMPHOID ORGANS AND LIVER

Kurkure *et al.* (2000) studied the protective effect of turmeric at the rate of 0.5 g / kg of feed in induced aflatoxicosis in cockerels. It was observed that turmeric treated group showed significantly lower weights of liver as compared with only aflatoxin B_1.

Al-Sultan (2003) studied the effect of supplementation of 0.25, 0.50 and 1.0 per cent turmeric on overall performance of broiler chicken. The higher bursa and thymus weight indices were detected in birds that received diet containing 0.5 per cent turmeric, while the higher spleen weight index was observed in birds received feed containing 1.0 per cent turmeric.

Samarasinghe *et al.* (2003) conducted two bio-assays to evaluate turmeric root powder and MOS as alternatives to feed antibiotics for broilers during four weeks. Significantly heavier livers were observed with birds fed on supplemented diets containing 1.0 per cent turmeric.

Jindamongkon *et al.* (2005) studied the effects of extracts from *Curcuma longa, Paedaria tomentosa* and *Tinospora crispa* as antibiotic substitutes on stress and immunity of broilers. It was observed that the spleen weight of the group fed with turmeric was higher than those fed antibiotics.

Durrani *et al.* (2006) while studying the effect of supplementation of turmeric powder at 0.25, 0.50 and 1.0 per cent levels in broiler chicks observed that the weight of heart and gizzard improved in the broilers supplemented with 0.25 and 0.5 per cent levels of turmeric. But no significant effect was noted.

Emadi and Kermanshahi (2006) studied the effect of turmeric powder on performance of broiler chicken. The results of the study indicated that weight of heart in broilers supplemented with 0.25 per cent turmeric was significantly higher than those fed 0.75 per cent. He reported that the weight of liver, pancreas and spleen did not reveal any statistical significance at 0.25, 0.50 and 0.75 per cent levels of inclusion of turmeric.

2.6 PROCESSING YIELDS AND LOSSES

Rejikumar and Narayanankutty (1992) studied the processing yields, losses and meat to bone ratio in eight week old broiler chicken and reported 72.76, 27.24 and 3.42 per cent ready to cook yield, total loss and feather loss respectively.

Samarasinghe *et al.* (2003) conducted two bioassays to evaluate turmeric root powder at three levels (0.1, 0.2 and 0.3 per cent) and Mannan - oligosaccharides as alternatives to feed antibiotics for broilers. He observed that turmeric at 0.1, 0.2 and 0.3 per cent levels significantly improved (up to 3.1 per cent) the carcass recovery (dressing percentage) of birds in both experiments.

Durrani *et al.* (2006) investigated the effect of supplementation of turmeric powder at 0.25, 0.50 and 1.0 per cent levels on performance of broiler chicken and reported that the dressing per cent for the birds fed 0.5 per cent turmeric was significantly higher than all other groups.

2.7 HAEMATOLOGICAL PARAMETERS

Soni *et al.* (1992) investigated the effect of turmeric and curcumin in reversing the aflatoxin induced liver damage produced in ducklings for a period of 14 days. The results of the studies on haematological parameters indicated that the total WBC count and Haemoglobin did not differ significantly in the ducklings.

Kurkure *et al.* (2001) studied the effect of dietary turmeric treatment to counteract aflatoxin induced haematological and biochemical alterations in chicks for a period of 28 days. Results indicated that there was a significant increase in total leucocyte count in the birds fed 0.5 per cent turmeric and aflatoxin. Turmeric treatment reduced the magnitude of haematological alterations induced due to dietary aflatoxin except that of absolute heterophils.

Mohan *et al.* (2001) conducted a feeding trial to determine the efficacy of turmeric, curcumin and chitosan in reversing the aflatoxin induced liver damage in broiler chicks. It was concluded that parameters as WBC count and Haemoglobin showed alteration of varying degrees. The value of Haemoglobin was highest in the birds fed 50 mg turmeric / bird /day along with aflatoxin. WBC count was highest in the group fed turmeric extract at the rate of 10 mg / bird/ day along with aflatoxin.

Al-Sultan (2003) studied the effect of supplementation of turmeric at 0.25, 0.50 and 1.0 per cent levels on overall performance of broiler chicken during a five weeks experimental period. It was concluded that the higher levels of turmeric inclusion, at 0.5 and 1.0 per cent increased both erythrocytic and total leucocytic count.

2.8 BIOCHEMICAL PARAMETERS

2.8.1 Serum Cholesterol

Srinivasan and Sambaiah (1991) studied the effect of spices on cholesterol 7 α – hydroxylase activity and on serum and hepatic cholesterol levels in male wistar rats. The results suggested that turmeric stimulates conversion of cholesterol to bile acids, an important pathway of elimination of cholesterol from the body.

Saudamini *et al.* (1992) found that oral administration of turmeric extract for 14 days significantly reduced the serum and tissue cholesterol in liver, lungs , kidney and brain in Swiss albino mice.

Hussain and Chandrasekhara (1993) studied the efficacy of curcumin and capsaicin in reducing the incidence of cholesterol gall stones in mice and hamster. Feeding a diet containing 0.5 per cent curcumin for 6 weeks reduced biliary cholesterol concentrations and cholesterol: phospholipids ratios markedly.

Babu and Srinivasan (1997) conducted an experiment to study the action of curcumin in Streptozotocin induced diabetic rats. Dietary curcumin at 0.5 per cent decreased liver triglyceride and cholesterol levels and hepatic cholesterol –7 α–hydroxylase activity was significantly higher in curcumin fed rats, suggesting a higher rate of cholesterol catabolism.

Kumar *et al.* (1998) conducted an experiment to study the effect of Lipotab Forte, a pharmaceutical herb formulation containing *Curcuma longa* in atherosclerosis of rabbits. It was observed that blood cholesterol and triglyceride levels were significantly reduced by Lipotab Forte treatment.

Kurkure *et al.* (2001) studied the effect of turmeric treatment to counteract aflatoxin induced haematological and biochemical alterations in White Leghorn cockerels . In one group, birds were fed turmeric at the rate of 0.5 per cent along with aflatoxin. Total cholesterol was lower in the group fed turmeric when compared to the birds fed control diet.

Ahn *et al.* (2003) studied the effect of curcuminoids and natural plants extract mixture on the cardiovascular system in rats for 7 weeks. The curcuminoids treated group revealed significantly decreased serum cholesterol, cholesterol ester, LDL-cholesterol and triglyceride.

Majighthiya *et al.* (2004) conducted an experiment to determine the effect of curcumin on serum triglycerides and total cholesterol in hyperlipidaemic Swiss albino mice. It was observed that treatment with 100 mg curcumin/ kg caused 6.2 and 5.0% reduction in total cholesterol and triglycerides respectively. Treatment with 200 and 400 mg curcumin/ kg caused a dose – dependent change in total cholesterol and triglycerides.

Kermanshahi and Riasi (2006) conducted a study to evaluate the effect of turmeric rhizome powder and soluble NSP degrading enzyme on some blood parameters of laying hens. The results of the study indicated that the total cholesterol in the birds fed 0.05 per cent turmeric was significantly lower than all other groups.

2.8.2 Serum Total Proteins

Sturkey (1976) reported that plasma or serum protein values as 4 or 5.24 for adult male and female chicken respectively and it could be affected by the state of dehydration, haemorrhage and level of protein nutrition.

Kurkure *et al.* (2001) studied the effect of dietary turmeric treatment to counteract aflatoxin induced haematological and biochemical alterations in broiler chicks. It was observed that value of serum total proteins was improved in aflatoxin plus turmeric (0.5 per cent) fed group, indicating restorative effect of turmeric during aflatoxicosis.

2.8.3 Serum Lipids

Babu and Srinivasan (1997) studied the effect of curcumin on blood and tissue lipids in Wister rats. It was observed that dietary curcumin at 0.5 per cent level decreased liver triglyceride and phospholipids levels in diabetic rats. Dietary curcumin also reduced liver triglyceride and cholesterol levels in diabetic rats fed on the high cholesterol diet.

Quiles *et al.* (1998) investigated the effect of ethanolic aqueous extract of *Curcuma longa* on lipid peroxidation in atherosclerotic rabbits. The group fed 1.66 mg/ kg extract had the lowest concentration of mitochondrial hydroperoxides. The results suggested that curcuma extracts may be protective in preventing lipid peroxidation of subcellular membranes in a dosage dependent manner.

Ramirez *et al.* (1997) studied the effects of turmeric on lipoprotein peroxides in humans. It was observed that daily intake of 20 mg curcumin for 60 days decreased high levels of peroxidation of both high density lipoproteins and low density lipoproteins

Ashok *et al.* (1999) investigated the effect of *Curcuma longa* extract in hyperlipaemic rabbits. It was observed that cholesterol, phospholipids and triglyceride levels were reduced. The tissue lipid profiles of liver and heart muscle showed similar changes in those noticed in serum lipids.

Sethu (2003) studied the effect of supplementation of *Spirulina platensis* on haematological and biochemical parameters in Austra White male chicken. Results indicated that the plasma lipid level was lower in the spirulina fed group compared to that of the control group. The value of total lipids ranged from 502.09 to 512.97 mg/ dl from fifth to eighth month of age in control group.

2.8.4 Liver Enzymes

Soni *et al.* (1992) investigated the effect of extracts of turmeric, garlic and asafoetida in the aflatoxin induced liver damage in ducklings for a period of 14 days. It was observed that serum glutamate pyruvate transaminase increased significantly after aflatoxin B treatment and remained elevated even after treatment with turmeric and curcumin.

Lalitha *et al.* (1999) studied the potential efficacy of Turmeric Antioxidant Protein (TAP) in protecting tissues from peroxidative damage in carbon tetrachloride treated rats. It was observed that the decreased activity of serum glutamate pyruvate transaminase (SGPT) and serum glutamate oxalacetate transaminase (SGOT) in the liver of carbon tetrachloride treated rats conferred protection of liver by TAP treatment.

Park *et al.* (2000) investigated the protective effects of curcumin on acute or subacute carbon tetrachloride induced liver damage in rats. It was observed that in rats with acute liver injury, curcumin at 100 and 200 mg/ kg lowered the activity of serum glutamate pyruvate transaminase to 52-53 per cent and serum glutamate oxaloacetate transaminase to 62 per cent of values in control rats. In rats with subacute liver injury, curcumin at 100 mg/ kg lowered the activity of SGPT to 34 per cent of control values.

Mohan *et al.* (2001) conducted an eight week feeding trial to determine the efficacy of turmeric, curcumin and chitosan in reversing aflatoxin induced liver damage in broiler birds. The blood picture, serum glutamate pyruvate transaminase and liver histology of birds were studied at the end of eighth week. It was observed that the liver damage was reversed to varying degrees by the feed additives, of which the turmeric gave the best result.

Miyakoshi *et al.* (2004) studied the hepato protective effect of turmeric on D-galactosamine induced liver injury in rats. It was observed that curcuminoids fraction and the sesquiterpenes fraction suppressed the increase of serum glutamate pyruvate transaminase and serum glutamate oxaloacetate transaminase.

2.8.5 Thigh Meat Cholesterol

Konjufca *et al.* (1997) found that supplementation of 1.5 per cent garlic in male broiler chicken fed from day old to 21 days of age decreased the activity of 3-hydroxy-3 methyl-glutaryl coenzyme A reductase (HMG – Co A) ,cholesterol

7 hydroxylase and thereby reduced cholesterol biosynthesis. The thigh meat cholesterol in the control group was in the range of 100 to 111 mg/dl.

Premkumar *et al.* (2002) while studying the effect of supplementation of copper and garlic in broilers reported that the thigh meat cholesterol in the control group ranged from 107 to 113 mg / dl at the end of sixth week of age. It was observed that supplementation of 1. 0 percent garlic reduced the breast meat cholesterol by 11.9, 15.1 and 11.0 per cent and thigh meat cholesterol by 9.3, 7.9 and 9.4 per cent in broilers at fifth, sixth and seventh week of age, respectively.

Lonkar (2006) studied the effect of dietary supplementation of neem seed cake and garlic powder on cholesterol content in broiler chicken and reported that the thigh meat cholesterol in the different dietary groups ranged from 97 to 111 mg/dl.

2.9 LIVABILITY

Durrani *et al.* (2006) conducted a trial on the effect of turmeric on performance of broiler chicks for a period of five weeks by supplementing 0.25, 0.5 and 1.0 per cent turmeric in the diet. The results of the experiment demonstrated that the mortality at the end of fifth week was 1 for the dietary group fed 1.0 per cent turmeric.

2.10 ECONOMICS

Durrani *et al.* (2006) studied the performance of broiler chicken for a period of five weeks by supplementing 0.5 and 1.0 per cent turmeric in the diet and found that the birds supplemented with 0.5 per cent turmeric gained higher profit per kg live weight. They reported that feed cost per unit body gain was lower in the turmeric supplemented groups.

Materials and Methods

3. MATERIALS AND METHODS

An experiment was conducted at the Department of Poultry Science, College of Veterinary & Animal Sciences, Mannuthy to study the effect of dietary supplementation of turmeric *(Curcuma longa)* on production performance, serum biochemical parameters and meat cholesterol content in broiler chicken. The study was conducted for a period of six weeks from 25th September to 8th November 2006.

One-hundred and ninety-two, day-old commercial broiler chicks (*Vencob)* were procured from Venkateshwara Hatcheries (P) Ltd. Palakkad, Kerala. They were wing banded and weighed individually. The chicks were randomly allotted to four treatment groups with four replicates of twelve birds each as detailed below.

Treatment	Number of replicates	Number of birds in each replicate	Inclusion of turmeric powder in diet (%)
T_1	4	12	0.0
T_2	4	12	0.2
T_3	4	12	0.4
T_4	4	12	0.6

The chicks were reared under deep litter system of management. Thorough cleaning and disinfection of the experimental shed was carried out prior to the commencement of the experiment. Litter materials were spread at a thickness of 6 cm in each pen. Feeders, waterers and other equipment were cleaned, disinfected and sun dried before use.

The chicks were brooded till four weeks of age. Standard management procedures were followed during the course of the experiment. Chicks were immunized against Ranikhet Disease and Infectious Bursal Disease. The birds were provided with feed and clean drinking water *ad libitum*.

EXPERIMENTAL RATION

Broiler starter diet was fed up to four weeks of age. Broiler finisher diet was given during fifth and sixth week of age. Both the rations were formulated as per Bureau of Indian Standards (BIS, 1992) specifications of nutrients for broiler chicken. The proximate analysis of the feed ingredients and rations were done according to procedure described by AOAC (1990). The turmeric rhizome was procured, sun dried and ground as fine powder before incorporation in the experimental ration.

The ingredient and chemical composition of starter and finisher rations are presented in Table 1 and 2 respectively. The performance of birds was evaluated for a period of six weeks. The following parameters were studied.

3.1 METEOROLOGICAL DATA

The wet and dry bulb thermometer readings were taken at forenoon and afternoon daily. The maximum and minimum temperatures were recorded for all days throughout the experimental period. From these data, weekly mean maximum and minimum temperatures and relative humidity were arrived at.

Table 1. Per cent ingredient composition of experimental diets

Ingredient	Starter diet	Finisher diet
Maize	45.00	56.00
De-oiled rice bran	7.00	6.00
Soyabean meal	32.00	23.00
Gingelly oil cake	4.00	3.00
Unsalted dried fish	10.00	10.00
Mineral mixture [1]	1.75	1.75
Salt	0.25	0.25
Total	100.00	100.00
Added per100 kg feed,		
Vitamin mixture, g [2]	10	10
DL Methionine, g	100	100
Lysine hydrochloride, g	100	100
Choline chloride, g	120	120
Toxin binder, g [3]	100	100
Coccidiostat, g	50	50

Note:

1 Mineral mixture composition: Supermin P mineral mixture without salt (Kwality Agrovet industries, Salem) Composition: Calcium: 30.0 per cent, Phosphorus: 9.0 per cent, Iron: 0.2 per cent, Iodine: 0.01 per cent, Zinc: 0.05 per cent, Manganese: 0.4 per cent, Copper: 0.4 per cent, Fluorine (max): 0.05 per cent, Acid Insoluble Ash (max): 2.5 per cent and Moisture: 3 per cent.

2. Vitamin mixture :Nicomix A+B2+D3+K (Nicholas Primal India Ltd., Mumbai)

Composition per gram: Vitamin A: 82,000 IU, Vitamin D3: 12,000 IU,Vitamin B2: 50 mg, Vitamin K: 10 mg

3. UTPP-5 Powder (Tetragon Chemic Pvt. Ltd., Bangalore) containing treated aluminosilicates, Propionates, Formates and Acetates.

Table 2. Per cent chemical composition of experimental diets (on dry matter basis)

Sl.No.	Nutrients	Starter Diet	Finisher Diet
1.	Dry matter	88.49	88.36
2.	Crude protein	23.18	20.04
3.	Ether extract	3.13	3.41
4.	Crude fibre	5.27	4.10
5.	NFE	60.45	62.7
6.	Total ash	7.97	9.75
7.	Acid insoluble ash	3.27	3.58
	Calculated values		
1.	ME (kcal / kg)	2810.16	2901
2.	Lysine	1.35	1.18
3.	Methionine	0.51	0.35
4.	Calcium	1.22	1.21
5.	Total phosphorus	0.50	0.50

3.2 BODY WEIGHT AND WEIGHT GAIN

The body weight of individual bird was recorded at weekly interval. From these data, the mean weekly body weight and weight gain per bird were calculated for various treatment groups.

