UTILIZATION OF TAMARIND (*Tamarindus indica L.*) PULP AS FEED SUPPLEMENT IN LAYER CHICKEN

T H E S I S

Submitted

In partial fulfillment of requirements for the degree of

M A S T E R O F V E T E R I N A R Y S C I E N C E
IN
ANIMAL NUTRITION

BY

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Enrollment No. V / 09 / 074

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(INDIA)

2016

DECLARATION OF STUDENT

I, hereby declare that the experimental research work and interpretation of the thesis entitled **"UTILIZATION OF TAMARIND (*Tamarindus indica L.*) PULP AS FEED SUPPLEMENT IN LAYER CHICKEN"** or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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With date

Declaration of Advisory Committee

Shri. **BIRADAR PARIKSHIT BABURAO** has satisfactorily prosecuted his course of research for a period of not less than one semester and that the thesis entitled, **"UTILIZATION OF TAMARIND (Tamarindus indica L.) PULP AS FEED SUPPLEMENT IN LAYER CHICKEN"** submitted by him is the result of original research work and is sufficient to warrant its presentation to the examination in the subject of **ANIMAL NUTRITION** for the award of **MASTER OF VETERINARY SCIENCE** degree by the Maharashtra Animal and Fishery Sciences University, Nagpur.

We also certify that the thesis or part thereof has not been previously submitted by him for a degree of any other University.

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PGR- ANNEXURE - XV
[See Rule No. 26.7]

CERTIFICATE

This is to certify that the thesis entitled "**UTILIZATION OF TAMARIND (*Tamarindus indica* L.) PULP AS FEED SUPPLEMENT IN LAYER CHICKEN"** Submitted by shri **BIRADAR PARIKSHIT BABURAO** to the Maharashtra Animal and Fishery Sciences University in partial fulfillment of the requirement for the degree of **MASTER OF VETERINARY SCIENCE (ANIMAL NUTRITION)** has been approved by the Student's Advisory Committee after oral examination in collaboration with the External Examiner.

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DATE: **(Biradar Parikshit Baburao)**

PLACE: UDGIR

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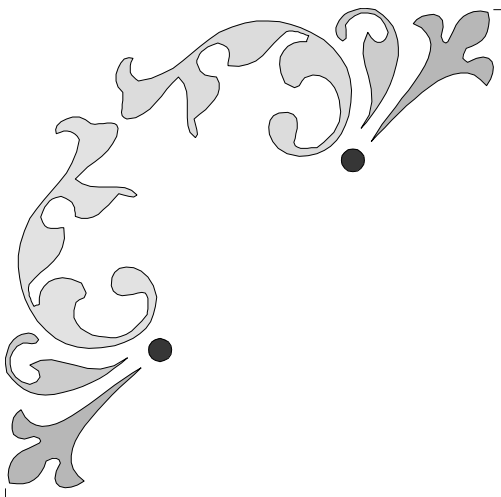
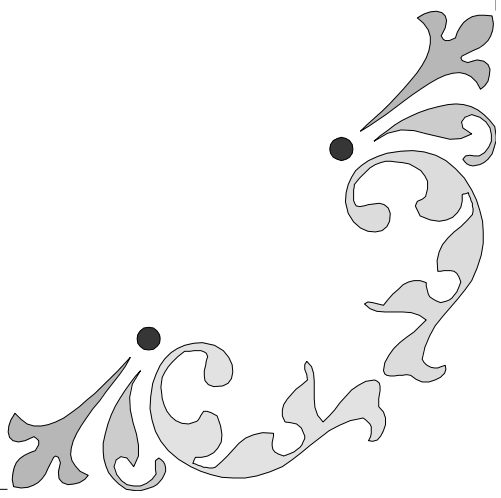
List of Abbreviations

@	-	At the dose rate
CF	–	Crude fiber
CP	–	Crude protein
DTPP	–	Dried Tamarind Pulp Powder
DM	–	Dry matter
DMB	–	Dry matter basis
et al.	-	et alia (and others)
EE	–	Ether extract
g/dl	–	grams per deciliter
g	–	Grams
Kg	–	Kilogram
ME	-	Metabolizable energy
mg/g	-	milligram per grams
mg/dl	-	milligram per deciliter
NFE	–	Nitrogen free extract
OM	–	Organic matter
%	-	Per cent



Introduction



CHAPTER – I

INTRODUCTION

The modern poultry farming has taken a shape of an industry with its two well defined facets viz., egg and meat production. Poultry is one of the fastest growing segments of the agricultural sector in India today. Egg production is estimated to have increased from 66 billion eggs in 2012 to 70 billion eggs in 2013, with per capita egg consumption at 57 eggs per annum. As a result, India ranks third in the world with annual egg production of 3.06 million tones behind China (1^{st}) and U.S. the (2^{nd}). In value term, total poultry market size is estimated Rs. 58,000 crore at the wholesale price level indicating value growth of 8% over 2012 (ICRA, 2013). The Indian Council of Medical Research (ICMR) has recommended consumption of 180 eggs per year for every individual.

A modernistic challenge in poultry production is to exploit the use of specific dietary supplements to boost the intrinsic potential of poultry birds to perform better (Adil *et al.*, 2010). Probiotics, enzymes, amino acid supplements, available minerals and herbal plants are all relatively new additions to the harmony of poultry nutritionists and have a very positive effect on nutrient utilization when used with appropriate feed ingredients. However, this has compromised their immunity and immune response which cannot be improved by use of antibiotics in feed due to their inherent ill effects on public health. Hence, to fulfill these lacunae the use of herbal preparations and traditional remedies has become the need of the hour.

A group of feed additives that have been generating interest in recent times as a replacement for banned antimicrobials in the poultry industry are the phytogenic feed additives (Jacela *et al.,*

2010). These phytogenic feed additives also called as phytobiotics or botanicals, are usually plant derived compounds that are used to improve productivity of livestock through improved feed intake, improved gut function, antimicrobial activity and anti-oxidative actions (Windisch *et al.,* 2008).

Tamarind or *Tamarindus indica* L. of the Fabaceae, subfamily Caesalpinioideae, is an important food in the tropics. It is a multipurpose tree of which almost every part finds at least some use (Kumar & Bhattacharya, 2008), either nutritional or medicinal. Tamarind is indigenous to tropical Africa but it has been introduced and naturalized worldwide in over 50 countries. The major production areas are in the Asian countries India and Thailand, but also in Bangladesh, Sri Lanka, Thailand and Indonesia (El-Siddig *et al.*, 2006).