3.3 FEED INTAKE

Feed intake of birds was recorded replicate wise at weekly interval. From these data, the average feed intake per bird per week was calculated for various treatment groups.

3.4 FEED CONVERSION RATIO

Feed efficiency was calculated in each replicate based on the data on body weight gain and feed intake.

3.5 PROCESSING YIELDS AND LOSSES

Two birds from each replicate were slaughtered at the end of experimental period to study the serum and meat biochemical characteristics and the processing yields and losses. The birds were fasted overnight. The jugular vein was severed and the birds were allowed to bleed for two minutes. Blood samples were collected with anticoagulant sodium salt of Ethylene Diamine Tetra Acetic acid (EDTA: 2mg/ml blood) for estimation of haematological parameters. Serum samples were collected in labelled tubes and stored at –20°C for biochemical analysis. Samples from thigh muscle were collected in polythene bags. Internal organs viz, liver, spleen, bursa and thymus were collected and weighed individually.

3.6 HAEMATOLOGICAL PARAMETERS

The Total Erythrocyte Count (TEC) and Total Leucocyte Count (TLC) were estimated by the method suggested by Natt and Herrick (1952). Volume of packed red blood cells was estimated as per standard procedures (Feldman *et al.* 2000). The concentration of Haemoglobin (Hb) was estimated by Acid Haematin method described by Feldman *et al.* (2000).

3.7 SERUM BIOCHEMICAL PARAMETERS

3.7.1 Serum Total Cholesterol, Lipid and Protein

At the time of slaughter, blood samples of two birds(one male and one female) from each replicate were collected in clean dry labelled glass tubes. The tubes were kept in slanted position at room temperature to facilitate the separation of serum. The serum total cholesterol was estimated colorimetrically by Ferric chloride method utilizing the kit supplied by Nice Chemicals Pvt. Ltd., Cochin – 682 024, India. Concentration of total lipids was estimated by Phosphovanilline method as described by Zoeliner (1962) using Labkit kit (M/s. Labkit Spain.) The serum total protein was estimated by Biuret method utilizing the kit supplied by Agappae Diagnostics Pvt. Ltd. Agappae Hills, Ernakulam, Kerala – 683 562, India.

3.7.2 Liver Enzymes

The level of Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) in the serum were determined by the procedure recommended by International Federation Of Clinical Chemistry and Laboratory Medicine (IFCC).

3.8 MEAT TOTAL CHOLESTEROL

At the time of slaughter, samples from thigh muscles were collected. The samples were preserved at –18°C under deep freeze. The lipid from thigh muscles was extracted by the method suggested by Folch *et al.* (1957). The total cholesterol was estimated from extracted lipid by one step method of Wybenga *et al.* (1970) utilizing the kit supplied by Qualigens Fine Chemicals, Dr. Annie Besant Road, Worli, Mumbai – 400 025, India.

3.9 LIVABILITY

The flock was constantly monitored to find whether any mortality was present and livability was calculated.

3.10 ECONOMICS

Cost of feed for different dietary treatments was calculated based on the cost of ingredients. Cost of feed per kg live weight for different dietary treatments was calculated based on body weight attained and recurring expenditure at six weeks of age.

3.11 STATISTICAL ANALYSIS

Data collected on various parameters were statistically analyzed as per methods described by Snedecor and Cochran (1994).

Results

4. RESULTS

4.1 METEOROLOGICAL PARAMETERS

During the experimental period from 25 th September to 5 th November, the mean maximum temperature was highest (36.07°C) during the first week and lowest (34.57°C) during the fourth week of the biological trial (Table 3). The difference in mean maximum temperature between the lowest and highest was only 1.5°C. Similarly, the mean minimum temperature was lowest (23.71°C) during the fourth week and highest (25.50°C) during the first week. The mean maximum temperature decreased from first to second week then elevated during third week and again declined during fourth and sixth weeks resulting in an overall mean of 35.23°C. The mean per cent relative humidity in the forenoon and afternoon were 76.74 and 63.65 respectively. All these indicated that climatograph of this locality fell within the hot and humid climate.

4.2 BODY WEIGHT

The data on mean bodyweight (g) of broiler chicken as influenced by dietary supplementation of turmeric powder is given in table 4 and graphically represented in Figure 1. The day old body weight of chicks among different groups, viz, T_1, T_2, T_3 and T_4 were 42.83, 43.94, 44.15 and 43.54 g respectively with an overall mean of 43.61 g. The statistical analysis of the data on day old body weight of chicks did not reveal significant difference between the dietary groups. Similarly, the body weight of chicks among different dietary groups, T_1, T_2, T_3 and T_4 at the end of first week of age were 186.98, 192.50, 187.50 and 187.71 g respectively with an overall mean of 188.67 g. The statistical analysis of the data did not reveal significant difference between the dietary groups.

The body weight of chicks among dietary groups viz, T_1, T_2, T_3 and T_4 at the end of second week of age were 404.58, 443.96, 434.58 and 424.90g respectively with an overall mean of 427.01 g. The birds fed with 0.2 per cent

Table 3. Mean weekly temperature (^{0}C) and relative humidity (%) inside the experimental house during the period from 25th September to 5th November, 2006.

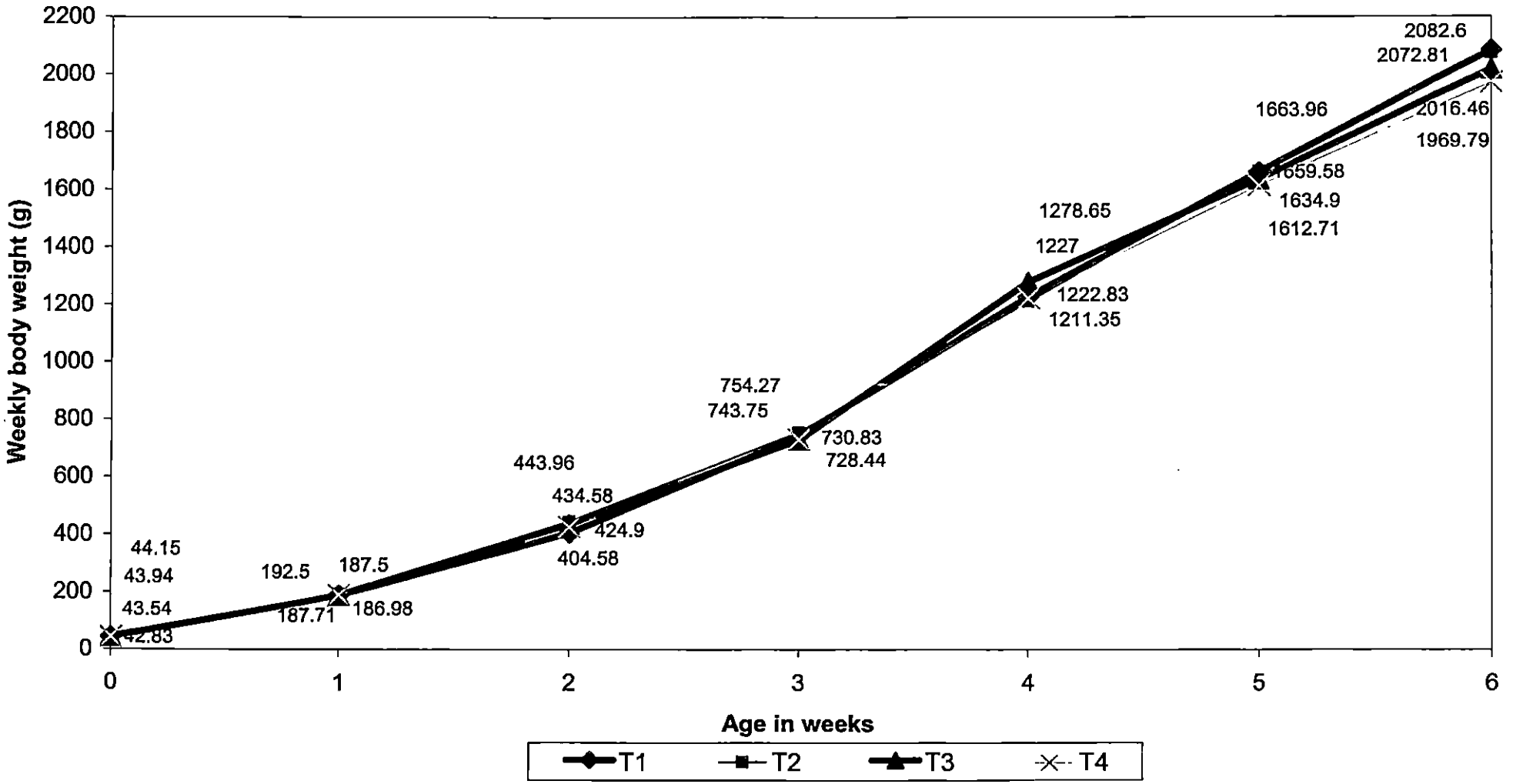
Weeks	Period	Temperature (^{0} C)		Relative humidity (%)	
		Maximum	Minimum	Forenoon	Afternoon
1	Sept 25-Oct 1	36.07	25.50	75.43	63.43
2	Oct 2-8	34.93	24.29	77.71	66.86
3	Oct 9-15	35.64	25.21	78.00	62.29
4	Oct 16-22	34.57	23.71	74.28	62.71
5	Oct 23-29	35.30	24.68	77.75	62.58
6	Oct 30-Nov 5	34.85	23.74	77.26	64.01
Overall mean Sept 25 - Nov 5		35.23	24.52	76.74	63.65

Table 4. Weekly mean body weight (g) of broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary group/ Turmeric %	Age in weeks						
	0	1	2	3	4	5	6
T_1 0.0	42.83 ±0.50	186.98 ± 2.99	404.58^{c} ± 5.77	743.75 ±9.58	1227.00^{b} ±16.79	1659.58 ± 22.17	2082.60^{a} ± 37.96
T_2 0.2	43.94 ± 0.56	192.50 ± 2.39	443.96^{a} ± 5.67	754.27 ±9.27	1211.35^{b} ±12.93	1663.96 ±21.16	2072.81^{a} ±31.91
T_3 0.4	44.15 ± 0.50	187.50 ±2.19	434.58^{ab} ± 5.05	728.44 ±11.07	1278.65^{a} ±16.40	1634.90 ±25.40	2016.46^{ab} ±29.48
T_4 0.6	43.54 ±0.39	187.71 ±2.84	424.90^{b} ±6.02	730.83 ± 9.36	1222.83^{b} ±17.81	1612.71 ±22.90	1969.79^{b} ±25.09
Overall mean	43.61 ±0.25	188.67 ± 1.31	427.01 ±2.99	739.32 ±4.94	1234.96 ±8.20	1642.79 ±11.49	2035.42 ±15.95

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.1 Mean weekly body weight (g) of broiler chicken as influenced by supplementation of turmeric powder in experimental diets



turmeric (T_2) showed significantly ($P \leq 0.05$) higher body weight than that in control (T_1) and the 0.6 per cent turmeric supplemented group (T_4) . The body weight of birds in the group T_1 was the lowest (404.58 g) and that in T_2 was the highest (443.96g). Dietary groups T_2 and T_3 were statistically comparable.

The mean body weight recorded at the end of third week of age for dietary groups T_1, T_2 T_3 and T_4 were 743.75, 754.27, 728.44 and 730.83 g respectively with an overall mean of 739.32 g. The statistical analysis of the data did not reveal significant difference among the dietary groups.

The mean body weight recorded at the end of fourth week of age for dietary groups T_1, T_2, T_3 and T_4 were 1227.00,1211.35, 1278.65and 1222.83 g respectively with an overall mean of 1234.96g The statistical analysis of the data revealed significant difference among the dietary groups. The birds fed with 0.4 per cent turmeric powder showed significantly higher body weight ($P \leq 0.05$) than the birds in other dietary groups.

The mean body weight recorded at the end of fifth week of age for dietary groups T_1, T_2, T_3 and T_4 were 1659.58, 1663.96, 1634.90 and 1612.71 g respectively with an overall mean of 1642.79 g. The statistical analysis of the data did not reveal any significant difference among the dietary groups.

The mean body weight recorded at the end of sixth week of age for dietary groups T_1, T_2, T_3 and T_4 were 2082.60, 2072.81, 2016.46 and 1969.79 g respectively with an overall mean of 2035.42 g. The statistical analysis of data revealed significant difference among the dietary groups. The body weight in T_4 was significantly ($P \leq 0.05$) lower than that in T_1 and T_2.

4.3 BODYWEIGHT GAIN

The data on mean weekly body weight gain (g) of broiler chicken as influenced by the supplementation of turmeric powder is given in Table 5 and the

fluctuation in weekly weight gain is graphically depicted in Figure 2. The mean body weight gain recorded at first week for the different dietary groups T_1, T_2, T_3 and T_4 were 144.15, 148.77, 143.35 and 144.17 g respectively with an overall mean of 145.11 g. Body weight gains among the dietary groups were comparable at the end of first week of age. Subsequently in all weeks, the body weight gain showed significant difference among dietary groups.

The mean body weight gains at second week of age were 217.60, 251.25, 247.08 and 237.19 g respectively with an overall mean of 238.28 g. The birds fed 0.2 per cent turmeric powder (T_2) showed significantly higher body weight gain than the birds of the control group and those fed 0.6 per cent turmeric ($P \leq 0.05$). Bodyweight gain in dietary group T_3 was statistically comparable with that in groups T_2 and T_4.

At third week of age, the body weight gain in dietary groups T_1, T_2, T_3 and T_4 were 339.17, 310.31, 293.85 and 305.94 g respectively with an overall mean of 312.32 g. The birds in all the turmeric supplemented diet groups had significantly ($P \leq 0.05$) lower body weight gain than the control group.

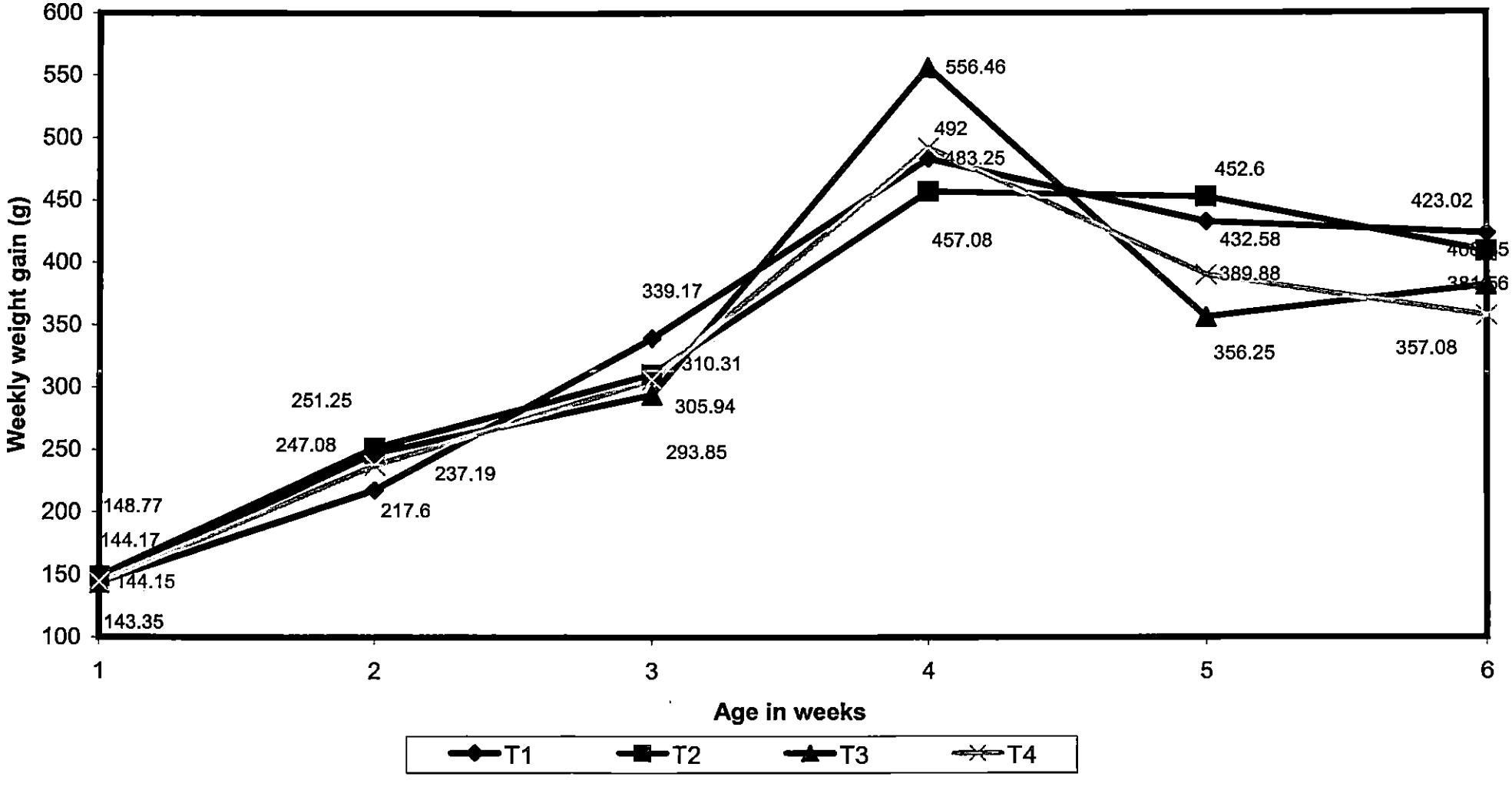
The fourth week body weight gains averaged 483.25, 457.08, 556.46 and 492.00 g in dietary groups T_1, T_2, T_3 and T_4 respectively with an overall mean of 497.20 g. The birds fed diet T_3 (0.4 per cent turmeric) showed significantly higher body weight gain than all other groups ($P \leq 0.05$).The weight gain at fourth week which was highest in T_3 (556.46 g) and lowest in T_2 (457.08 g) reversed in fifth week wherein gain was the highest in T_2 (452.60 g) and the lowest in T_3 (356.25 g) and was statistically significant. The mean body weight gains were 432.58, 452.60, 356.25 and 389.88 g in T_1, T_2, T_3 and T_4 respectively with an overall mean of 407.83 g at this age. The dietary groups T_1 and T_2 were statistically comparable. The dietary groups T_3 and T_4 were also statistically comparable.