Tamarind is a moderate-sized to large, evergreen tree, up to 24m in height and 7m in girth. The morphology of the tree in detail has been described by several authors (Singh, 1982; Parkash and Drake, 1985; George and Radhakrishna, 1993; ICFRE, 1993; Dubey, et al., 1997). The most useful part is the pod. Pods are 7.5–20 cm long, 2.5 cm broad and 1 cm thick, more or less constricted between the seeds, slightly curved, brownish-ash coloured, scurfy. There are 3–12 seeds in each pod contained in loculi, enveloped by a tough, leathery membrane, so-called endocarp. Outside the endocarp is the light-brownish, red, sweetish acidic, edible pulp, traversed by a number of branched, ligneous strands. The outermost covering of the pod is fragile and easily separable. The pods begin to ripen from February to April (Cowan, 1970; Duke, 1981).

The most valuable and commonly used part of the tamarind tree is the fruit. The major volatile constituents of tamarind pulp include furan derivatives (44.4%) and carboxylic acids (38.2%), the components of which are furfural (38.2%), palmitic acid (14.8%),

oleic acid (8.1%) and phenylacetaldehyde (7.5%) (Wong et al., 1998). According to Lee et al. (1975), the most abundant volatile constituent of tamarind is 2-acetyl-furan, coupled with traces of furfural and 5-methylfurfural, which form the total aroma of tamarind. The total content of volatile compounds in fruit pulps can be around 3 mg/kg.

The most outstanding characteristic of tamarind is its sweet acidic taste. The acid due mostly to tartaric acid (2, 3-dihydroxybutanedioic acid, C4 H6 O 6, a dihydroxydicarboxylic acid), ranging from 12.2-23.8%, and uncommon in other plant tissues (Ulrich, 1970). According to Kumar and Bhattacharyya (2008), the tamarind fruit contains about 55% pulp, 34% seeds and 11% shell (pod). Tamarind has been reported to have anti-diabetic (Koyagura, 2013), anti-inflammatory (Landi librandi *et al*. 2007), cholesterol lowering (Chowdhury *et al*. 2005), anti-obesity (Ukwani *et al*. 2008; Khairunnuur *et al. 2011),* antifungal (Abubakar *et al.* 2010), antioxidant (Khairunnuur *et al.* 2009; Bhutkar *et al.* 2011; Atawodi *et al.* 2014 ; Shridhar *et al.* 2014), antipyretic (Izquierdo *et al. 2007)* and antimicrobial (Doughari 2006; Abukakar *et al.* 2008; Daniyan *et al.* 2008) properties. In addition, it has appetizing and stimulatory effect in the digestive process (Cabuk *et al.,* 2003). Aengwanich *et al*. (2009) found that polyphenolic compound in the extracts could reduce heat stress in broiler chickens, with all these beneficial properties of tamarind, reported on its value for poultry are limited.

Now a day's consumers are becoming more health conscious. The demand for low cholesterol diet is increasing. Hence, present study was designed to determine the influence of supplementing tamarind pulp on egg cholesterol.

Objectives:

1 To study the effect of Tamarind (*Tamarindus indica L.*) pulp on growth performance of layer chicken.

2 To study the effect of Tamarind (*Tamarindus indica L.*) pulp on serum biochemical parameters in layer chicken.

3 To study the effect of Tamarind (*Tamarindus indica L.*) pulp on egg production.

4 To study the effect of Tamarind (*Tamarindus indica L.*) pulp on physical and biochemical properties of egg.

Review of Literature

CHAPTER - II
REVIEW OF LITERATURE

Tamarind (*Tamarindus indica*, Fabaceae), a tropical fruit found in Asia is highly valued for its pulp. Tamarind fruit pulp has a sweet acidic taste due to a combination of high contents of tartaric acid and reducing sugars. The pulp is used for seasoning, in prepared foods, to flavour confections, curries and sauces, and as a major ingredient in juices and other beverages. Anti-oxidant, anti-inflammatory, anti-microbial and anti-fungal activity has been documented from several plant parts. Tamarind is also extensively used in traditional medicine. The traditional uses, its phytochemistry and pharmacognosy is reviewed by many research workers. In the present study, effect of tamarind fruit pulp was assessed with regards to its potency to reduce serum as well as egg yolk cholesterol in layer poultry birds. Poultry egg is known to contain many essential nutrients including protein, fat, calcium, phosphorus, retinol, α-tocopherol, folate, and other B vitamins. Egg yolk contains sterols, phospholipids, and triglycerides. The yolk from a large egg may contain 213 mg of cholesterol. Over 95% of the yolk cholesterol is associated with triglyceride-rich lipoproteins. In order to avoid elevations in blood cholesterol and reduce the risk of coronary heart disease, consumption of not more than 300 mg of cholesterol daily and limited consumption of eggs has been recommended. The use of nutritional strategies to reduce egg cholesterol concentrations is an attractive alternative. In support of present study, the literature is collected for proper evaluation.

Mohamedain *et al.* (1996) studied the effect of 2% and 10% dietary *Tamarindus indica L.* ripe fruit on Brown Hisex chicks. There was a decrease in body weight gain and efficiency of feed utilization; also soft faeces was observed between days 21 and 35.

Hepatonephropathy due to consumption of 10% *Tamarindus indica L* food was confirmed by changes in serum enzyme activity as well as in total protein, cholesterol and uric acid concentrations. No hematological abnormality was observed in birds fed *Tamarindus indica L*. The hepatocytes and the cells of the renal convoluted tubules had not completely reverted to normal at the end of 2 week recovery period.

Tyagi and Bohra (2003) assessed the *in vitro* study of antifungal activity of *Tamarindus indica* against *Aspergillus flavus* and *Fusarium oxysporum* The crude ethanolic and aqueous extracts (at 7, 8 and 9 ml/plate) of leaves, stems, fruit pulp, seeds and bark of *T. indica* were found toxic against *A. flavus* and *F. oxysporum in vitro*. *F. oxysporum* was completely inhibited by the ethanolic extracts of pulp and leaves at 8 ml/plate, whereas *A. flavus* by the ethanolic extract of leaves at 9 ml/plate. The stem and bark extracts were less effective. Chemical analysis revealed the presence of alkaloids and triterpenoids in each plant parts, and the absence of flavonoids in pulp and bark and phenols in bark.

Chowdhury *et al.* (2005) studied the potential of dietary tamarind to alter serum and egg yolk cholesterol concentrations and overall performance in different layer strains. Thirty, 43-week-old, Hisex Brown, ISA Brown, Lohmann Brown, Starcross Brown, Babcock B-300, and Starcross-579 strains (5 hens per strain) were fed diets supplemented with 0 (control), 2, 4, 6, or 8% oven-dried tamarind for 6 weeks. Egg production, egg mass, and efficiency of feed utilization followed a quadratic response with a maximum when the diet contained 2% tamarind and a minimum when 8% tamarind was fed ($P < 0.05$). There were no differences ($P > 0.05$) among strains for egg production, egg weight, yolk weight, egg mass, feed

consumption, or feed efficiency. Yolk weight increased linearly ($P < 0.05$) with increasing levels of dietary tamarind in week 1, 2, and 3 as well as when averaged over 6 week. Egg yolk cholesterol concentrations were not affected by dietary tamarind. Serum cholesterol concentrations, however, decreased quadratically with increasing levels of dietary tamarind ($P < 0.05$). It was concluded that 2% supplemental dietary tamarind could decrease serum cholesterol concentrations and increase layer performance.

Rahimi G. (2005) conducted study to determine the effects of dietary forage legume supplementation on plasma triglyceride and cholesterol concentrations, egg yolk cholesterol contents and egg shell characteristics in indigenous laying hens at Mazandaran Native Fowls Breeding Station in north of Iran. A total of 60 laying hens were kept under commercial conditions from 35-45 weeks of age and were fed a commercial isocaloric and isonitrogenous corn-soybean meal diet. Birds were divided randomly into six treatment groups of ten birds each, and fed diets containing 0, 0.75, 1.25, 2.5, 5 and 10% added forage legume for 10 weeks. The results showed that there were no significant differences in final body weight, egg weight and yolk weight due to different forage legume treatments. Forage legume supplementation to the diet did not significantly affect plasma cholesterol and triglyceride concentration, while it has significantly ($p<0.05$) reduced egg yolk cholesterol concentrations. Egg yolk cholesterol content was reduced from 16.41mg/g yolk in control group to 13.01mg/g yolk in 10% forage legume supplemented diet. The results demonstrate that there is no co-linearity response on plasma cholesterol level and egg yolk cholesterol content to the dietary forage legume supplementation.

Doughari (2006) determined antimicrobial activity of *Tamarindus indica* L. The phytochemical constituents of the dried

powdered plant parts were extracted using aqueous and organic solvents (acetone and ethanol). The antimicrobial activity of the concentrated extracts were evaluated by determination of the diameter of zone of inhibition against both gram negative and gram positive bacteria and fungi using the paper disc diffusion method. Results of the phytochemical studies revealed the presence of tannins, saponins, sesquiterpenes, alkaloids and phlobatamins and the extracts were active against both gram positive and gram negative bacteria. The activity of the plant extracts were not affected when treated at different temperature ranges (4°C, 30°C, 60°C and 100°C), but was reduced at alkaline pH. Studies on the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of the extracts on the test organisms showed that the lowest MIC and the MBC were demonstrated against *Salmonella paratyphi, Bacillus subtilis* and *Salmonella typhi* and the highest MIC and MBC was exhibited against *Staphylococcus aureus*. It was concluded that *Tamarindus indica* has broad spectrum antibacterial activity and a potential source of new classes of antibiotics that could be useful for infectious disease chemotherapy and control.

Iftekhar *et al.* (2006) determined the effect of *Tamarindus indica* fruits on blood pressure and lipid-profile in human model: an *in vivo* approach. Fruits of *Tamarindus indica* were evaluated for their effects on lipid profile, systolic and diastolic blood pressure and body weight in human subjects. Dried and pulverized pulp of T. indica fruits, at a dose of 15 mg/kg body weight, was found to reduce total cholesterol level ($p = 0.031$) and LDL-cholesterol level ($p = 0.004$) to a significant extent. Though the fruits exerted no conspicuous effect on body weight and systolic blood pressure, it significantly reduced the diastolic pressure as confirmed by independent sample t-test at 5% significance level.

Martinello *et al.* (2006) studied the hypolipemic and antioxidant activities of *Tamarindus indica* L. pulp fruit extract in hypercholesterolemic hamsters. The present study addressed the effects of the crude extract from the pulp fruit of *Tamarindus indica* L. on lipid serum levels and early atherosclerotic lesions in hypercholesterolemic hamsters *in vivo*, and the extract's antioxidant action, *in vitro*. Animals were fed on either chow or atherogenic diet during 10 weeks and concomitantly received either water or *Tamarindus indica* L. extract for drinking. Treatment of hypercholesterolemic hamsters with the *Tamarindus indica* L pulp fruit extract (5%) led to a decrease in the levels of serum total cholesterol (50%), non-HDL cholesterol (73%), triglyceride (60%), and an increase of high-density lipoprotein (HDL) cholesterol levels (61%). *In vitro*, the extract presented radical scavenging ability, as assessed by the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and superoxide radical assays, and led to decreased lipid peroxidation in serum, as assessed by the thiobarbituric acid reactive substances (TBARS) assay. *In vivo*, the extract improved the efficiency of the antioxidant defense system, as assessed by the superoxide dismutase, catalase and glutathione peroxidase activities. Together these results indicate the potential of tamarind extracts in diminishing the risk of atherosclerosis development in humans.

Izquierdo *et al.* (2007) conducted an experiment on rats to observe the effect of tamarind pulp containing polysaccharide (TpPs) on fever. Pyrexia was induced in rats by subcutaneous yeast injection, and in mice with an intraperitoneal injection of a lipopolysaccharide (LPS) from *Escherichia coli.* Animals were treated with different oral TpPs doses (5–100 mg/kg). A significant dose-dependent reduction of the rectal temperature was observed. They analyzed the effect on cytokines response to *in vitro*. TpPs

treatment in peritoneal exudates cells (PECs), as well as in response to LPS cell stimulation. The IL-1β and IL-6 cytokines were measured in the supernatants through Enzyme Linked Immuno Sorbent Assay. Cells treated with LPS (10 µg/mL) or TpPs (100 µg/mL) alone resulted in a significant release of IL-1β. The results indicate that, depending upon the experimental conditions, TpPs (0.005–0.5 µg/mL) abolished the IL-1β response to LPS cell stimulation, but at higher doses (50–100 µg/mL) increased it, and reduced significantly the IL-6 response. In febrile rats and Balb/c mice, TpPs did prevent fever in a dose-dependent manner.