Table 5. Mean weekly and cumulative body weight gain (g) of broiler chicken as influenced by supplementation of turmeric in experimental diets

Dietary group/ Turmeric %	Age in weeks						Cumulative body weight gain	
	1	2	3	4	5	6	0-4	0-6
T_1 0.0	144.15 ±2.72	217.60^{c} ±4.13	339.17^{a} ±6.01	483.25^{b} ±12.65	432.58^{ab} ±17.09	423.02^{a} ±33.38	1184.17^{b} ±16.60	2039.77^{a} ±37.87
T_2 0.2	148.77 ±2.30	251.25^{a} ±4.45	310.31^{b} ±5.11	457.08^{b} ±10.32	452.60^{a} ±15.00	408.85^{ab} ±19.12	1167.42^{b} ±12.93	2028.88^{a} ±31.93
T_3 0.4	143.35 ±2.04	247.08^{ab} ±4.19	293.85^{b} ±9.37	556.46^{a} ±16.88	356.25^{c} ±23.90	381.56^{ab} ±16.97	1240.75^{a} ±17.31	1978.56^{ab} ±30.24
T_4 0.6	144.17 ±2.71	237.19^{b} ±4.08	305.94^{b} ±4.60	492.00^{b} ±12.90	389.88^{bc} ±6.61	357.08^{b} ±10.41	1179.29^{b} ±17.69	1926.25^{b} ±24.93
Overall mean	145.11 ±1.23	238.28 ±2.29	312.32 ±3.46	497.20 ±7.15	407.83 ±8.77	392.63 ±10.90	1192.91 ±8.31	1993.36 ±16.00

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.2 Mean weekly body weight gain (g) of broiler chicken as influenced by supplementation of turmeric powder in experimental diets



The mean body weight gain at sixth week of age for the dietary groups T_1, T_2, T_3 and T_4 were 423.02, 408.85, 381.56 and 357.08 g respectively with an overall mean of 392.63 g. The highest gain (423.02 g) shown in the control group was significantly higher than that of group supplemented with 0.6 per cent turmeric (T_4). Dietary groups T_2 and T_3 were intermediary and statistically comparable with T_1 and T_4.

The cumulative body weight gain up to four weeks of age in the dietary groups T_1, T_2, T_3 and T_4 were 1184.17, 1167.42, 1240.75 and 1179.29 g respectively with an overall mean of 1192.91 g. The weight gain in T_3 was significantly higher than all other dietary groups.

The cumulative body weight gain up to six weeks of age in the dietary groups T_1, T_2, T_3 and T_4 were 2039.77, 2028.88, 1978.56 and 1926.25 g respectively with an overall mean of 1993.36 g. The weight gains noticed in T_1 and T_2 were significantly higher than that of T_4. The group T_3 was intermediary and was statistically comparable with all other groups.

4.4 FEED INTAKE

The data on mean daily feed intake at weekly intervals as influenced by dietary supplementation of turmeric powder in broiler diets is given in Table 6 and graphically represented in Fig. 3. The overall mean feed intake per bird recorded during the first, second, third, fourth, fifth and sixth week of age for the dietary groups were 28.54, 55.41, 70.66, 103.32, 106.10 and 109.21 g respectively. The data on mean feed intake for the first week of age did not reveal any significant difference between the dietary groups. The mean values recorded for the dietary groups T_1, T_2, T_3 and T_4 were 29.28, 29.42, 28.14 and 27.32 g respectively with an overall mean of 28.54 g.

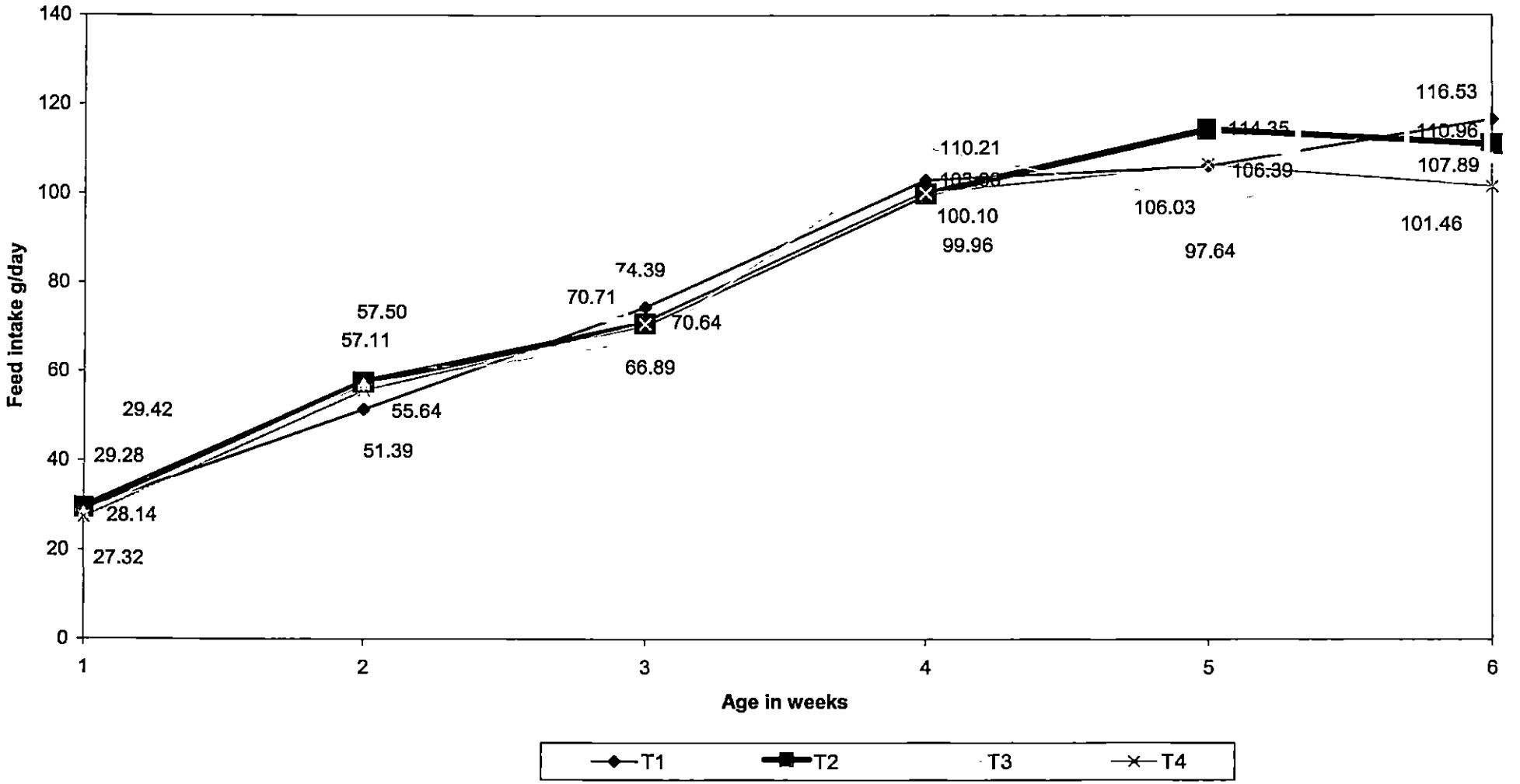
The mean feed intake per bird at second week of age revealed significant difference among the dietary groups ($P \leq 0.05$). The feed intake in the turmeric

Table 6. Mean daily feed intake and cumulative feed intake per bird (g) of broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary group/ Turmeric %	Age in weeks						Cumulative feed intake	
	1	2	3	4	5	6	0-4	0-6
T_1 0.0	29.28 ±0.86	51.39^{b} ±1.40	74.39^{a} ±2.14	103.00^{ab} ±1.63	106.03 ±5.26	116.53 ±9.96	1806.50 ±25.63	3392.50 ±64.01
T_2 0.2	29.42 ±0.92	57.50^{a} ±0.60	70.71^{ab} ±0.56	99.96^{b} ±2.91	114.35 ±2.93	110.96 ±9.55	1803.25 ±24.94	3380.44 ±92.44
T_3 0.4	28.14 ±0.47	57.11^{a} ±0.97	66.89^{b} ±2.50	110.21^{a} ±1.60	97.64 ±3.06	107.89 ±4.97	1836.50 ±16.92	3275.23 ±93.06
T_4 0.6	27.32 ±0.50	55.64^{a} ±1.53	70.64^{ab} ±0.80	100.10^{b} ±2.96	106.39 ±2.13	101.46 ±3.61	1776.00 ±24.11	3230.99 ±19.19
Overall mean ± SE	28.54 ±0.36	55.41 ±0.80	70.66 ±.08	103.32± 1.50	106.10 ±3.09	109.21 ±3.93	1805.56 ±11.74	3319.81 ±37.38

Means bearing the same superscript within the same column did not differ significantly ($P \leq 0.05$)

Fig.3 Mean daily feed intake (g) in broilers as influenced by supplementation of turmeric powder in experimental diets



supplemented groups were significantly higher than that in the control group. Dietary groups T_2, T_3 and T_4 were comparable. At third week of age the mean feed intake of birds in group T_3 was significantly ($P \leq 0.05$) lower than the control group and was statistically comparable with the other two turmeric supplemented groups.

The above trend was changed during the fourth week of age. Significantly higher ($P \leq 0.05$) feed intake was observed in the birds fed 0.4 per cent turmeric (T_3) at fourth week of age. The other two turmeric supplemented groups (T_2 and T_4) were statistically comparable with the control group (T_1) .

The mean cumulative daily feed intake of birds from 0 – 4 weeks of age in the dietary groups T_1 , T_2, T_3 and T_4 were 1806.50, 1803.25 , 1836.50 and 1776.50 g respectively with an over all mean of 1805.56 g. No significant difference was noticed among the groups.

The mean cumulative feed intake of birds from 0 – 6 weeks of age for the dietary groups T_1 , T_2, T_3 and T_4 were 3392.50 , 3380.44 , 3275.23 and 3230.99 g respectively with an overall mean of 3319.81 g. Statistical analysis of data did not reveal significant difference between the dietary groups.

4.5 FEED CONVERSION RATIO

The data on mean feed conversion ratio of birds as influenced by the dietary supplementation of turmeric powder is presented in Table 7 and depicted in Figure 4. Data on feed conversion ratio revealed significant difference among the dietary groups during first, third, fourth and fifth week of age. The mean FCR obtained at first week of age for the dietary groups T_1 , T_2, T_3 and T_4 were 1.42 , 1.38 , 1.37 and 1.33 respectively with an overall mean of 1.37.At first week of age, the FCR was significantly ($P \leq 0.05$) superior in 0.6 per cent turmeric supplemented dietary group than the control group. The other two groups were statistically comparable.

Table 7. Weekly mean feed conversion ratio and cumulative feed conversion ratio of broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary Group & Turmeric %	Age in weeks						Cumulative feed conversion ratio	
	1	2	3	4	5	6	0-4	0-6
T_1 0.0	1.42^{a} ±0.01	1.65 ±0.01	1.53^{b} ±0.01	1.49^{ab} ±0.01	1.78^{b} ±0.04	1.93 ±0.02	1.52 ±0.01	1.64 ±0.01
T_2 0.2	1.38^{ab} ±0.00	1.60 ± 0.02	1.60^{a} ±0.01	1.53^{a} ±0.03	1.77^{b} ±0.05	1.91 ±0.03	1.53 ±0.00	1.63 ±0.01
T_3 0.4	1.37^{ab} ±0.02	1.62 ± 0.02	1.60^{a} ±0.02	1.39^{c} ±0.02	1.92^{a} ±0.00	1.98 ±0.01	1.49 ±0.01	1.65 ±0.00
T_4 0.6	1.33^{b} ±0.02	1.64 ±0.02	1.62^{a} ±0.01	1.42^{bc} ±0.02	1.90^{a} ±0.01	1.99 ±0.00	1.50 ±0.00	1.65 ±0.00
Overall mean ± SE	1.37 ±0.01	1.63 ±0.01	1.58 ±0.01	1.45 ±0.01	1.84 ±0.02	1.95 ±0.01	1.51 ±0.00	1.64 ±0.00

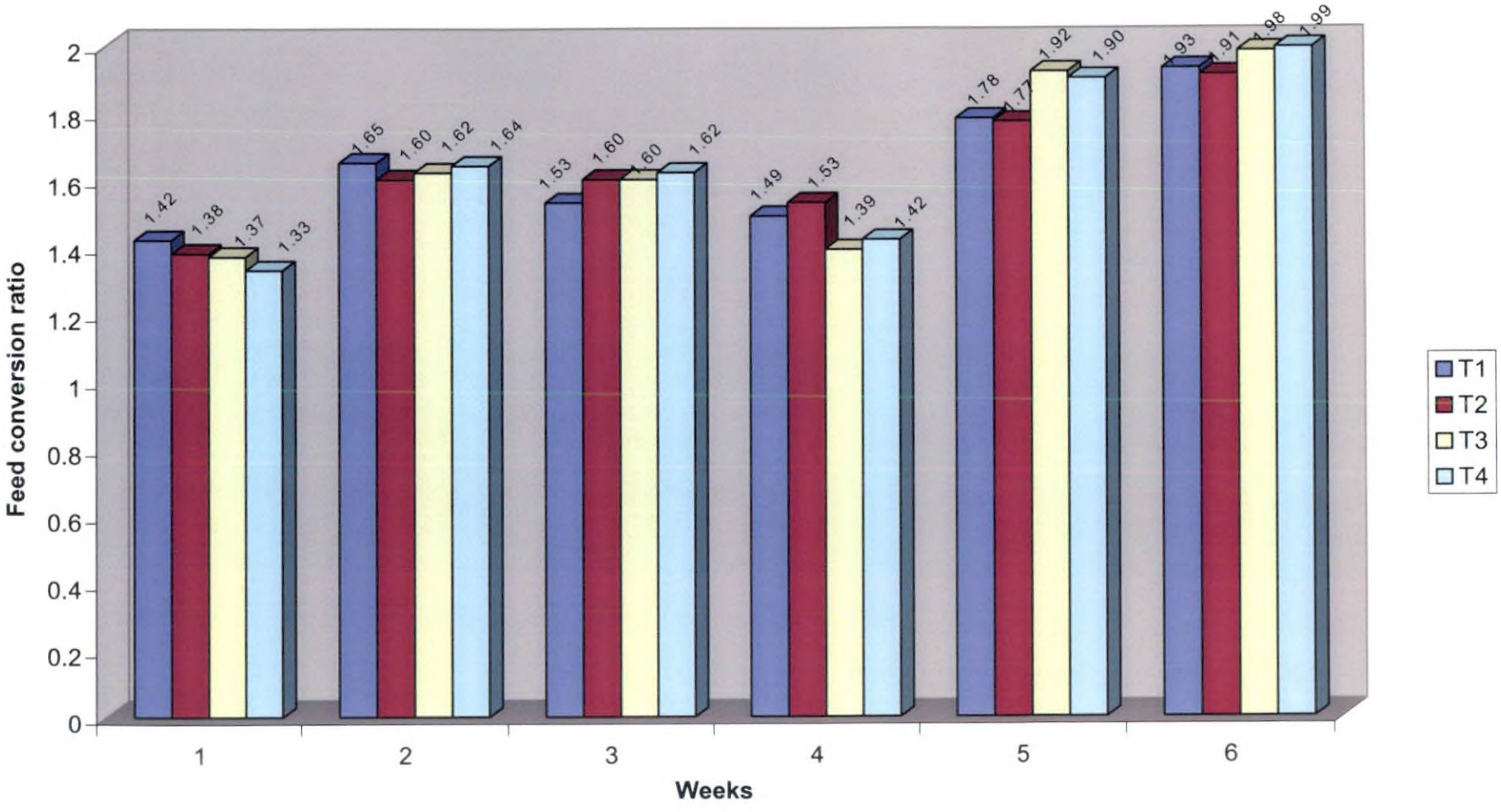
Means bearing the same superscript within the same column did not differ significantly ($P \leq 0.05$)

In the second week of age, the FCR values were ranging from 1.60 to 1.65 without any significant difference among the dietary groups. At third week of age, the FCR in all turmeric supplemented groups were poor in comparison to control group and significant difference existed between control and treatment groups. The values were 1.53, 1.60, 1.60 and 1.62 in T_1 , T_2, T_3 and T_4 groups respectively .At fourth week of age superior feed efficiency was noted in 0.4 per cent turmeric diet group (T_3) which was significantly different from 0.2 per cent turmeric supplemented group (T_2) and control group (T_1) and was statistically comparable with 0.6 per cent turmeric group (T_4) .The FCR for the dietary groups T_1 , T_2, T_3 and T_4 were 1.49 , 1.53 , 1.39 and 1.42 respectively with an overall mean of 1.45 .The mean FCR for the dietary groups T_1 , T_2, T_3 and T_4 were 1.78 , 1.77 , 1.92 and 1.90 at fifth week of age. The dietary groups T_3 and T_4 were statistically comparable. Likewise, T_1 and T_2 were also comparable. The FCR recorded for the groups T_3 and T_4 was significantly higher than the control group (T_1). At sixth week of age, the FCR for the dietary groups T_1 , T_2, T_3 and T_4 were 1.93, 1.91, 1.98 and 1.99 respectively with an overall mean of 1.95. Statistical analysis of the data did not reveal significant difference among the dietary groups.

The mean cumulative feed efficiency up to four and six weeks of age is set out in Table 7. The mean cumulative feed efficiency of birds up to four weeks of age calculated for the dietary groups T_1, T_2, T_3 and T_4 were 1.52, 1.53, 1.49 and 1.50 with an overall mean of 1.51.

The mean cumulative feed efficiency of birds up to six weeks of age recorded for dietary groups T_1, T_2, T_3 and T_4 were 1.64, 1.63, 1.65 and 1.65 respectively with an overall mean of 1.64. The statistical analysis of the data on cumulative feed efficiency up to four and six weeks of age did not reveal any significant difference among the dietary groups.

Fig.4 Mean feed conversion ratio of broiler chicken as influenced by supplementation of turmeric powder in experimental diets



4.6 PROCESSING YIELDS AND LOSSES

The mean processing yields and losses recorded in broiler chicken slaughtered at six weeks of age fed diets supplemented with turmeric at different levels are presented in Table 8 and the pattern is graphically depicted in Figure 5.

The dressed yields in the various dietary groups were 83.18, 83.69, 84.20 and 84.26 per cent with an overall mean of 83.83 per cent. The dressed yield in the groups T_3 and T_4 was significantly higher than that of control group ($P \leq 0.05$) while that in T_2 was intermediary and comparable with all other groups.

The eviscerated yield of the dietary groups T_1, T_2, T_3 and T_4 were 67.32, 66.85, 66.76 and 66.51 per cent respectively with an overall mean of 66.86 per cent. The eviscerated yield in group T_1 was significantly higher than that of T_4 ($P \leq 0.05$). Among the dietary groups, T_1, T_2 and T_3 were in a homogenous group and T_2, T_3 and T_4 formed another homogenous group. The giblet yield recorded for the dietary groups T_1, T_2, T_3 and T_4 were 4.67, 5.12, 5.31 and 5.20 per cent respectively with an overall mean of 5.07 per cent. The giblet yields in groups T_2, T_3 and T_4 were comparable to each other and all the mean values were significantly higher than that of control group T_1. However, statistical analysis of the data pertaining to ready to cook yield did not reveal significant differences among the dietary groups and the mean values for the dietary groups T_1, T_2, T_3 and T_4 were 71.96, 71.96, 72.04 and 71.67 per cent respectively with an overall mean of 71.91 per cent.

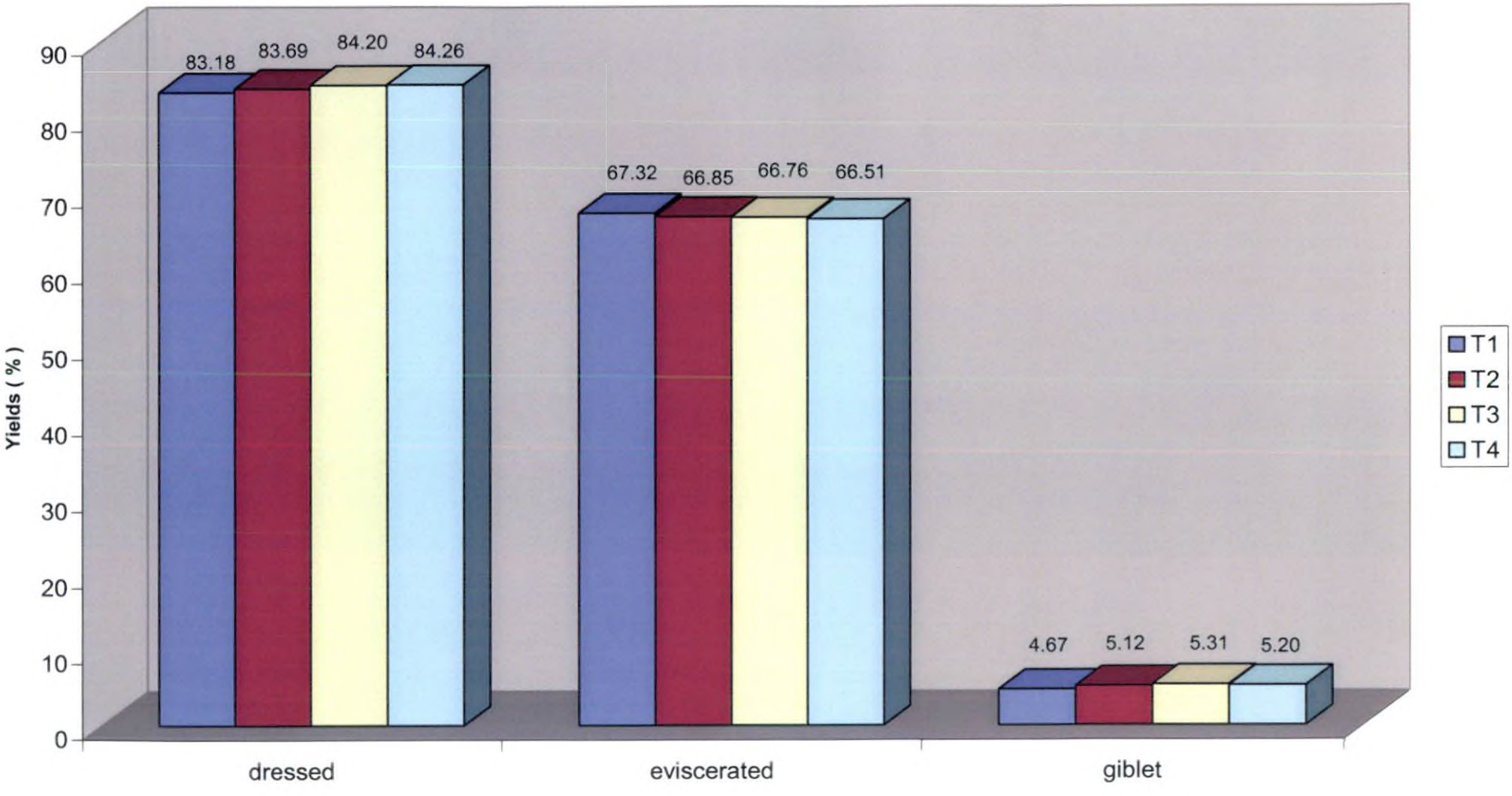
The blood loss was comparable among the dietary groups T_1, T_2, T_3 and T_4 and the mean values were 5.04, 4.72, 4.83 and 4.60 per cent with an overall mean of 4.80 per cent. The feather loss in dietary group T_2 was intermediary and was statistically comparable with T_1 and T_4. The control group (T_1) recorded significantly higher mean value than that in T_3 ($P \leq 0.05$). The feather loss

Table 8. Mean per cent processing yields and losses in broiler chicken as influenced by turmeric powder supplementation in experimental diets

Dietary Group/ Turmeric %	Yields				Losses		
	Dressed	Eviscerated	Giblet	Ready-to-Cook	Blood	Feather	Total
T_1 0.0	83.18^{b} ±0.15	67.32^{a} ±0.18	4.67^{b} ±0.07	71.96 ±0.19	5.04 ±0.05	11.73^{a} ±0.11	28.04 ±0.19
T_2 0.2	83.69^{ab} ±0.24	66.85^{ab} ±0.37	5.12^{a} ±0.11	71.96 ±0.41	4.72 ±0.15	11.56^{ab} ±0.12	28.04 ±0.41
T_3 0.4	84.20^{a} ±0.34	66.76^{ab} ±0.25	5.31^{a} ±0.09	72.04 ±0.24	4.83 ±0.21	11.03^{c} ±0.22	27.96 ±0.24
T_4 0.6	84.26^{a} ±0.10	66.51^{b} ±0.14	5.20^{a} ±0.04	71.67 ±0.15	4.60 ±0.15	11.13^{bc} ±0.14	28.33 ±0.15
Overall mean	83.83 ±0.76	66.86 ±0.13	5.07 ±0.05	71.91 ±0.13	4.80 ±0.07	11.36 ±0.09	28.09 ±0.13

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.5 Mean processing yields in broiler chicken as influenced by supplementation of turmeric powder in experimental diets



recorded for dietary groups T_1, T_2, T_3 and T_4 were 11.73, 11.56, 11.03 and 11.13 per cent respectively with an overall mean of 11.36 per cent. The total processing loss recorded for the dietary groups T_1, T_2, T_3 and T_4 were 28.04, 28.04, 27.96 and 28.33 per cent respectively with an overall mean of 28.09 per cent. Statistical analysis of the data on total loss did not reveal significant difference among the dietary groups.

4.7 WEIGHT OF LYMPHOID ORGANS AND LIVER

The weight and per cent weight of organs viz., bursa of fabricious, spleen, thymus and liver are presented in Table 9 and 10 respectively and the pattern is graphically represented in Figure 6.The weight of bursa of the broilers of dietary groups T_1, T_2, T_3 and T_4 were 4.88, 4.83, 5.13 and 5.46 g respectively with an overall mean of 5.08 g. The bursa of broilers fed with 0.6 per cent turmeric (T_4) showed significantly higher weight than the birds of all other groups. Dietary groups T_1 and T_2 were statistically comparable.

The weight of spleen for the dietary groups T_1, T_2, T_3 and T_4 were 2.83, 3.02, 3.18 and 3.26 g respectively with an overall mean of 3.07 g. The broilers of the groups T_3 and T_4 had significantly higher spleen weight than the birds fed with control diet ($P \leq 0.05$). Group T_2 was statistically comparable with all other groups. The mean weight of thymus for the dietary groups T_1, T_2, T_3 and T_4 were 1.00, 1.01, 1.04 and 1.14 g respectively with an overall mean of 1.05 g. The weight of thymus exhibited by birds fed with 0.6 per cent turmeric (T_4) was significantly higher than all other groups ($P \leq 0.05$). The groups T_1 and T_2 were statistically comparable. The weight of liver of broilers in the dietary groups T_1, T_2, T_3 and T_4 were 50.90, 53.72, 51.23 and 52.76 g respectively with an overall mean of 52.15 g. The weight of liver in the birds fed 0.2 per cent turmeric (T_2) was significantly higher than that of control group ($P \leq 0.05$). Dietary groups T_3 and T_4 were statistically comparable with T_1 and T_2.

Table 9. Mean weight of lymphoid organs and liver of broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary Group/ Turmeric %	Weight (g)			
	Bursa	Spleen	Thymus	Liver
T_1 0.0	4.88^{c} ±0.06	2.83^{b} ±0.39	1.00^{c} ± 0 .008	50.90^{b} ±0.81
T_2 0.2	4.83^{c} ±0.06	3.02^{ab} ±0.19	1.01^{c} ± 0.006	53.72^{a} ±0.85
T_3 0.4	5.13^{b} ±0.07	3.18^{a} ±0.34	1.04^{b} ± 0.005	51.23^{ab} ±1.07
T_4 0.6	5.46^{a} ±0.11	3.26^{a} ±0.13	1.14^{a} ± 0.005	52.76^{ab} ±0.77
Overall mean	5.08 ±0.05	3.07 ±0.32	1.05 ± 0.001	52.15 ±0.46

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.6 Mean weight of lymphoid organs and liver as influenced by supplementation of turmeric powder in experimental diets

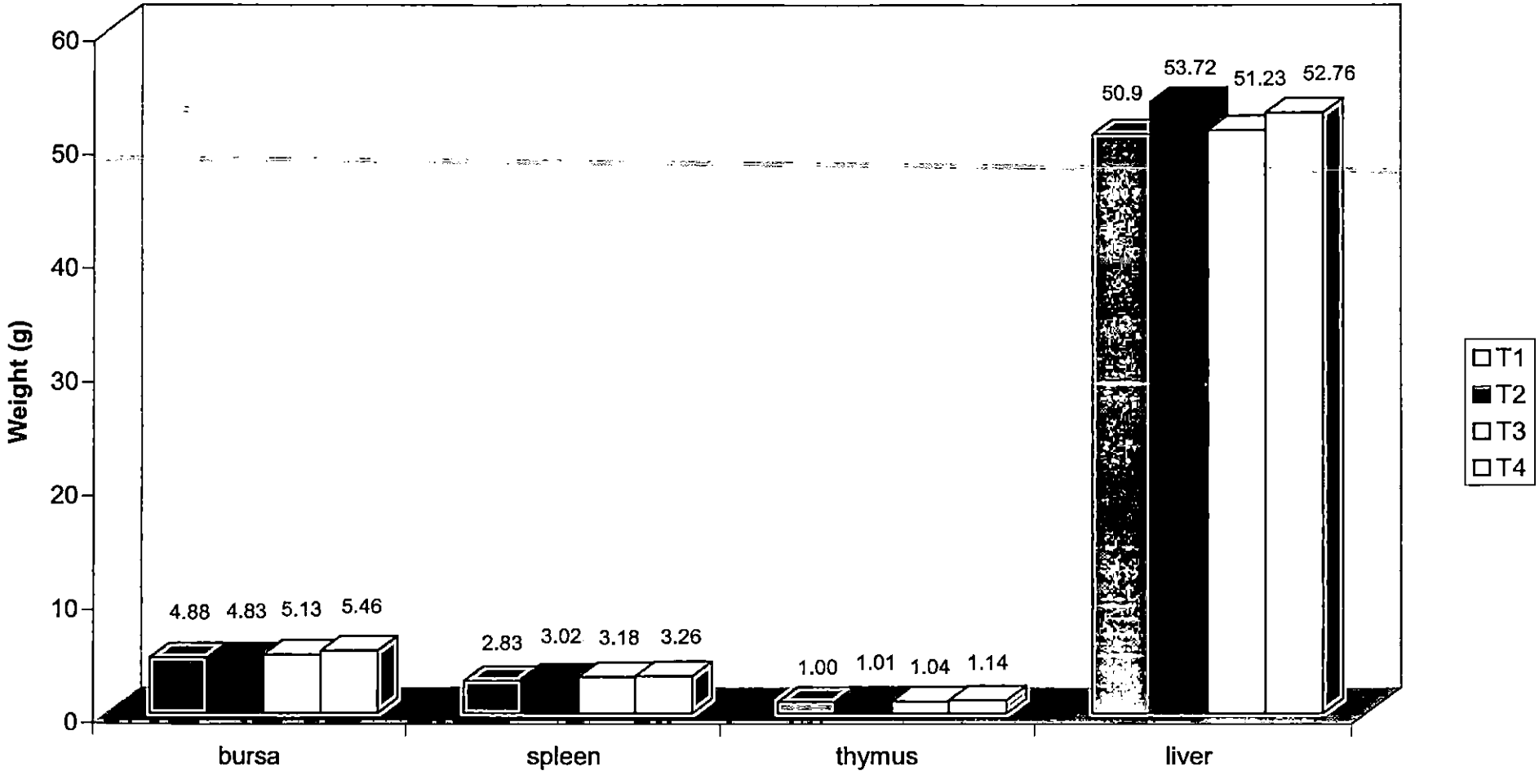


Table 10. Mean per cent weight of lymphoid organs and liver in broiler chicken as influenced by the supplementation of turmeric powder in experimental diets

Dietary group/ Turmeric %	Per cent weight			
	Bursa	Spleen	Thymus	Liver
T_1 0.0	0.13 ±0.009	0.22 ±0.010	0.045[b] ±0.001	2.38 ±0.08
T_2 0.2	0.14 ±0.006	0.23 ±0.010	0.046[b] ±0.002	2.54 ±0.07
T_3 0.4	0.14 ±0.008	0.24 ±0.009	0.048[ab] ±0.002	2.40 ±0.10
T_4 0.6	0.15 ±0.006	0.25 ±0.010	0.055[a] ±0.001	2.49 ±0.09
Overall mean	0.14 ±0.003	0.24 ±0.005	0.04 ±0.001	2.45 ±0.04

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

The dietary groups T_1, T_2, T_3 and T_4 revealed mean per cent weight of bursa as 0.13, 0.14, 0.14 and 0.15 per cent respectively with an overall mean of 0.14 per cent. Statistical analysis of the data did not reveal significant difference among the dietary groups. The per cent weight of spleen of broilers fed with diets T_1, T_2, T_3 and T_4 were 0.22, 0.23, 0.24 and 0.25 per cent respectively with an overall mean of 0.24 per cent. Statistical analysis of the data did not reveal significant difference among the dietary groups. The per cent weight of thymus in broilers fed diets T_1, T_2 ,T_3 and T_4 averaged 0.04, 0.04 , 0.04 and 0.05 per cent respectively with an overall mean of 0.04 per cent. The birds fed 0.6 per cent turmeric (T_4) revealed higher per cent weight of thymus than that of control group and those fed 0.2 per cent turmeric (T_2). Dietary groups T_3 and T_4 were statistically comparable. Likewise, T_1 and T_2 were statistically comparable.

The per cent weight of liver for the dietary groups T_1, T_2, T_3 and T_4 were 2.38, 2.54, 2.40 and 2.49 respectively with an overall mean of 2.45 per cent. Statistical analysis of the data did not reveal significant difference among the dietary groups.