Librandi *et al*. (2007) conducted an experiment to evaluate a crude hydro alcoholic extract (Ext) from the pulp of the tamarind (*Tamarindus indica*) fruit as a source of compounds active on the complement system (CS) *in vitro*. The activity of 0.8 mg/mL of the extract on the classical/lectin pathways (CP/LP) increased after 30 min of pre-incubation, while that of the alternative pathway (AP) decreased after 15 min at 1 mg/ml. Since the CS is a mediator of inflammation, studies were also made *in vivo*, taking advantage of a model of hypercholesterolemia in hamsters to investigate the role of CS in the phase preceding the inflammatory process of atherosclerosis. Hamsters fed on a diet rich in cholesterol showed increased lytic activity of the CP/LP and AP after 45 days. The activity levels of C2 and factor B components increased the classical/ lectin and alternative pathways of the CS respectively. Early events cooperating to trigger the process of atherosclerotic lesions are not completely understood, and these alterations of complement may participate in these events. When treatment with a diet rich in cholesterol was associated to the furnishing of Ext, evaluation of complement components and complement lytic activity showed values similar to those of the controls, showing that treatment with Ext blocked the increase of complement activity

caused by the cholesterol-rich diet. They concluded that Ext had no effect on the complement system *in vivo*. The Ext activity on the CS may be of interest for therapy and research purposes.

Salma *et al*. (2007) conducted a study to investigate the effects of dietary *Rhodobacter capsulatus* on the laying hen. A total of forty, 23-wk-old Hy-Line Brown laying hens were randomly assigned into 4 treatment groups (10 laying hens/group) and fed diets supplemented with 0 (control), 0.01,0.02 and 0.04% *R.capsulatus* during the 60-d feeding period. Dietary supplementation of *R. capsulatus* (0.04%) reduced ($P<0.05$) cholesterol and triglycerides concentration in serum (15 and11% respectively), as well as in egg-yolk (13 and 16% respectively) over a 60-days feeding period. Cholesterol and triglycerides concentrations in serum as well as egg-yolk were changed linearly in accordance with increasing levels of dietary *R.capsulatus*. Supplementation of *R.capsulatus* in diet increased high-density lipoprotein cholesterol level and decreased ($P < 0.05$) atherogenic index in serum. Yolk color was improved ($P<0.05$) in the group fed the 0.04% *R. capsulatus* supplemented diet compared with the control group. Hepatic cholesterol and triglycerides were reduced ($P < 0.05$) by 0.04% R. capsulatus. Moreover, the supplementation of *R. capsulatus* in layer diets did not appear to cause any adverse effects on egg production, shell weight, shell thickness, Haugh unit, yolk index, and feed conversion efficiency in comparison the control group. It is postulated that known and unknown factors present in *R. capsulatus* presumably are responsible for the hypocholesterolemic effect on laying hens. Therefore, the dietary supplementation of *R. capsulatus* may lead to the development of low-cholesterol chicken eggs as demanded by health-conscious consumers.

Warda *et al.* (2007) determined antibacterial activity of *Tamarindus indica* L. fruit and *Piper nigrum* seed. Petroleum ether, ethanol and water extract from *Tamarindus indica* L. ripe fruits and *Piper nigrum* seeds in different concentrations (10-100%) were evaluated for their possible antibacterial activity against four standard pathogenic microorganisms, *Staphylococcus aureus, E. coli, Pseudomonas aeruginosa* and *Salmonella typhi*. The result reported that ethanol extract from *Tamarindus indica* L. fruit in different concentrations (10-100%) exhibited higher activity against all test bacteria, *Staphylococcus aureus, E. coli, Pseudomonas aeruginosa* and *Salmonella typhi* than that from *piper nigrum* seed.

Abukakar *et al.* (2008) studied the phytochemical screening and antibacterial activity of *Tamarindus indica* L. pulp extract. Antibacterial activity of aqueous pulp extract of this plant was carried out against four bacteria; *Staphylococcus aureus, E. coli, Pseudomonas aeruginosa* and *Salmonella typhi* by disc diffusion methods. Phytochemical constituents present in the extract were found to include saponins (2.2%), Alkakoids (4.32), and glycoids (1.59%). Aqueous pulp extract of *Tamarindus indica* L. showed antibacterial activity against all the tested bacteria in order to sensitivity as *Staphylococcus aureus> E. coli> Pseudomonas aeruginosa* with exception *Salmonella typhi*. The antibacterial activity of aqueous pulp extracts on *Staphylococcus aureus* showed sensitivity at at 80, 120, 140, 160 and 180 mg mL-1 of extract with 0.2, 0.3, 0.6, 0.8 and 10.0 mm zones of inhibition respectively while *E.coli* revealed 0.2, 0.2, 0.4, and 0.6mm zones of inhibition at 120,140,160 and 180 mg mL-1 of extract, respectively. *Pseudomonas aeruginosa* was only sensitive at 140,160 and 180 mg mL-1 of extract with 0.4, 0.6 and 0.8 mm zones of inhibition respectively.

Daniyan *et al.* (2008) studied evaluation of the antimicrobial activities and phytochemical properties of extracts of *Tamaridus indica* against some diseases causing bacteria. Crude aqueous and ethanol extracts of *Tamaridus indica* were investigated for antibacterial activity. The susceptibility of five clinical bacterial isolates against these two crude extracts was determined using the disk diffusion method. The ethanol extracts produced strong antibacterial activity against *Escherichia coli, Klebsiella pneumoniae, Salmonella paratyphi* A and *Pseudomonas aeruginosa*. *Staphylococcus aureus* was resistant to the extracts. The aqueous extracts have the least antibacterial activity compared to ethanol extract except against *P. aeruginosa*. The phytochemical analysis revealed the presence of alkaloids, flavonoids, saponins and tannins. The antibacterial activity of the extracts against the test bacteria suggest that there is a scientific basis for their utilization in traditional medicine for the treatment of some bacterial infections as claimed by traditional medical practitioners.

Ukwuani *et al.* (2008) investigated anti-obesity effects of pulp extract *Tamarindus indica* which is used by traditional herbalists as a purgative, drug vehicle and antiobesity agent. The effect of 28 days administration of *Tamarindus indica* pulp extract on the body weight and lipid profile of the rats were evaluated. There was significant increase in the weight of the control compared to the treated which significantly decreased ($p<0.05$) especially rats given higher doses (2700 to 4500 mg/kg body weight). Serum cholesterol and Low Density Lipoprotein (LDL) revealed significant decrease ($p<0.05$), while High Density Lipoprotein (LDL) triglyceride increased in the treatment group compared to the control. Xenical treated group was not significantly different ($p<0.05$) from the control. Triglycerides were significantly increased ($p<0.05$) and LDL significantly

decreased ($p<0.05$) in the pulp extract treated group as compared to Xenical treated group.