4.8 HAEMATOLOGICAL PARAMETERS

4.8.1 Haemoglobin

The value of mean Haemoglobin observed at the end of sixth week of age as influenced by the dietary inclusion of turmeric are represented in Table 11 and graphically depicted in Figure 7. The value of mean haemoglobin observed at the end of sixth week of age for dietary groups T_1, T_2 , T_3 and T_4 were 8.35, 8.61, 8.76 and 9.03 g per cent with an overall mean of 8.69 g per cent. The statistical analysis of the data revealed significant difference among the dietary groups ($P \leq 0.05$). The highest value (9.03 per cent) was observed in birds fed 0.6 per cent turmeric (T_4) and lowest in the control group (8.35 per cent) .The values in 0.2 and 0.4 per cent turmeric diet groups were also significantly($P \leq 0.05$) lower than 0.6 per cent turmeric group.

4.8.2 Packed Cell Volume

Mean packed cell volume observed at the end of sixth week of age as influenced by different dietary inclusion of turmeric are represented in Table 11 and graphically depicted in Figure 7. The value of packed cell volume observed at the end of sixth week of age for dietary groups T_1, T_2, T_3 and T_4 were 26.88, 27.01, 27.88 and 28.38 per cent with an overall mean of 27.54 per cent. The birds fed with 0.4 per cent turmeric (T_3) and 0.6 per cent turmeric (T_4) had significantly higher packed cell volume than the birds in other groups (T_1 and T_2) and the latter groups were comparable. Likewise, T_3 was comparable with T_4.

4.8.3 Total Leucocyte Count (TLC)

The mean total leucocyte count observed at the end of sixth week of age is represented in Table 11 and graphically depicted in Figure 7.The mean total leucocyte count observed for the dietary groups T_1 T_2, T_3 and T_4 were 22.16, 25.07, 26.35 and 30.49 thousand per μL with an overall mean of 26.02 thousand per μL. Statistical analysis of the data revealed significant differences among the dietary groups ($P \leq 0.05$). The birds fed with 0.6 per cent turmeric (T_4) had significantly higher total leucocyte count than the birds of other turmeric dietary groups (T_2 and T_3) which were significantly ($P \leq 0.05$) higher than the control group. Inclusion of higher levels of turmeric powder resulted in a significantly higher total leucocyte count in the birds of different dietary groups.

4.8.4 Total Erythrocyte Count (TEC)

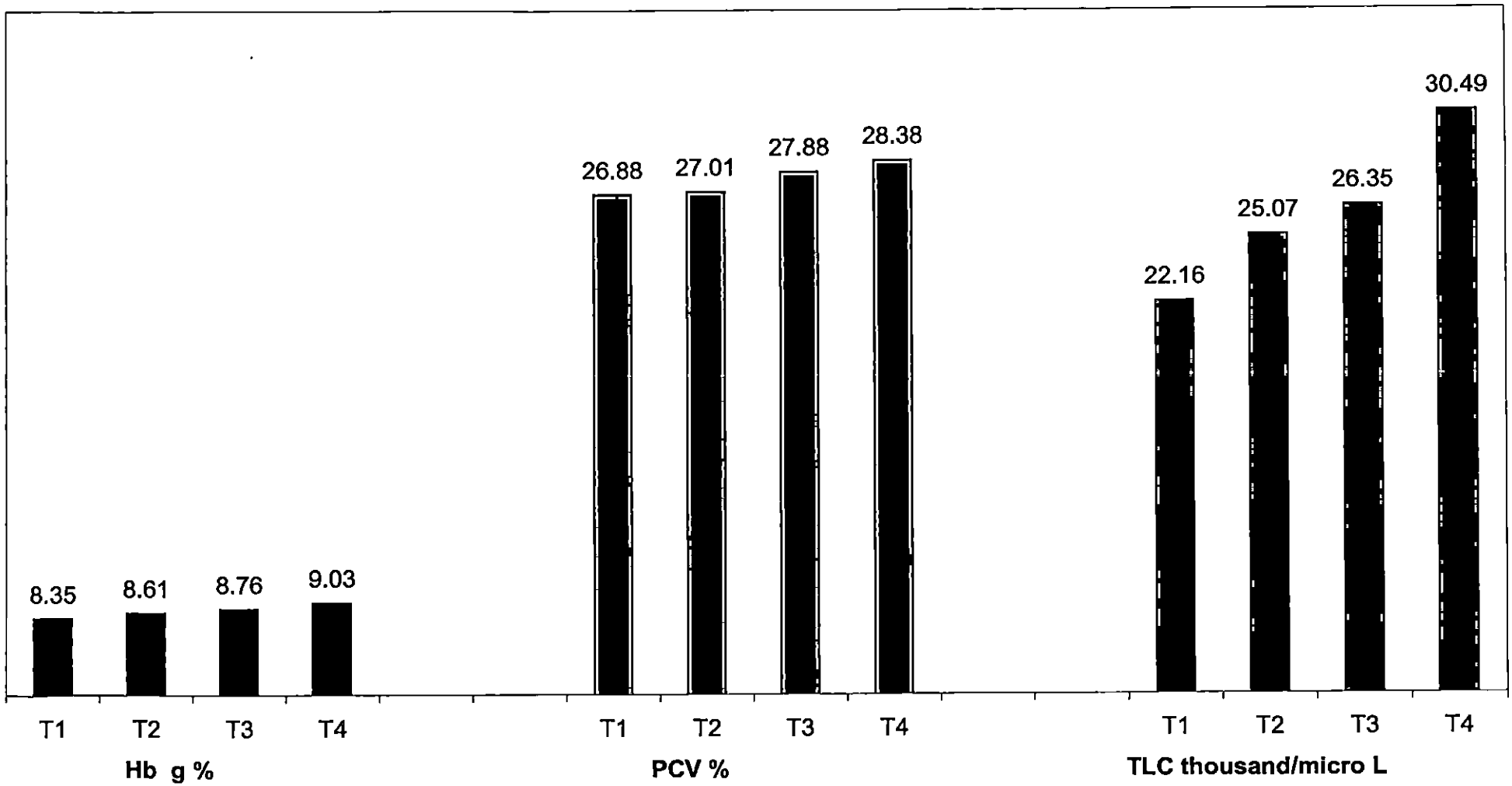
The mean total erythrocyte count observed at the end of sixth week of age is represented in Table 11. The mean total erythrocyte count observed for the dietary groups T_1, T_2, T_3 and T_4 were 2.97, 3.02, 3.10 and 3.12 millions per μ L with an overall mean of 3.05 millions per μ L. Statistical analysis of the data did not reveal significant difference between the dietary groups. However numerical increase was noted in TEC with increasing levels of turmeric supplementation.

Table 11. Mean haematological parameters in broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary group/ Turmeric %	Hb (g %)	PCV (%)	TLC (thousand per μ L)	TEC (millions per μ L)
T_1 0.0	8.35^{c} ±0.05	26.88^{b} ±0.23	22.16^{d} ±0.20	2.97 ±0.06
T_2 0.2	8.61^{b} ±0.05	27.01^{b} ±0.20	25.07^{c} ±0.45	3.02 ±0.05
T_3 0.4	8.76^{b} ±0.08	27.88^{a} ±0.07	26.35^{b} ±0.20	3.10 ±0.04
T_4 0.6	9.03^{a} ±0.05	28.38^{a} ±0.14	30.49^{a} ±0.56	3.12 ±0.02
Overall mean	8.69 ±0.05	27.54 ±0.13	26.02 ±0.56	3.05 ±0.02

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.7 Mean haematological parameters in broiler chicken as influenced by supplementation of turmeric powder in experimental diets



4.9 BIOCHEMICAL PARAMETERS

4.9.1 Serum Total Cholesterol

The mean serum total cholesterol (mg per dl) estimated at the end of sixth week of age is set out in Table 12 and graphically represented in Figure 8. The serum total cholesterol levels for dietary groups T_1, T_2, T_3 and T_4 were 175.89, 172.87, 166.02 and 157.44 mg per dl with an overall mean of 168.05 mg per dl. The values in 0.4 and 0.6 per cent turmeric supplemented dietary groups were significantly ($P \leq 0.05$) lower than the control group, while 0.2 per cent turmeric group was intermediary. The difference between the 0.4 and 0.6 per cent turmeric group was also statistically significant.

4.9.2 Serum Total Protein

The mean serum total protein levels in broiler chicken at the end of sixth week of age are presented in Table 13. The mean serum total protein levels at sixth week of age were 3.56, 3.68, 3.70 and 3.80 g per dl respectively with an overall mean of 3.68 g per dl. Statistical analysis of the data on serum total proteins did not reveal any significant difference between the dietary groups. There was numerical increase in serum protein values with increasing levels of turmeric in the diet.

4.9.3 Serum Total Lipids

The mean value of plasma total lipids estimated at the end of sixth week of age is represented in Table 13 and graphically set out in Figure 9. The values of the mean plasma total lipids for the dietary groups T_1, T_2 , T_3 and T_4 were 714.38, 704.88, 618.38 and 599.27 mg per dl with an overall mean of 659.23 mg per dl. The control group was comparable with T_2 and both these mean values of plasma lipids were significantly higher than that of all other groups ($P \leq 0.05$).

Table 12. Mean serum total cholesterol and thigh meat total cholesterol (mg/dl) in broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary Group / Turmeric %		Serum total cholesterol (mg/dl)	Thigh meat total cholesterol (mg /dl)
T_1	0.0	175.89^{a} ±2.21	113.08^{a} ± 0.66
T_2	0.2	172.87^{ab} ±2.46	112.35^{ab} ± 0.52
T_3	0.4	166.02^{b} ±2.88	110.95^{b} ± 0.67
T_4	0.6	157.44^{c} ±2.21	111.54^{ab} ± 0.48
Overall mean		168.05 ±1.72	111.98 ± 0.31

Means bearing the same superscript within the same column did not differ significantly ($P \leq 0.05$)

Fig.8 Mean serum total cholesterol in broiler chicken as influenced by supplementation of turmeric powder in experimental diets

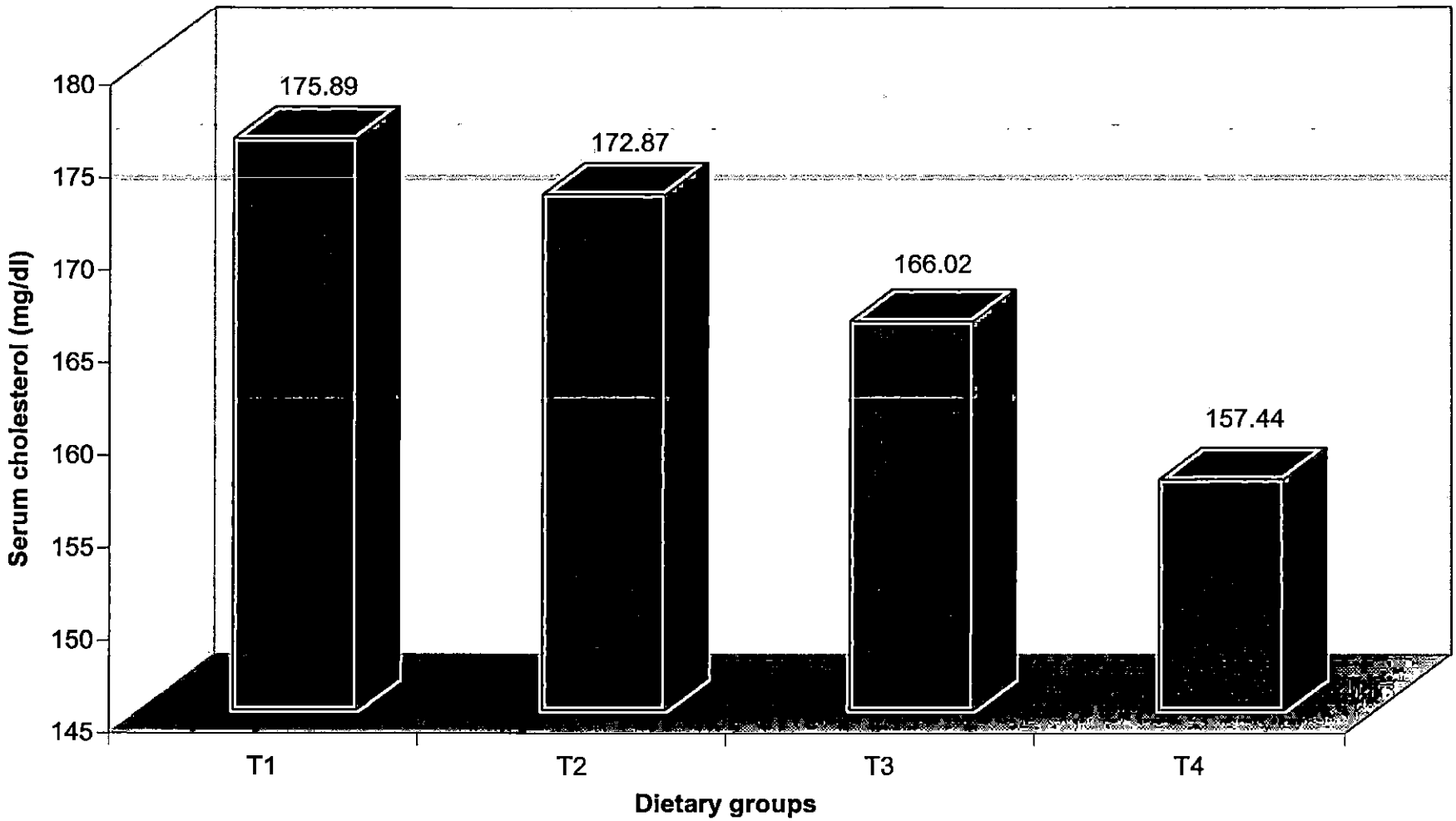
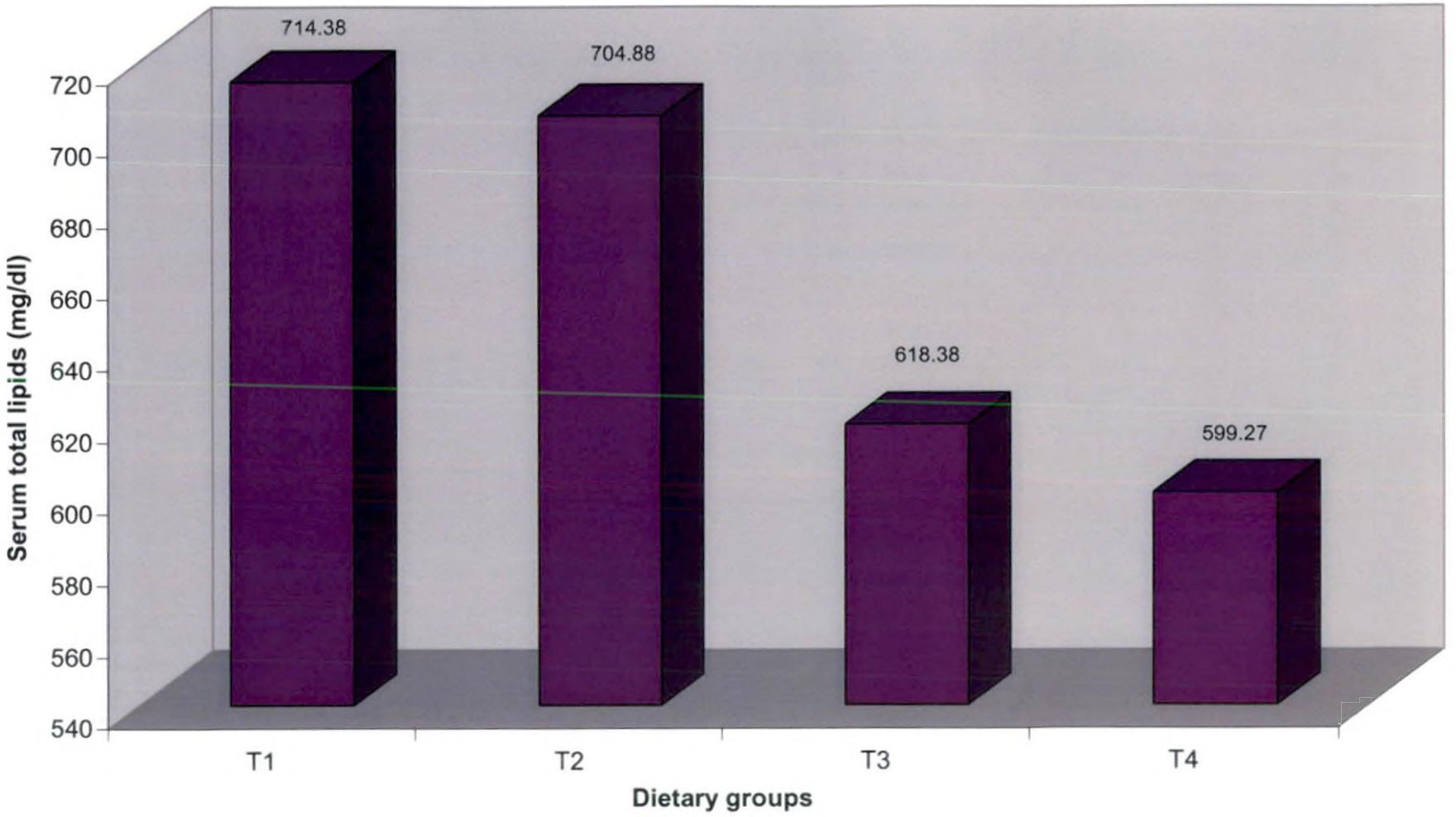


Table 13. Mean serum total protein (g/dl) and lipids (mg/dl) of broiler chicken as influenced by supplementation of turmeric powder in experimental diets.