Khairunnuur *et al.* (2009) assessed the nutritional composition, *in vitro* antioxidant activity and Artemia salina l. lethality of pulp and seed of *Tamarindus indica* L. extracts. This study was designed to examine the nutritional composition, antioxidant activity and medium lethal concentration (LC50 value) of *Tamarindus indica* L. pulp and seed extracts *in vitro*. The extraction was set at 40°C, 60°C and 100°C for 12 hours, 6 hours and 15 minutes respectively to determine the optimum extraction parameter whereas the anti-oxidant activity of the extracts was measured using iron (III) reduction (FRAP) assay. Total phenolic content (TPC) of the extracts was estimated as gallic acid equivalent by Folin-Ciocalteau method. Toxicity potential of the extract was assessed *in vitro* by Artemia salina lethality test both in seed and pulp samples. The results showed that tamarind seed contained a higher percentage of carbohydrate, protein, fat and energy (15%, 82%, 95% and 33.13%, respectively) than the pulp. On the other hand, the pulp demonstrated a high moisture (51.1%) and ash (34.84%) content than the seed. For the mineral analysis, tamarind seed contained higher Ca and C (1.0% and 50.73%, respectively) than the pulp (0.27% and 40.40% respectively). No heavy metals were detected in both samples. Seed extracted at 60°C/6 hours and 100°C/15 minutes showed the highest TPC value and were significantly different ($p<0.05$) than the seed extracted at 40°C/12 hours. Anti-oxidant activity was positively correlated to the TPC value of the extracts ($R=0.991$). The pulp and seed extracted at 100°C/15 minutes showed the highest FRAP value among its groups (216.17 ± 14.06 μ mol (Fe)/g and 659.74 ± 16.40 μ mol (Fe)/ g respectively). This study indicated that tamarind pulp and seed extracts possess beneficial antioxidant properties and the optimum extraction

parameter was 100°C for 15 minutes. In Artemia salina lethality test, tamarind pulp caused significant mortality of the crustacean larvae with LC50 in the range of 26-28 μL/ml. Tamarind seed were not toxic to Artemia salina since the LC50 of the extracts was higher than 1000 μL/ml.

Khalid *et al.* (2010) studied in *vivo* effects of *Tamarindus indica* L. aqueous fruit extract on the antinociceptive activities in rodent models. The analgesic effect was evaluated using acetic acid-induced writhing, hot plate and formalin tests. The extract (60–600 mg/kg) significantly ($p<0.05$) inhibited the writhing test in a dose-dependent manner with the percentage of analgesia recorded between 51.8 and 74.1%. In addition, the extract also significantly ($p<0.05$) increased the latency time in the hot plate test in a dose dependent manner. Further study showed that the extract elicited inhibitory activity in both the early and late phases of the formalin test. Moreover, pretreatment with 5 mg/kg naloxone, a nonselective opioid receptor antagonist, significantly ($p<0.05$) modified the antinociceptive effect of the extract in all tests. The aqueous extract of *Tamarindus indica* possesses potential antinociceptive activity at both the peripheral and central levels, which are mediated via activation of the opioidergic mechanism.

Paula (2009) conducted a study to evaluate the modulator effect of a crude hydroalcoholic extract (ExT) of Tamarind on some peripheral human neutrophil functions. The neutrophil reactive oxygen species generation, triggered by opsonized zymosan (OZ), n-formyl-methionyl-leucyl-phenylalanine (fMLP) or phorbol myristate acetate (PMA), and assessed by luminol- and lucigenin-enhanced chemiluminescence (LumCL and LucCL, respectively), was inhibited by ExT in a concentration-dependent manner. ExT was a more

effective inhibitor of the PMA-stimulated neutrophil function [IC50 (in microg/10(6) cells)=115.7+/-9.7 (LumCL) and 174.5+/-25.9 (LucCL)], than the OZ- [IC50=248.5+/-23.1 (LumCL) and 324.1+/-34.6 (LucCL)] or fMLP-stimulated cells [IC50=178.5+/-12.2 (LumCL)]. The ExT also inhibited neutrophil NADPH oxidase activity (evaluated by O2 consumption), degranulation and elastase activity (evaluated by spectrophotometric methods) at concentrations higher than 200 microg/10(6) cells, without being toxic to the cells, under the conditions assessed. Together, these results indicate the potential of ExT as a source of compounds that can modulate the neutrophil-mediated inflammatory diseases.

Ranjan *et al.* (2009) investigated the effects of *Tamarindus indica* L. and *Moringa oleifera* M. extracts on fluoride toxicity in rabbits. Aqueous extracts of *T. indica* fruit pulp (100mg/kg body weight) and *Moringa oleifera* seeds (50mg/kg body weight) orally once daily for 90 days lowered plasma fluride concentration in rabbit receiving fluorinated drinking water (200 mg NaF/ liter water). Cortical indices and metaphysical width in animals receiving extract also revealed beneficial effect of plant extracts. Change in plasma biochemistry suggested less hepatic and renal damages in animal receiving plant extracts along with fluorinated water in comparison to that receiving fluorinated water alone. Preliminary result revealed these plant extracts have some potential to mitigate fluoride toxicity.

Abubakar *et al.* (2010) performed acute toxicity and antifungal studies of ethanolic leaves, stem and pulp extract of *Tamarindus indica* L. The acute oral toxicity studies of the pulp extract of *Tamarindus indica* L. at 3000mg/kg and 5000mg/kg body weight resulted in no mortality. This suggests that the LD50 is greater than 5000mg/kg body weight and can be classified as practically non-toxic and considered safe by the recommendations of World Health

Organization (WHO) and Organization for Economic and Cultural Development (OECD). Antifungal activity of ethanolic extract of *Tamarindus indica* L (leaves, stem bark and pulp) against *A. niger, A.flavus* and *F. oxysporum* was studied. The result showed a dose dependent increase in inhibition of growth of these organisms. Of the three plant parts the stem bark did not inhibit growth of *A. niger* and slightly inhibited the growth of *A.flavus* and *F.oxysporum* .It was concluded that the pulp and especially the leaves of *Tamarindus indica* L could be a promising antifungal agent and the result confirmed the use of this plant in traditional medicine for the treatment of fungal infections.

Adeola *et al.* (2010) observed the comparative analyses of phytochemicals and antimicrobial properties of extracts of wild *Tamarindus indica pulps.* The methanol and hexane crude extracts obtained from its pulp were evaluated *in vitro* to determine their inhibition activities on human pathogenic microorganisms made up of five bacteria and three fungi. All the bacterial strains were sensitive to both extracts at concentrations ranging from 25 to 125 mg/ml, using the agar broth cup diffusion procedure. Only the hexane extract exhibited intrinsic antifungal properties on *Penicillium* species. Preliminary phytochemical screening of both extracts indicated the presence of alkaloids and tannins. Both the antimicrobial and phytochemical properties of the extracts of the pulp varied for locations of the tamarind. Natural products present in tamarind pulp have potential of being used as agents for animals and/or plants protector against pathogenic microorganisms.

Caluwe *et al.* (2010) reviewed the traditional uses, phytochemistry and pharmacology of *Tamarindus indica* L. Tamarind (Tamarind*us indica*, Fabaceae), a tropical fruit found in Africa and

Asia is highly valued for its pulp. Tamarind fruit pulp has a sweet acidic taste due to a combination of high contents of tartaric acid and reducing sugars. The pulp is used for seasoning, in prepared foods, to flavor confections, curries and sauces, and as a major ingredient in juices and other beverages. Commercial tamarind-based drinks are available from many countries. Vitamin B content is quite high; carotene and vitamin C contents are low. Presence of tannins and other dyeing matters in the seed test a make the whole seed unsuitable for consumption, but they become edible after soaking and boiling in water. Tamarind kernel powder is an important sizing material in textile, paper and jute industries. Seeds are gaining importance as an alternative source of proteins, and are besides rich in some essential minerals. Seed pectin can form gels over a wide pH range. Leaves and flowers can be eaten as vegetables, and are prepared in a variety of dishes. They are used to make curries, salads, stews and soups. Tamarind leaves are a fair source of vitamin C and α-carotene; mineral content is high, particularly P, K, Ca and Mg. Anti-oxidant, anti-inflammatory, anti-microbial and anti-fungal activity has been documented from several plant parts. Tamarind is also extensively used in traditional medicine. The traditional uses, its phytochemistry and pharmacognosy is reviewed to provide with a particular orientation to its value in sub-Sahara Africa.

Ekambaram *et al.* (2010) determined the therapeutic efficacy of *Tamarindus indica* to protect against fluoride-induced oxidative stress in the liver of female rats. To evaluate the protective effect of tamarind pulp against fluoride (F)- induced oxidative stress in the liver, adult female Wister rats were treated daily for 45 days with sodium fluoride (300 ppm NaF = 136.7 ppm fluoride ion) in drinking water, alone or in combination with tamarind pulp (20 mg/kg bw by oral intubation). Malondialdehyde (MDA), antioxidant enzyme

activities of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSH-Px), and ascorbic acid level in the liver, and levels of calcium and F, plus activities of aspartate transaminase (AST) and alanine transaminase (ALT) in serum were determined 24 hr after the last treatment. In the NaF-treated animals, a significant increase in MDA content and a concomitant decrease in antioxidant enzyme activities of SOD, CAT, GSH-Px, and the ascorbic acid level in liver and increased activities of AST and ALT, and increased calcium and F concentrations in serum were observed. Administration of tamarind pulp together with NaF produced significant amelioration in all parameters studied, indicating that tamarind pulp is able to prevent free radical induced oxidative stress by F, attributable to its antioxidant property. It is concluded that tamarind pulp may be useful to prevent the oxidative damage caused by consumption of excessive amounts of F.

Latha *et al.* (2010) conducted an experiment to evaluate medicinal plants and their derivatives as potential source in treatment of obesity. Since the time immemorial plants have been in use as sources of medicine throughout the world. The demand for plant-based medicines is ever growing as crude or processed products from plants have less or no adverse effects. The present review covers the taxonomy, habitat, distribution, extraction and identification of active principle of potential medicinal plants used in obesity treatment. The different biochemical markers used to evaluate the anti-obese effect of each plant is also considered.

Bhadoriya *et al.* (2011) reviewed potential benefits of Tamarindus *indica.* Tamarind is a monotypic genus and belongs to the subfamily Caesalpinioideae of the family Leguminosae

(Fabaceae), *Tamarindus indica* L., commonly known as Tamarind tree is one of the most important multipurpose tropical fruit tree species in the Indian subcontinent. Tamarind fruit was at first thought to be produced by an Indian palm, as the name Tamarind comes from a Persian word “Tamar-I-hind,” meaning date of India. Its name “Amlika” in Sanskrit indicates its ancient presence in the country. *T.indica* is used as traditional medicine in India, Africa, Pakistan, Bangladesh, Nigeria,and most of the tropical countries. It is used traditionally in abdominal pain, diarrhea and dysentery, helminthes infections, wound healing, malaria and fever, constipation, inflammation, cell cytotoxicity, gonorrhea, and eye diseases. It has numerous chemical values and is rich in phytochemicals, and hence the plant is reported to possess antidiabetic activity, antimicrobial activity, antivenomic activity, antioxidant activity, antimalarial activity, hepatoprotective activity, antiasthmatic activity, laxative activity, and anti-hyperlipidemic activity. Every part of the plant from root to leaf tips is useful for human needs. Thus the aim of the present review is to describe its morphology, and explore the phytochemical constituents, commercial utilization of the parts of the plant, and medicinal and pharmacologic activities so that *T. indica*'s potential as multipurpose tree species can be understood.

Bhutkar *et al.* (2011) determined anti-oxidative effect of *Tamarindus indica* in Alloxan induced diabetic rats. In diabetics, oxidative stress has been found mainly due to an increased production of free radicals due to persistent hyperglycemia and a sharp reduction of antioxidants defences and the tissue antioxidant status which leads to the development of diabetic complications. Treatment of diabetic patients with an antioxidants may be of advantage in attenuating these complications. *Tamarindus indica* is amongst the numerous herbal remedies prescribed in the Indian traditional system of medicine for treatment of diabetes mellitus. In

the present investigation the anti-oxidative effect of administration of ethanolic extract of bark of T.indica (TIEt) at a dose of 100 mg/kg bw and 200 mg/kg bw for 45 days to normoglycemic and alloxan induced diabetic rats was studied. The extract caused reduction in blood glucose of diabetic rats and produced a significant decrease in peroxidation products, viz., thiobarbituric acid reactive substances. Reduced glutathione (GSH) and glycogen content which had shown significant decrease following induction of diabetes, were found to be increased in the hepatic tissue of alloxanized rats treated with TIEt. The diabetic rats treated with TIEt (200mg/kg) significantly reversed all these changes to near normal. These results clearly exhibit the antioxidant property of TIEt extract. The effect of TIEt extract at 200 mg/kg body weight was more effective than glibenclamide.