Dietary Group / Turmeric %	Serum total protein (g/ dl)	Total lipids (mg/dl)
T_1 0.0	3.56±0.10	714.38^a ± 5.20
T_2 0.2	3.68±0.11	704.88^a ± 4.34
T_3 0.4	3.70±0.11	618.38^b ± 4.76
T_4 0.6	3.80±0.09	599.27^b ± 3.30
Overall mean	3.68±0.05	659.23 ± 4.96

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.9 Mean serum total lipids in broiler chicken as influenced by supplementation of turmeric powder in experimental diets



The dietary group T_4 showed the lowest level of lipids (599.27 mg per dl) and was statistically comparable to T_3.

4.9.4 Liver Enzymes

4.9.4.1 Alanine Aminotransferase (ALT)

The mean serum Alanine aminotransferase estimated at the end of sixth week of age is represented in Table 14 and graphically given in Figure 10. The mean values estimated at the end of sixth week of age for the dietary groups T_1, T_2 , T_3 and T_4 were 6.50, 6.13, 5.38 and 4.75 U per L with an overall mean of 5.69 U per L. The mean values in group T_4 was significantly ($P \leq 0.05$) lower than all other groups. The values between T_1 and T_2 and T_2 and T_3 were comparable.

4.9.4.2 Aspartate Aminotransferase (AST)

The mean serum Aspartate aminotransferase values estimated at the end of sixth week of age is represented in Table 14 and graphically depicted in Figure 11. The mean values estimated at the end of sixth week of age for the dietary groups T_1, T_2 , T_3 and T_4 were 177.63, 176.88, 174.50 and 174.38 U per L with an overall mean of 175.84 U per L. Significantly lower values were observed in 0.4 and 0.6 per cent turmeric groups ($P \leq 0.05$). Dietary groups T_1 and T_2 were comparable. Likewise T_3 and T_4 were also comparable.

4.10 THIGH MEAT CHOLESTEROL

The mean thigh meat total cholesterol estimated at the end of sixth week of age is presented in Table 12 and graphically represented in Figure 12. The mean thigh meat total cholesterol values for the dietary groups T_1, T_2, T_3 and T_4 were 113.08, 112.35, 110.95 and 111.54 mg per dl respectively with an overall mean of 111.98 mg per dl. Lowest value obtained in 0.4 per cent turmeric

Table 14. Mean level of liver enzymes (U per L) in broiler chicken as influenced by supplementation of turmeric powder in experimental diets

Dietary Group / Turmeric %		ALT(U / L)	AST(U/ L)
T_1	0.0	6.50^{a} ±0.33	177.63^{a} ±0.89
T_2	0.2	6.13^{ab} ±0.30	176.88^{a} ±0.58
T_3	0.4	5.38^{bc} ±0.26	174.50^{b} ±0.33
T_4	0.6	4.75^{d} ±0.25	174.38^{b} ±0.32
Overall mean		5.69 ±0.18	175.84 ±0.38

Means bearing the same superscript within the column did not differ significantly ($P \leq 0.05$)

Fig.10 Mean level of ALT in serum of broilers as influenced by supplementation of turmeric powder in experimental diets

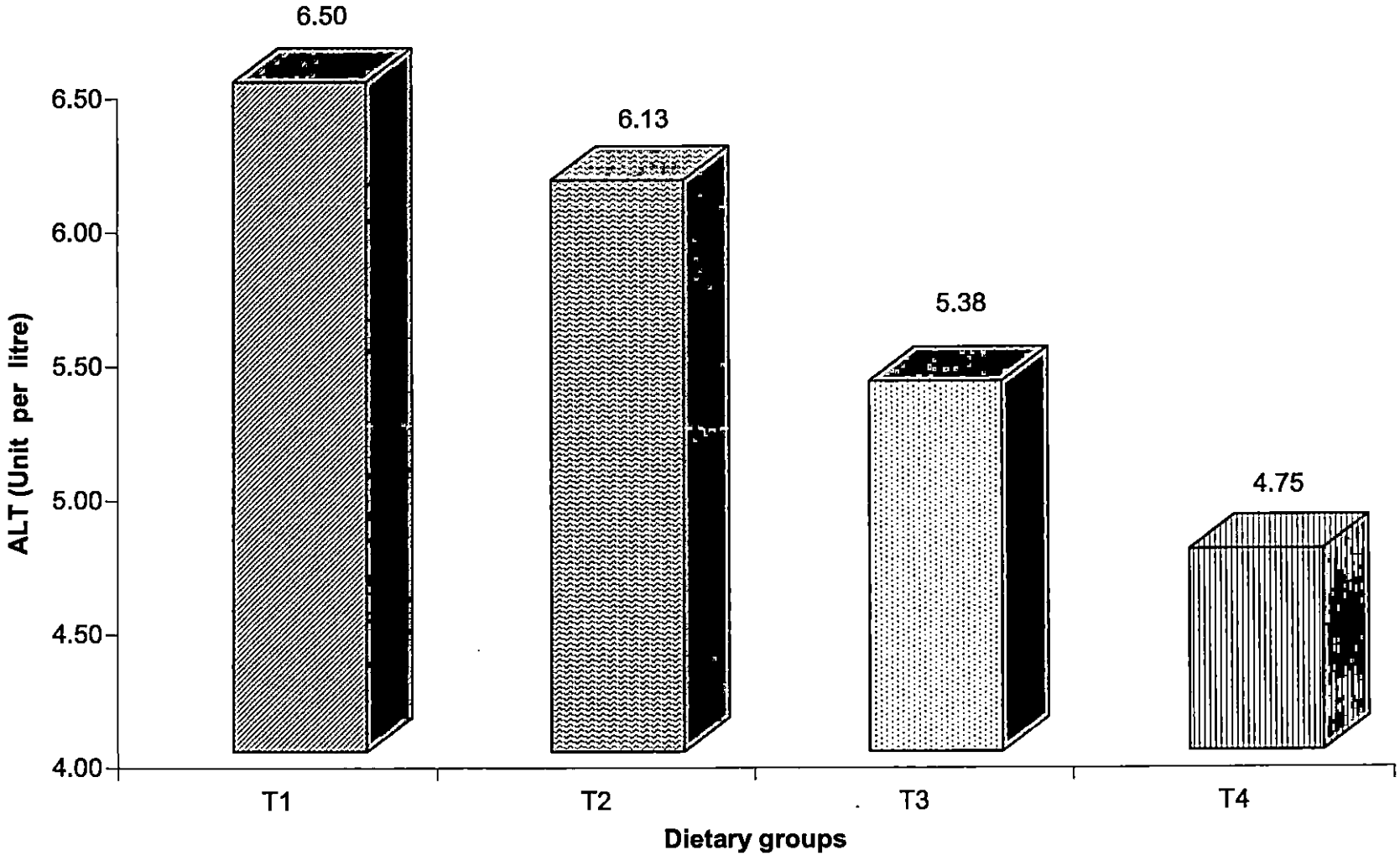


Fig.11 Mean level of AST in serum of broiler chicken as influenced by supplementation of turmeric powder in experimental diets

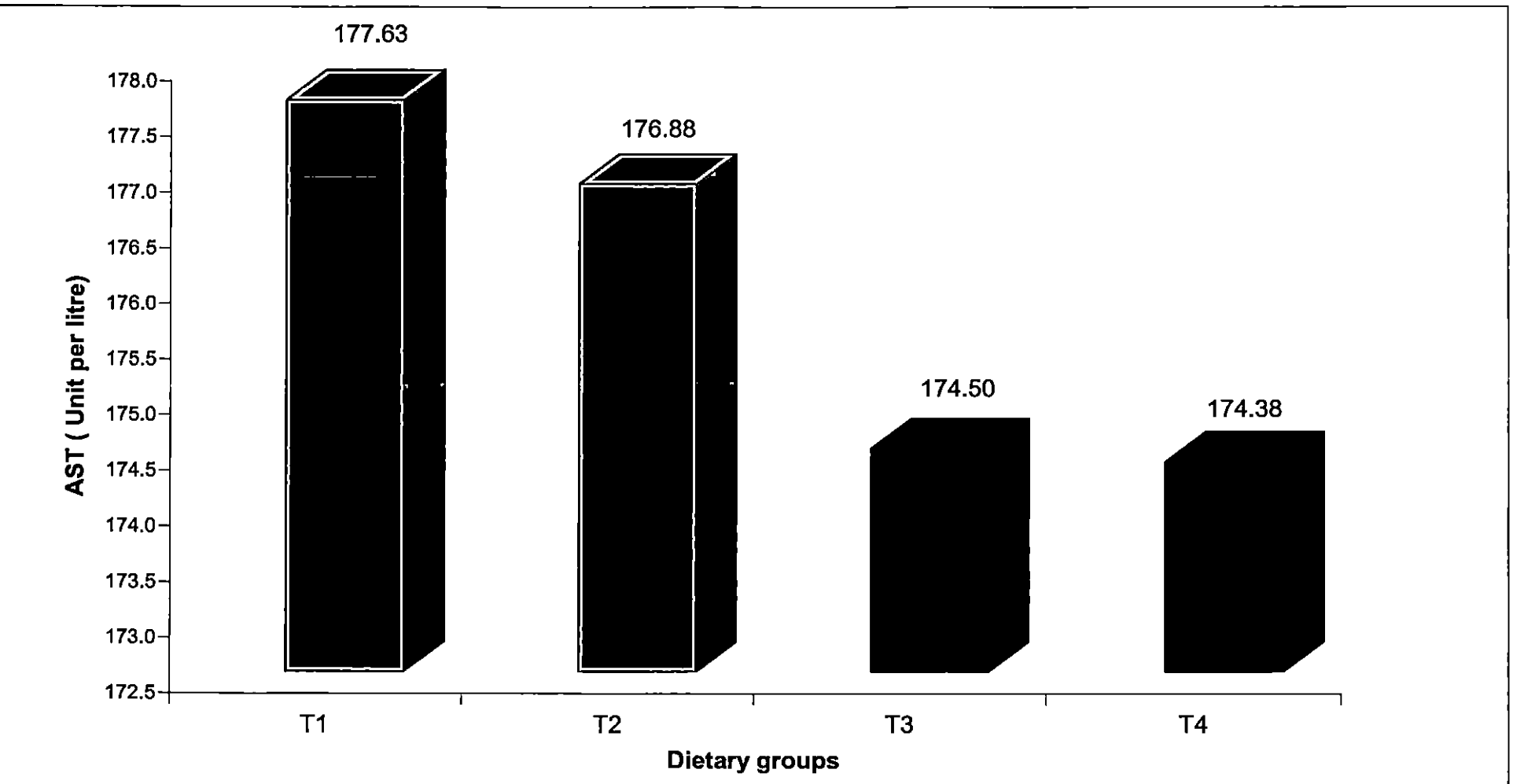
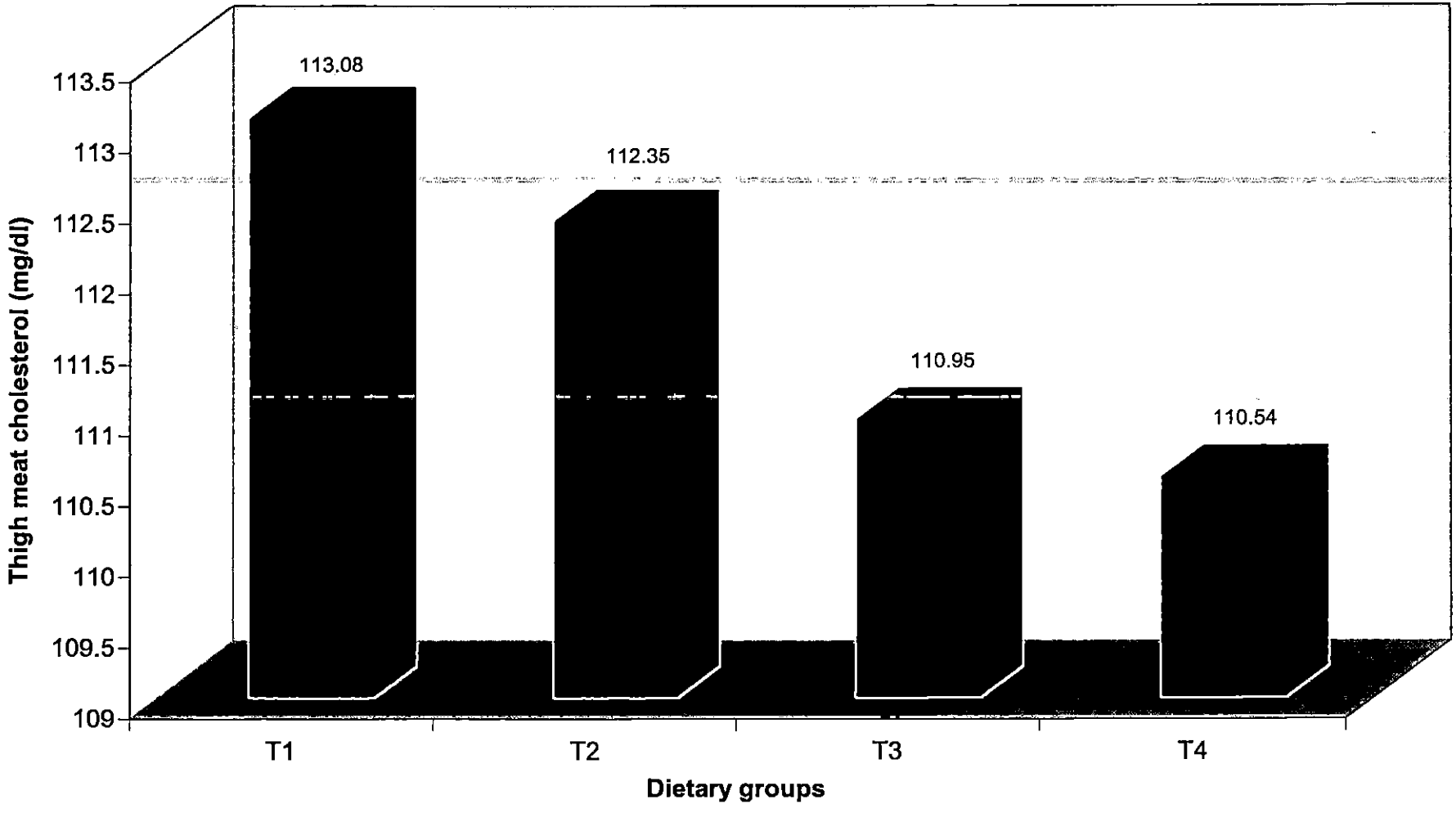


Fig.12 Mean thigh meat cholesterol in broiler chicken as influenced by supplementation of turmeric powder in experimental diets



supplemented dietary group was significantly different from the control group. Values in the turmeric groups T_2 and T_4 were intermediary and comparable.

4.11 LIVABILITY

There was no mortality in the dietary groups during the entire experimental period of six weeks and so the livability was 100 per cent.

4.12 ECONOMICS

The economics of broiler production as influenced by dietary supplementation of turmeric powder was worked out and presented in Table 15.The cumulative feed intake noticed for the dietary groups T_1, T_2, T_3 and T_4 were 3270 , 3303 , 3291 and 3221 g respectively. The total feed cost for the dietary groups T_1, T_2, T_3 and T_4 were 39.24, 39.97, 40.16 and 39.62 rupees respectively. The cost of production per bird for the dietary groups T_1, T_2, T_3 and T_4 at sixth week of age averaged 56.24, 56.97, 57.16 and 56.62 rupees respectively. The higher feed cost for the birds fed 0.4 per cent turmeric might have led to the higher cost of production per bird in the group. The return from bird sale averaged 68.73, 68.40, 66.54 and 65.00 rupees for the dietary groups T_1, T_2, T_3 and T_4 respectively .The increased return noticed for the control group might be due to the higher mean body weight noticed for the group at sixth week of age . Margin of return over feed cost for the dietary groups T_1, T_2, T_3 and T_4 were 29.49, 28.43, 26.39 and 25.38 rupees respectively. The net profit per bird for the dietary groups T_1, T_2, T_3 and T_4 averaged 14.12 , 13.08, 11.03 and 9.99 rupees respectively. The net profit per kg body weight at sixth week of age was Rs 6.78, 6.31, 5.47 and 5.07 for the dietary groups T_1, T_2, T_3 and T_4 respectively . The net profit per kg body weight was more for the control group.

Among the turmeric supplemented groups, the net profit per kg body weight was more (Rs 6.31) in broilers fed 0.2 per cent turmeric (T_2) followed by

Table.15. Economics of broiler production as influenced by supplementation of turmeric powder in experimental diets.

Sl.No.	Particulars	Dietary groups – Turmeric %			
		T_1 0.0	T_2 0.2	T_3 0.4	T_4 0.6
1	Mean body weight at 6 th week(g)	2082.60	2072.81	2016.46	1969.79
2	Cumulative feed intake, 0-6 wk/ bird(g)	3270	3303	3291	3221
3	Total feed cost (Rs.)	39.24	39.97	40.16	39.62
4	Cost per kg feed (Rs)	12.00	12.10	12.20	12.30
5	Cost of production/bird (Rs.)	56.24	56.97	57.16	56.62
6	Return from bird sale (Rs)	68.73	68.40	66.54	65.00
7	Margin of return over feed cost (Rs.)	29.49	28.43	26.39	25.38
8	Net profit per bird (Rs.)	14.12	13.08	11.03	9.99
9	Net profit/ kg body weight (Rs.)	6.78	6.31	5.47	5.07

dietary groups T_3 and T_4. Less net profit per kg body weight calculated for the turmeric supplemented groups could be due to the high cost of feed and the lower mean body weight at sixth week. The group supplemented with 0.2 per cent turmeric (T_2) was more economical than the groups fed 0.4 per cent (T_3) and 0.6 per cent turmeric (T_4). When compared to the control group, the turmeric supplemented groups revealed lower economic benefit.