Dey *et al.* (2011) investigated *in vivo* efficacy of tamarind (*Tamarindus indica*) fruit extract on experimental fluoride exposure in rats. The study was undertaken to determine the efficacy of hydro-methanolic (1:1) extract of tamarind (*Tamarindus indica* L.) fruit pulp in removing body fluoride burden. Thirty rats were divided into five groups. Keeping no fluoride group as the control, rats of no treatment, low dose, middle dose and high dose groups received sodium fluoride orally at the rate of 200mg per kg body weight daily for 14weeks. Rats of low dose, middle dose and high dose group simultaneously received tamarind fruit pulp extract at three doses, viz. 25 (low), 50 (medium) and 100mg (high) per kg body weight orally, respectively. Fluoride concentration in blood, urine and long bone of experimental rats was monitored to assess the efficacy of the extract. Mean serum fluoride concentration in fluoride exposed rats was 0.145±0.009 and 0.783±0.042µg/ml on days 0 and 98. In comparison, fluoride concentrations in tamarind treated rats were 0.179±0.021 and 0.633±0.015; 0.179±0.021 and 0.502±0.025 and 0.176±0.021 and 0.498±0.030µg/ml in low, medium and high dose

groups, respectively on day 0 and day 98 of the experiment. There was a significant ($p \leqslant 0.01$) increase in urinary fluoride excretion from day 28 onwards. The mean fluoride concentration in long bones of treated rats was significantly lower than the values recorded in fluoride exposed rats. These findings suggest that concomitant use of tamarind fruit pulp extract can reduce fluoride concentration in blood and bone and enhanced urinary excretion, indicating the ameliorative potential of fruits of tamarind in fluoride toxicity.

Jindal *et al.* (2011) investigated hypolipidemic and weight reducing activity of the ethanolic extract of *Tamarindus indica* fruit pulp in cafeteria diet- and sulpiride-induced obese rats. Cafeteria diet was administered for 40 successive days to male Wistar rats and sulpiride (20 mg/kg, i.p.) was administered for 28 successive days to female Wistar rats. In separate groups of animals, the ethanolic extract (50 and 100 mg/kg p.o.) of *Tamarindus indica* fruit was administered along with cafeteria diet for 40 successive days to Wistar male rats and along with sulpiride for 28 successive days to Wistar female rats. Cafeteria diet alone significantly increased body weight, serum total cholesterol, triglycerides, and glucose levels and decreased HDL cholesterol in male rats as compared to control. Sulpiride per se significantly increased the levels of glucose, triglycerides, cholesterol and there was no significant effect on HDL-cholesterol in female rats as compared to control. Ethanolic extract showed a significant decrease in body weight, serum cholesterol, and triglycerides and a significant increase in HDL-cholesterol in cafeteria diet- and sulpiride-induced obese rats as compared to their respective control groups.

Khairunnuur *et al.* (2011) investigated antiobesity effect of *Tamarindus indica* L. pulp aqueous extract in high-fat diet-induced

obese rats. Obesity and overweight are associated with atherosclerosis, fatty liver, hyperlipemia, diabetes mellitus, and various types of cancer. The global prevalence of overweight and obesity has reached epidemic proportions. Here, we investigated the effect of *Tamarindus indica* pulp aqueous extract (TIE) in diet-induced obese Sprague– Dawley rats. The animals were divided into five groups and labeled as follows: the normal control (NC) group received normal diet; the positive control (PC) group received high fat diet; and the TIE 5, 25, and 50 groups, after the induction of obesity via a high-fat diet, received TIE at 5, 25, or 50 mg/kg orally for 10 weeks. It was observed that TIE decreased the levels of plasma total cholesterol, low density lipoprotein (LDL), and triglyceride, and increased high-density lipoprotein (HDL), with the concomitant reduction of body weight. Moreover, TIE decreased plasma leptin and reduced fatty acid synthase (FAS) activity and enhanced the efficiency of the antioxidant defense system. The TIE exhibits antiobesity effects, as indicated by a significant reduction in adipose tissue weights, as well as lowering the degree of hepatic steatosis in the obesity induced rats. The extract possesses hepatoprotective activity, as it reversed the plasma liver enzymes level elevation prior to the high-fat diet. In conclusion, TIE improved obesity-related parameters in blood, liver, and adipose tissue in a rat model and suppressed obesity induced by a high-fat diet, possibly by regulating lipid metabolism and lowering plasma leptin and FAS levels. A dose-dependent effect of TIE is detected, where TIE at 50 mg/kg showed the most prominent effect, followed by TIE at 25 mg/kg and, subsequently, 5 mg/kg.

Ramesh *et al.* (2011) conducted a study to evaluate the effect of hypocholesteramic herbal preparation Abana and garlic paste on lipid profile and production performance in layers. A total of one hundred and eighty BV-300 commercial layers of about 48

weeks age were randomly distributed into 18 groups of 10 layer birds in each. Six dietary treatments with the diet supplemented with Abana at 80 mg/kg body weight and 120 mg/kg body weight and garlic paste at 0.5 % individually and in combination were formulated for three periods of 28 days each. Each dietary treatment was offered to three groups of layers reared in individual cages for 28 days in each period. All the birds received similar management practices except the dietary treatments. The feed intake and body weight gains were recorded every 28 days. At the end of every 28 days the serum and egg yolk was collected form each replicate, pooled and analyzed for High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL), Very Low Density Lipoprotein (VLDL) and triglycerides in serum and cholesterol level in egg yolk. Results indicated that there was reduction in the egg yolk cholesterol level but was not significant.

Yingyuen *et al.,* (2011) performed an experiment on 60 laying birds of 18-34 weeks by randomly distributing birds in 4 groups to determine the effects of dried black cumin and tamarind pulp and combination of both. The birds in group1 (control) were fed with basal diet only without any supplement of black cumin and tamarind. Group 2 were supplemented with 0.1% black cumin in basal diet .Group 3 were supplemented with Tamarind indica 0.4%. Group 4 were supplemented with combination of 0.1% black cumin + 0.4% Tamarind indica for 16 weeks. There were no significant differences in feed efficiency ratio, egg production and egg weight between treatment groups, however average daily feed intake was highest in the groups fed with 0.4% tamarind and 0.1% black cumin +0.4% tamarind in diet. Egg yolk colour score, yolk index, white index, shell thickness were not significantly different. However Hough unit was lowest in control group. Egg yolk lipid concentration in black cumin & tamarind diet groups showed statistical significant reduced

cholesterol and tri-acyl-glycerol concentration with statically significant ($P<0.05$).