Discussion

5. DISCUSSION

The results obtained in the study to find out the effect of dietary supplementation of turmeric powder on the overall production performance of broiler chicken are discussed in this chapter.

5.1 METEOROLOGICAL PARAMETERS

The microclimate inside the experimental house (Table 3) showed that the mean maximum temperature was the highest (36.07°C) during the first week and the lowest (34.57°C) during the fourth week of the biological trial. The difference of 1.5°C between the lowest and highest values was non significant. The overall mean per cent relative humidity in the forenoon and afternoon were 76.74 and 63.65 per cent respectively. The results were in accordance with the findings of Somanathan (1980) who indicated that climatograph of this locality fall within the hot humid zone of climate.

5.2 BODY WEIGHT

The body weight of broilers for different dietary groups (Table 4) indicated that the weight of day-old chicks was uniform among experimental groups. The low, medium and high (0.2, 0.4 and 0.6 per cent respectively) levels of turmeric in this study did not bring any significant variations in body weight during the first week.

In the second week, birds in all turmeric treated groups showed significantly higher body weight than the control group. This was in partial agreement with the findings of Samarasinghe *et al.* (2003) and Durrani *et al.* (2006) who reported higher weight in broilers fed 0.1 and 0.5 per cent turmeric respectively. The increased body weight of birds fed turmeric powder might be

due to increased secretion of digestive juices, resulting in increased nutrient utilisation.

The effect observed in second week was not exhibited at third week. This is evident from the results pertaining to body weight gain (Table 5) and might be due to lower rate of growth in all the turmeric supplemented groups. During fourth week of age, the birds fed 0.4 per cent turmeric powder (T_3) showed significantly higher body weight ($P \leq 0.05$) than other groups due to significantly higher weight gain recorded in the group.

In the starter phase, among the turmeric supplemented groups, the significantly higher body weight was seen in T_3 at fourth week. Contrary to the significantly higher weight gain of T_3 noticed at fourth week, significantly lower gain was observed at fifth week. Higher weight gain was revealed by the birds supplemented with 0.2 per cent turmeric (T_2) .

At the end of the experiment at sixth week, the body weight of broilers in groups fed 0.2 and 0.4 per cent turmeric levels (T_2 and T_3) were comparable with that of control group (T_1).This result was in accordance with the findings of Emadi and Kermanshahi (2006) who reported that the weight gain of broilers was not significantly affected by turmeric supplementation at 0.25 , 0.50 and 0.75 per cent. The significant reduction in body weight noticed in T_4 (0.6 per cent) group might be due to the sex difference, wherein the highest number of males were present in group T_1 than that in T_4 .

On a detailed comparison of the body weight of male broilers present in different groups separately, it was imperative that lower body weight was noticed in male broilers fed 0.6 per cent turmeric powder (T_4). In females, the body weight of T_4 group was numerically lower than the other two turmeric supplemented groups. Both these factors might have caused the depression in body weight of birds in the T_4 group. Based on the results obtained in the present

study, it can be concluded that supplementation of turmeric is effective up to 0.4 per cent level but inclusion of 0.6 per cent is not advisable.

5.3 BODY WEIGHT GAIN

The data on mean body weight gain of broilers for different dietary groups presented in Table 5 revealed significant ($P \leq 0.05$) difference between the dietary groups every week except during the first week. The body weight gain among all the dietary groups were comparable at the end of first week. This may be due to the uniform feed intake recorded during the period. Numerically higher weight gain of 148.77 g was noticed in the group fed 0.2 per cent turmeric (T_2). Variations in weight gain among the different dietary groups were narrow. Emadi and Kermanshahi (2006) reported that supplementation of turmeric powder in broiler chicken at 0.25 , 0.50 and 0.75 per cent levels did not influence body weight gain.

At second week of age, the dietary group T_2 fed with 0.2 per cent turmeric showed significantly higher body weight gain than T_1 and T_4. The weight gain of broilers fed 0.4 per cent turmeric (T_3) was intermediary and comparable to those fed 0.2 and 0.6 per cent turmeric (T_2 and T_4). The low weight gain in the control group was due to the lower feed intake in the group.

At third week of age all the turmeric supplemented groups had significantly lower weight gain than the broilers of the control group. This is supported by the fact that the feed intake in the turmeric supplemented groups were significantly lower than the control group. The weight gain in all the turmeric supplemented groups was statistically comparable. Contrary to the present findings, Al-Sultan (2003) and Durrani *et al.* (2006) reported that the inclusion of turmeric powder in broiler diets increased body weight gain at 0.5 per cent level inclusion.

Among the weekly weight gains of the different dietary groups, the highest values were observed during the fourth week of age. The highest value of 556.46 g was noticed in broilers fed with 0.4 per cent turmeric (T_3) followed by T_4 , T_1 and T_2 with gains of 492.00 , 483.25 and 457.08 g respectively. The broilers fed with 0.2 and 0.4 per cent turmeric were comparable with the control group. The cumulative body weight gain recorded in the starter phase revealed significantly higher gain in the dietary group T_3 .

As evident from Figure 2, the weight gain was reduced in all the dietary groups at fifth week of age. The significantly higher weight gain of T_3 noticed during the fourth week changed to a significantly lower value at fifth week due to the lowest feed intake in the group T_3. The difference between the highest value in T_2 and lowest in T_3 revealed significant difference. The dietary groups T_1 and T_2 were comparable as in the case with T_3 and T_4.

At sixth week of age, the weight gain was reduced further in all dietary groups except T_3 . Broilers of the control group had significantly higher weight gain than those of the group T_4 .The weight gain in T_2 and T_3 were comparable with T_1 and T_4 while feed intake did not reveal any significant difference among the dietary groups .

5.4 FEED INTAKE

Data on mean weekly feed intake (g) per bird and cumulative feed intake of broilers during 0-4 and 0-6 weeks of age for different dietary groups is presented in Table 6. Statistical analysis of the data revealed that feed intake was not affected by turmeric powder supplementation at first week in the starter phase and during fifth and sixth weeks of age in the finisher phase.

At second week of age, significantly higher feed intake was observed in turmeric supplemented dietary groups T_2, T_3 and T_4 than that of the control group (57.50 , 57.11 , 55.64 and 51.39 g respectively). On the contrary, Samarasinghe

et al. (2003) and Emadi and Kermanshahi (2006) reported that feeding turmeric powder at 0.1 and 0.5 per cent levels respectively in broiler rations did not improve feed intake.

At third week of age, significantly higher feed intake was noticed in the control group in comparison to T_3 and this is in close agreement with the findings of Al-Sultan (2003) and Durrani *et al.* (2006) who reported significant decrease in feed intake of birds fed 0.5 per cent turmeric. In all the turmeric supplemented groups (T_2, T_3 and T_4) feed intake was uniform.

At fourth week of age the feed intake was significantly higher only in group fed 0.4 per cent turmeric (T_3) in comparison to T_2 and T_4 ($P<0.05$) .Correspondingly, the weight gain in T_3 was significantly higher than the other groups at fourth week of age.

In the finisher phase, weekly feed intake was non significant both at fifth and sixth weeks of age. The highest intake of 114.35 g was observed in the group T_2 fed 0.2 per cent turmeric at fifth week of age followed by T_4 , T_1 and T_3 wherein the mean values were 106.39 , 106.03 and 97.64 g respectively .At sixth week of age highest feed intake of 116.53 g was observed in the control group followed by T_2, T_3 and T_4 with mean values of 110.96 , 107.89 and 101.46 g respectively.

Data on cumulative feed consumption during 0-4 weeks and 0-6 weeks did not differ significantly between dietary groups in spite of the significantly higher feed intake in the group T_3 at fourth week of age. The effect of the lower feed intake in the control group at second week of age was not reflected in the cumulative feed intake due to increased feed intake in the subsequent weeks.

5.5 FEED CONVERSION RATIO (FCR)

FCR calculated week wise (Table 7) revealed significant differences in all weeks except second and sixth week of age. The FCR noticed for the broilers fed 0.6 per cent turmeric (T_4) was significantly better than control group at first week of age ($P \leq 0.05$). In the present study, in all levels of turmeric supplemented groups , the FCR was comparable and is in agreement with the findings of Al-Sultan (2003) who reported better FCR in broilers fed 0.5 per cent turmeric (2.08) as compared to those fed 0.25 and 1.0 per cent turmeric (2.27 and 2.31). At second week of age, all the dietary groups were comparable and the mean values of FCR were in the range of 1.60 to 1.65. This is in accordance with the study of Emadi and Kermanshahi (2006) who reported that turmeric powder at 0.25 to 0.75 percent had no significant effect on feed to gain ratio.

At third week of age, the turmeric supplemented groups showed significantly lower weight gain and poor FCR ($P \leq 0.05$) than the control group. Although the dietary groups T_2, T_3 and T_4 formed a homogenous group, relatively better FCR in group T_3 was due to numerically lower feed consumption.

At fourth week of age, better FCR of 1.39 in the group fed 0.4 per cent turmeric (T_3) was significantly superior than in the control group (1.49) and 0.2 per cent turmeric supplemented group (1.53). At this age, the weight gain in group T_3 was significantly higher than all other groups. Among the supplemented groups, T_3 and T_4 were comparable and values in both these groups (1.39 and 1.42) were significantly better than that of T_2 (1.53).

In the finisher phase, the FCR values observed at fifth week of age in T_1 (1.78) and T_2 (1.77) were significantly better than T_3 (1.92) and T_4 (1.90) due to the better weight gain in the former groups. At sixth week of age, the mean feed conversion ratios in the dietary groups ranged from 1.91 to 1.99 and were statistically comparable each other.

The mean cumulative feed conversion ratios up to four and six weeks of age between the dietary groups showed only narrow differences. Cumulative feed conversion ratio ranged between 1.49 and 1.53 (0-4 weeks) and 1.63 and 1.65 (0-6 weeks). During 0-4 weeks of age, the mean value observed in T_3 , T_4 , T_1 and T_2 were 1.49 , 1.50, 1.52 and 1.53 and the mean body weight gain in T_3 was significantly higher than all other groups. Even though the cumulative FCR during 0-6 weeks of age was comparable in all dietary groups, the body weight at sixth week of age in 0.6 per cent turmeric supplemented group (T_4) was significantly lower than control (T_1) and 0.2 per cent turmeric group (T_2) . Results of the present study indicated that supplementation of turmeric at 0.6 per cent level is not advisable.

5.6 PROCESSING YIELDS AND LOSSES

The data on processing yields and losses recorded at the end of six weeks of age are presented in Table 8. The statistical analysis of the data revealed that ready-to-cook yield was comparable among the dietary groups whereas the dressed, eviscerated and giblet yields showed significant difference by the supplementation of turmeric in diets. The dressed yield in the turmeric supplemented groups T_3 and T_4 were significantly higher than that of control group ($P \leq 0.05$). This finding is in close agreement with the studies of Samarasinghe *et al.* (2003) who reported significant improvement in carcass recovery of birds fed turmeric powder at 0.1, 0.2 and 0.3 per cent and Durrani *et al* (2006) who reported significantly higher dressing per cent in broilers fed 0.5 per cent turmeric.

The eviscerated yield in the group T_4 was significantly ($P \leq 0.05$) lower than that of control group due to the lower body weight in the former group at sixth week of age. However in all turmeric supplemented groups, the processing yields viz., dressed, eviscerated, giblet and ready to cook yields were comparable among each other.

The giblet yields in turmeric supplemented groups T_2, T_3 and T_4 were comparable with each other and all the mean values were significantly higher than that of control group ($P \leq 0.05$). The improved giblet yield was the evidence of higher proportion of liver, heart and gizzard put together. Since these organs were not weighed separately, the individual contribution of each to the giblet yield could not be arrived at. Al-Sultan (2003) has reported higher weight of liver in broilers fed 0.5 per cent turmeric. Emadi and Kermanshahi (2006) have reported improvement in the weight of heart and gizzard by supplementation of 0.5 per cent turmeric. Moreover, the higher weight of organs may be due to the immunomodulatory action of turmeric as reported by Jindamongkon *et al.* (2005).

The ready to cook yield noticed for the dietary groups T_1 , T_2 , T_3 and T_4 were 71.96, 71.96 , 72.04 and 71.67 per cent respectively. In the present study per cent ready-to-cook yield in control birds are well within the normal range as reported by Rejikumar and Narayanankutty (1992).The effect of the higher eviscerated yield in control group was not reflected in the ready to cook values due to the significantly higher giblet yields in the turmeric supplemented groups.

The data on blood loss and total loss did not differ significantly among the dietary groups. The feather loss noticed in the groups T_3 and T_4 were significantly lower than that of control group. The lower feather loss resulted in the significantly higher dressed yield in these groups compared to the control group.

5.7 WEIGHT OF LYMPHOID ORGANS AND LIVER

The average weight of bursa, spleen, thymus and liver and the respective percentages over sixth week body weight as influenced by dietary supplementation of turmeric are presented in Table 9 and 10 respectively. The bursa and thymus of broilers fed 0.6 per cent turmeric (T_4) showed significantly higher weight than that of all other groups. The bursal weight of broilers of the

different dietary groups T_1 , T_2 , T_3 and T_4 averaged 4.88, 4.83, 5.13 and 5.46 g respectively. The control group and the group fed 0.2 per cent turmeric were comparable. The average spleen weight recorded for the dietary groups T_1, T_2, T_3 and T_4 were 2.83, 3.02, 3.18 and 3.26 g respectively. The broilers of the groups T_3 and T_4 had significantly higher spleen weight than the birds fed with control diet ($P \leq 0.05$). Group T_2 was statistically comparable with all other groups. The weight of thymus in the broilers of the dietary groups T_1, T_2, T_3 and T_4 were 1.00, 1.01, 1.04 and 1.14 g respectively. The weight of thymus exhibited by birds fed with 0.6 per cent turmeric (T_4) was significantly higher than all other groups ($P \leq 0.05$). The dietary groups T_1 and T_2 were statistically comparable. The weight of liver in the dietary groups T_1, T_2, T_3 and T_4 averaged 50.90 , 53.72 , 51.23 and 52.76 g respectively. The weight of liver in all the turmeric supplemented groups were comparable each other and that in birds fed 0.2 per cent turmeric (T_2) was significantly higher than that of control group ($P \leq 0.05$). The present study indicated that, as the level of turmeric increased in the diet, significantly higher weight of bursa and thymus were noticed both at 0.4 and 0.6 per cent levels of turmeric. An increment of 0.2 per cent of turmeric in diets T_3 and T_4 lead to 0.30 and 0.33 g increase in weight of bursa which was statistically significant.

The data on mean per cent weight of organs revealed statistical significance only for thymus which averaged 0.045, 0.046, 0.048 and 0.055 per cent for T_1, T_2 , T_3 and T_4 respectively. Significantly higher per cent weight was exhibited by birds fed with 0.6 per cent turmeric (T_4) than that of groups T_1 and T_2 ($P \leq 0.05$). This is in close agreement with the study of Al-Sultan (2003) who reported higher thymus weight index in broilers fed 0.5 per cent turmeric. The bursa in T_1, T_2, T_3 and T_4 were 0.13, 0.14, 0.14 and 0.15 per cent and that of spleen were 0.22, 0.23, 0.24 and 0.25 per cent respectively with non significant difference between dietary groups. This is in close agreement with the findings of Emadi and Kermanshahi (2006) who reported that the weight of spleen in broiler

chicken was not affected by supplementation of turmeric at 0.25 , 0.50 and 0.75 per cent levels of inclusion.

The per cent liver for the dietary groups T_1, T_2, T_3 and T_4 were comparable each other and the mean values were 2.38, 2.54, 2.40 and 2.49 respectively. This result is in accordance with the finding of Samarasinghe *et al.* (2003) who reported that per cent liver in broilers was not affected by the supplementation of turmeric at 0.1, 0.2 and 0.3 per cent levels of inclusion.

5.8 HAEMATOLOGICAL PARAMETERS

The mean values of haematological parameters observed at the end of sixth week of age as influenced by the dietary inclusion of turmeric are represented in Table 11. The supplementation of turmeric powder significantly increased the haematological parameters viz., Haemoglobin, packed cell volume and total leucocyte count ($P \leq 0.05$) while the total erythrocyte count did not reveal significant difference among the dietary groups.

5.8.1 Haemoglobin

The mean values of haemoglobin observed at the end of sixth week of age in the groups T_1, T_2, T_3 and T_4 averaged 8.35, 8.61 , 8.76 and 9.03 g per cent respectively. The mean value observed in T_4 was significantly higher than that of all other groups ($P \leq 0.05$). The dietary group T_2 was statistically comparable with T_3. The salient features of these findings are in close agreement with Mohan *et al.* (2001) who reported a higher haemoglobin value in broilers fed with 50 mg turmeric per bird per day along with aflatoxin.

5.8.2 Packed Cell Volume

The mean packed cell volume observed at the end of sixth week of age as influenced by dietary inclusion of turmeric averaged 26.88, 27.01, 27.88 and 28.38 per cent for T_1, T_2, T_3 and T_4 respectively. The birds fed with 0.4 and

0.6 per cent turmeric (T_3 and T_4) had significantly higher packed cell volume than that of T_1 and T_2 ($P \leq 0.05$). Dietary groups T_1 and T_2 were comparable. Likewise, the mean values of birds fed 0.4 per cent turmeric (T_3) and those fed 0.6 per cent turmeric (T_4) were comparable .

5.8.3 Total Leucocyte Count

The mean total leucocyte count observed at the end of sixth week of age for the different dietary groups T_1, T_2, T_3 and T_4 were 22.16, 25.07, 26.35 and 30.49 thousand per µL respectively. The birds fed with 0.6 per cent turmeric (T_4) had significantly higher total leucocyte count than the birds of other dietary groups ($P \leq 0.05$). The inclusion of higher levels of turmeric powder resulted in a significantly higher total leucocyte count in the birds of different dietary groups. This finding was in an agreement with those of Kurkure *et al.* (2001), Mohan *et al.* (2001) and Al-Sultan (2003) who reported that inclusion of turmeric at 0.5 per cent resulted in increased leucocyte count in broilers. Increase in total leucocytic count might be due to the immunostimulatory activity of Curcumin, the active principle of turmeric (Kurkure *et al.*, 2000; Bansal *et al.*, 2001 and Xiaohua *et al.*, 2004).

5.8.4 Total Erythrocyte Count

The mean total erythrocyte count observed at the end of sixth week of age for the dietary groups T_1, T_2, T_3 and T_4 were 2.97, 3.02, 3.10 and 3.12 millions per µ L respectively. Though numerical increase in the erythrocyte count was noticed for higher levels of turmeric, statistical analysis of the data did not reveal significant difference between the dietary groups .This result support the findings of Al-Sultan (2003) who reported increased erythrocyte count with 0.5 and 1.0 per cent dietary inclusion of turmeric in broilers.

5.8.5 Serum Total Cholesterol

The mean serum total cholesterol estimated at the end of sixth week of age for the dietary groups T_1, T_2, T_3 and T_4 set out in Table 12 averaged 175.89, 172.87, 166.02 and 157.44 mg per dl respectively.The mean values were significantly ($P \leq 0.05$) lower in the 0.4 and 0.6 per cent turmeric supplemented groups (T_3 and T_4) when compared to the control group. This finding is in close agreement with Kurkure *et al.* (2001) who reported significant reduction in serum total cholesterol of cockerels fed 0.5 per cent turmeric. A similar trend of reduction in serum cholesterol by supplementation of turmeric was observed in experimental animals (Srinivasan and Sambaiah., 1991; Hussain and Chandrasekhara., 1993; Kumar *et al.*, 1998; Ahn *et al.*, 2003 and Majighthiya *et al.*, 2004). The principle behind the hypocholesterolemic action of turmeric can be explained by the fact that active principle curcumin stimulates bile fluid as well as biliary cholesterol secretion and enhance excretion of bile acids and cholesterol (Ramprasad and Sirsi., 1956).

5.8.6 Serum Total Protein

The mean serum total protein levels in broiler chicken at the end of sixth week of age presented in Table 13 for the dietary groups T_1, T_2, T_3 and T_4 were 3.56 , 3.68 , 3.70 and 3.80 g per dl respectively. Statistical analysis of the data on serum protein did not reveal significant difference between the dietary groups. The mean serum protein values recorded in the control birds were within the normal range as reported by Sturkey (1976). The present study indicated that the supplementation of turmeric powder did not affect the serum protein level in broilers.

5.8.7 Serum Total Lipids

The mean value of serum total lipids estimated at the end of sixth week of age represented in Table 13 for the dietary groups T_1, T_2, T_3 and T_4 were

714.38, 704.88, 618.38 and 599.27 mg per dl respectively. The mean values in the turmeric supplemented groups T_3 and T_4 were significantly lower than the control group ($P \leq 0.05$). The dietary group fed 0.4 per cent turmeric (T_3) was comparable to the group fed 0.6 per cent turmeric (T_4). A similar trend in reduction of total lipids was observed in experimental animals by supplementation of turmeric (Babu and Srinivasan., 1997 and Ashok *et al.*, 1999). The hypolipidaemic effects of turmeric may be attributed to the fact that it reduces the low density lipoprotein and very low density lipoprotein levels in the serum and increases the high density lipoprotein : total cholesterol ratio. (Dixit *et al.*, 1988).

5.9 LIVER ENZYMES

The mean value of liver enzymes estimated at the end of sixth week of age is represented in Table 14. Statistical analysis of the data revealed significant difference between the dietary groups.

5.9.1 Alanine Aminotransferase

The mean values of serum Alanine aminotransferase estimated at the end of sixth week of age represented in Table 14 for the dietary groups T_1, T_2 , T_3 and T_4 averaged 6.50, 6.13, 5.38 and 4.75 U per L respectively. The reduction in this enzyme level was observed with increasing levels of turmeric level. The mean values in the groups T_3 and T_4 were significantly lower than that of control group. Difference between dietary groups T_1 and T_2 and also between T_2 and T_3 were statistically non significant. Park *et al.* (2000) and Miyakoshi *et al.* (2004) reported that the active principles of turmeric lowered the activity of Alanine aminotransferase in rats.

5.9.2 Aspartate Aminotransferase

The mean serum Aspartate aminotransferase estimated at the end of sixth week of age presented in Table 14 averaged 177.63, 176.88, 174.50 and 174.38 U per L for the dietary groups T_1, T_2, T_3 and T_4 respectively. The maximum reduction of the enzyme level was observed in T_4 followed by T_3, T_2 and T_1. Dietary groups T_1 and T_2 were comparable. Likewise T_3 and T_4 were also statistically comparable. The reduced level of the enzyme may be due to the decreased activity caused by curcumin, the active principle of turmeric (Park *et al.*, 2000 and Miyakoshi *et al.*, 2004)

5.10 THIGH MEAT CHOLESTEROL

The mean thigh meat total cholesterol estimated at the end of sixth week of age for the dietary groups T_1, T_2, T_3 and T_4 presented in Table 12 averaged 113.08, 112.35, 110.95 and 111.54 mg per dl respectively. The mean value obtained for the dietary groups were significantly lower than the control group ($P \leq 0.05$). Dietary groups T_2 and T_4 were intermediary and were comparable with all other groups. The reduction in the thigh meat cholesterol might be due to the hypocholesterolemic and hypolipidaemic actions of Curcumin, the active principle of turmeric. (Babu and Srinivasan 1997, Ahn *et al.*, 2003.)

5.11 LIVABILITY

There was no mortality recorded during the entire experimental period. The overall livability in turmeric supplemented broilers was 100 per cent. Inclusion levels of turmeric in the present study were well tolerated by the birds.

5.12 ECONOMICS

The economics of broiler production as influenced by dietary supplementation of turmeric powder was worked out and presented in Table 15.The mean body weight at sixth week for the dietary groups T_1, T_2, T_3 and T_4

were 2082.60, 2072.81, 2016.46 and 1969.79 g respectively. The mean cumulative feed intake noticed for the dietary groups T_1, T_2, T_3 and T_4 were 3270, 3303, 3291 and 3221 g respectively. The total feed cost for the dietary groups T_1, T_2, T_3 and T_4 were Rs. 39.24, 39.97, 40.16 and 39.62 respectively. The average cost of production, return by sale of birds and margin of return over feed cost at sixth week of age was calculated to study the cost benefit. The cost of production included cost of starter and finisher rations and miscellaneous items of expenditure for vaccination, medication and litter materials. The birds were sold at the rate of Rs. 33 per kg and sale price of poultry manure at the rate of Rs. 0.50 per kg was accounted for arriving net profit. The net profit per kg body weight at sixth week of age was Rs. 6.78, 6.31, 5.47 and 5.07 for the dietary groups T_1, T_2, T_3 and T_4 respectively and it was higher for the control group .The low cost of feed and significantly better body weight at the end of six weeks of age for the control diet in comparison with group T_4 led to the higher profit margin in the control group.

Among the turmeric supplemented groups, the higher rate of return for the group fed 0.2 per cent turmeric is due to the higher body weight at sixth week of age. The net profit per kg body weight calculated for the turmeric supplemented group T_4 was the lowest due to the high cost of feed coupled with significantly lower mean body weight at sixth week of age.

The birds fed diet supplemented with 0.2 per cent turmeric (T_2) was more economical than those fed 0.4 and 0.6 per cent levels. Compared to the control birds, all the turmeric supplemented groups were economically less beneficial. Contrary to these findings, Durrani *et al* (2006) reported that the broilers supplemented with 0.5 per cent turmeric revealed higher per kg live weight.

Eventhough the profit margin was lower by feeding turmeric, the additional beneficial effects as increased dressed and giblet yields and low cholesterol meat in the turmeric supplemented groups are much worthy and

requires further studies to establish the merits of supplementation of turmeric in broiler diets.

Summary

6. SUMMARY

An experiment was conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to study the effect of dietary supplementation of turmeric (*Curcuma longa*) on performance of broiler chicken. The study was conducted for a period of six weeks with one hundred and ninety two, day-old commercial broiler chicks (Vencob). The chicks were wing banded, weighed individually and randomly allotted to four dietary groups T_1, T_2, T_3 and T_4. Each group comprised of four replicates of twelve birds each. The group T_1 was fed a control ration formulated as per the BIS specifications (1992) and this ration was supplemented with turmeric powder at 0.2, 0.4 and 0.6 per cent levels in T_2, T_3 T_4 respectively.

Standard managemental practices were followed throughout the experimental period. Feed and water were provided *ad libitum*. The birds were provided with starter ration from 0-4 weeks of age and thereafter finisher ration during fifth and sixth week of age.

The production performance of broilers was evaluated for a period of six weeks. The weekly body weight was recorded individually and feed consumption was recorded replicate wise. From these data, weekly weight gain and feed conversion ratios were calculated. The processing yields and losses, thigh meat cholesterol, haematological parameters, serum biochemical parameters and liver enzymes were determined at the end of six weeks of age. The cost-benefit analysis in dietary supplementation of turmeric was also ascertained.

Based on the results obtained in the present study, the following conclusions were made.

1) The mean body weight of broilers at six week of age in dietary groups T_1, T_2, T_3 and T_4 were 2082.60, 2072.81, 2016.46 and 1969.79 g respectively and it was significantly lower in the group T_4 than that of

control group ($P \leq 0.05$). The mean body weight in groups T_2 and T_3 were comparable with the control group.

2) The mean cumulative feed intake per bird up to sixth week of age were 3.39, 3.38, 3.27 and 3.23 kg in dietary groups T_1, T_2 , T_3 and T_4 respectively .

3) The cumulative FCR up to six weeks of age recorded for the dietary groups T_1, T_2, T_3 and T_4 were 1.64, 1.63, 1.65 and 1.65 respectively. The cumulative feed intake and FCR did not reveal statistical difference between the dietary groups.

4) The per cent dressed yield in broilers fed 0.4 and 0.6 per cent turmeric (T_3 and T_4) was significantly higher than the control group while the eviscerated yield percentage in group T_4 (67.32) was significantly lower than the control group ($P \leq 0.05$).

5) The giblet yield in dietary groups T_1, T_2 , T_3 and T_4 were 4.67 , 5.12 , 5.31 and 5.20 per cent respectively and the mean values in all turmeric supplemented groups were significantly higher than that of control group ($P \leq 0.05$).

6) Dietary supplementation of turmeric powder did not influence the per cent ready to cook yield among the dietary groups and the mean values in T_1, T_2 ,T_3 and T_4 were 71.96, 71.96, 72.04 and 71.67 per cent respectively .

7) The feather loss in the dietary group T_3 (11.03 per cent) was significantly lower than that of control group T_1 (11.73 per cent) whereas the blood loss and total loss were not influenced by the dietary supplementation of turmeric.

8) The spleen weight of 3.18 and 3.26 g in the broilers fed 0.4 and 0.6 per cent turmeric (T_3 and T_4 respectively) exhibited significantly higher mean

values than that in the control group (2.83 g). The mean weight of thymus and bursa (1.14 and 5.46 g respectively) in broilers of the dietary group T_4 was significantly higher than all other groups. Significantly higher liver weight was noticed in group T_2 (53.72 g) when compared to the control group (50.90 g).

9) The mean values of Hb in the turmeric supplemented groups T_2 , T_3 and T_4 (8.61, 8.76 and 9.03 g per cent respectively) were significantly higher than that of control group (8.35 g per cent). The mean PCV was significantly higher in the groups T_3 and T_4 (27.88 and 28.38 per cent) when compared to T_1 and T_2 (26.88 and 27.01 per cent respectively). The total leucocyte count was lowest in the control group (22.16 thousand per μL) and highest in the group T_4 (30.49 thousand per μL) showing significant increase with the addition of 0.2, 0.4 and 0.6 per cent turmeric powder in diets.

10) The supplementation of turmeric at 0.4 and 0.6 per cent levels (T_3 and T_4) resulted in significant ($P \leq 0.05$) reduction in serum cholesterol level to 166.02 and 157.44 mg per dl respectively when compared to the mean value of 175.89 mg per dl in the control group.

11) The serum total protein values in the dietary groups T_1, T_2 , T_3 and T_4 were 3.56, 3.68 , 3.70 and 3.80 g / dl respectively and were statistically comparable.

12) The supplementation of turmeric at 0.4 and 0.6 per cent levels (T_3 and T_4) significantly ($P \leq 0.05$) reduced the serum total lipids in broilers and the mean values in T_3 and T_4 (618.38 and 599.27 mg per dl respectively) were lower when compared to the control group (714.38 mg per dl).

13) The supplementation of turmeric at 0.4 and 0.6 per cent levels significantly ($P \leq 0.05$) reduced the level of liver enzymes Alanine

aminotransferase (ALT) and Aspartate aminotransferase (AST). The mean values of ALT were 5.38 and 4.75 U / L in T_3 and T_4 groups while that of AST were 174.50 and 174.38 U / L respectively .The level of both these enzymes were significantly lower than that recorded in control group (6.50 and 177.63 U per L respectively).

14) The supplementation of turmeric at 0.4 per cent significantly ($P \leq 0.05$) reduced the thigh meat cholesterol in broilers (110.95 mg / dl) in comparison to that recorded in control group (113.08 mg/dl)

15) The livability of broilers in all experimental groups was 100 per cent.

16) The cost benefit analysis revealed that the net profit per bird was the highest in the group fed control ration (Rs.14.12) followed by T_2 (Rs.13.08), T_3 (Rs.11.03) and the lowest being in the group T_4 fed 0.6 per cent turmeric (Rs.9.99).

Based on the results obtained in the present study, it was concluded that profit margin was reduced by supplementation of turmeric in broiler diets. The beneficial effects in the haematological and biochemical profile of broilers indicated improved health status worth emulating long term studies to establish the merits of supplementation of turmeric in broiler diets.

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EFFECT OF DIETARY SUPPLEMENTATION OF TURMERIC (*Curcuma longa*) ON PRODUCTION PERFORMANCE OF BROILER CHICKEN

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ABSTRACT

An experiment was conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to study the effect of dietary supplementation of turmeric (*Curcuma longa*) on performance of broiler chicken. One hundred and ninety two, day-old commercial broiler chicks (Vencob) were reared under four dietary groups with four replicates of twelve birds each. The group T_1 was the control group and turmeric powder was supplemented in the basal diet at 0.2 per cent (T_2), 0.4 per cent (T_3) and 0.6 per cent (T_4). The chicks were reared under standard managemental conditions up to six weeks of age. The broiler starter ration was fed from zero to four weeks of age and finisher ration from five to six weeks of age.

Results of the present study revealed that supplementation of turmeric at 0.6 per cent level significantly ($P \leq 0.05$) depressed the final body weight of broilers at 6 weeks of age. The cumulative feed intake and feed conversion ratio up to sixth week of age did not reveal significant difference between the dietary groups. The ready to cook yield, blood loss and total loss were not influenced by the dietary supplementation of turmeric. The dressed yield in groups fed 0.2 and 0.4 per cent turmeric were significantly higher ($P \leq 0.05$) than that of the control group. The giblet yield in all the turmeric supplemented groups were significantly higher than the control group ($P \leq 0.05$). The per cent weight of thymus and bursa were increased by the supplementation of 0.6 per cent turmeric.

The dietary supplementation of turmeric improved the haematological parameters as haemoglobin, packed cell volume, total leucocyte and erythrocyte counts. The dietary supplementation of turmeric at 0.4 and 0.6 per cent levels (T_3 and T_4) resulted in a significant ($P\leq 0.05$) reduction in serum cholesterol level. The supplementation of turmeric did not influence the level of serum total protein. The supplementation of turmeric at 0.4 and 0.6 per cent levels (T_3 and T_4) significantly ($P\leq 0.05$) reduced the serum total lipids in broilers. The level of liver enzymes ALT and AST was significantly ($P\leq 0.05$) reduced by the supplementation of turmeric at 0.6 per cent level. The supplementation of turmeric at 0.4 per cent reduced the thigh

meat cholesterol in broilers ($P \leq 0.05$). Livability of birds in all dietary groups was 100 per cent.

The results obtained in the present study showed that the supplementation of turmeric at the levels 0.2, 0.4 and 0.6 per cent employed in the study had no deleterious effect in broilers .The net profit per kg body weight was reduced as a result of inclusion of turmeric powder in broiler diet. However, the higher dressed and giblet yields, lower meat cholesterol consequent to turmeric supplementation seems to be advantageous.