Saleh *et al.* (2012) studied the influence of an aqueous solution of tamarind pulp on growth and carcass characteristics of broiler chickens. One week old broilers were divided into 4 treatment groups replicated 4 times in a completely randomized design. The control group was given 0g/L tamarind pulp (TP) while the other groups received 20g/L, 30g/L and 40g/L tamarind pulp in drinking water. The group that was given 30g/L TP had higher ($P<0.05$) final weight, body weight gain and feed efficiency. There were no significant ($P<0.05$) difference observed for water intake, slaughter weight, dressed weight and dressing percentage. Tamarind pulp had significant ($P<0.05$) influence on all cut- up parts. It was concluded that aqueous solution of 30g/L tamarind pulp in drinking water will improve performance without adverse effects on carcass measurements of broiler chickens.

Sharma *et al*. (2012) studied the protective role of diet supplements (*Spirulina, Tamarind* Pulp and their combination) on a freshwater fish *G.affinis* exposed at sublethal concentration of fluoride (F)(10 ppm), Al (3 ppm) and aluminum fluoride (AlF_3) (35.4 ppm) in the microcosms (15L sized) for 30-60day in winter (90 days in summer).toxic effects of chemicals were manifested as higher fish mortality (4-50%) and acid (30%) and alkaline phosphatase (25-50%) contains, but reduction in RBC counts (5-55%) and protein content (29%) compared with controls. Alterations in values of these parameters were found maximum in aluminum exposed fish suggesting it as the most toxic among the tested chemicals. Diet supplements reduced toxicity of tested chemicals, especially when *spirulina* and tamarind were given together.

Atawodi *et al.* (2013) investigated antioxidant effects of *Tamarindus indica* following acute and chronic carbon tetrachloride induced liver injury. This study aimed at evaluation of *in vivo* antioxidant effects of the methanolic extracts of different parts of *Tamarindus indica* Linn. in rats. To this end, rats were administered (pre-treatment) with plant extracts (5 mg/kg) for 3 days and intoxication with carbon tetrachloride (0.6 mL/kg) for acute liver injury experiment. The chronic liver injury experiment on the other hand involved intoxication with 0.3 mL/kg of carbon tetrachloride at every 72 h interval with concomitant 24 h administrations of the extracts (5 mg/kg) for twelve days. Malondialdehyde (MDA), catalase and superoxide dismutase (SOD) were determined from liver, kidney and heart homogenates as indicators of oxidative stress. Serum catalase and SOD as well as packed cell volume (PCV) of the blood were also determined The results obtained showed a statistically significant ($p<0.05$) enhancement in the levels PCV, catalase and SOD activities in the extract-treated groups relative to the controls while the MDA was significantly lowered ($p<0.05$) in the extract-treated groups when compared to the CCl4 control. The extracts showed potent antioxidant potential in the following order; fruit pulp > stem bark > fruit bark > seeds > root bark > leaves. These results suggest that *T. indica* possesses strong antioxidant properties to justify its usage in traditional medicine and culinary purposes leading to extra health benefits on its use as food in many tropical countries.

Chor Yin Lin *et al*. (2013) conducted experiment to evaluate the antioxidant activities and potential hypercholesterolemic properties of *T. indica* using *in vivo* and *in vitro* approaches. In *in vitro* study they found *T. indica* fruit pulp had significant amount of phenolic and Flavonoid content and possessed antioxidant activity.

In *in vivo* study, Hamster feed with high cholesterol diet for 10 week showed elevated serum triglyceride, total cholesterol, HDL and LDL. Administration of *T. indica* fruit pulp to hypercholesterolemic Hamster they found significantly lowered serum triglyceride, total cholesterol and LDL level. *T. indica* pulp on hypercholesterolemic hamster also protected against oxidative damage by increasing hepatic antioxidant enzymes, antioxidant activities and preventing hepatic lipid peroxidation.

Gupta *et al.* (2013) reported ameliorative effect of *Tamarindus indica* L. on biochemical parameters of serum and urine in cattle from fluoride endemic area. The present study was undertaken to evaluate the ameliorative effect of tamarind (*Tamarindus indica* L.) in endemic fluorosis in cattle. Eighteen cows (3-6 years) were divided into three groups (Group I, II and III) of six animals in each. Groups I and II served as healthy and disease controls, respectively. Dried powder of tamarind fruit pulp was given for 90 days to Group III (treatment group) at the dose rate of 100 grams per animal. Calcium, phosphorus, alkaline phosphatase and fluoride concentration in serum and collagen degradation marker i.e. hydroxyproline in urine were considered for evaluating the efficacy of tamarind fruit pulp. A significant increase in calcium level was observed in cows treated with tamarind (6.49 ± 0.17 mg/dL) as compared to the disease control (5.80 ± 0.41 mg/dL). Increased activity of serum alkaline phosphatase (118.38 ± 2.93 units/L) and the higher concentration of hydroxyproline (27.88 ± 1.01 µg/mL) in cows of fluoride endemic area were decreased significantly ($P<0.05$) after supplementation of tamarind (95.24 ± 2.76 units/L and 20.17 ± 1.56 µg/mL, respectively). In conclusion the present study found that dried powder of *Tamarindus indica* fruit pulp has ameliorative potential on management of fluorosis in cattle.

Koyagura *et al.* (2013) determined anti-diabetic and hepatoprotective activities of *Tamarindus indica* fruit pulp in alloxan induced diabetic rats. Animals were divided into 5 groups (n = 6). Normal and diabetic control groups received normal saline and alloxan (150 mg/kg body weight intraperitoneally) respectively. Animals were made diabetic by injection of single dose of alloxan in three test groups and after that they were treated with ethanolic extract of fruit pulp of *Tamarindus indica* 300 and 500 mg/kg/body weight orally and metformin 150 mg/kg body weight orally respectively for 14 days. Antidiabetic activity was estimated by measuring serum glucose and lipid profile; and hepatoprotective activity was measured by estimating serum liver enzyme levels and histopathological changes in liver tissues. Results were analyzed by One way ANOVA followed by Scheffe multiple comparison tests ($p<0.01$). The two dose levels of *Tamarindus indica* significantly altered alloxan induced changes in serum glucose, lipid profile and serum enzyme levels. But in liver histopathology, higher dose (500 mg/kg) of plant showed complete regeneration whereas lower dose (300 mg/kg) showed only partial improvement in liver histopathology profile. Present study revealed that *Tamarindus indica* possesses antidiabetic and hepatoprotective activity in alloxan induced diabetic rats.

Ursula *et al.* (2013) studied antioxidant and hypolipidemic properties of fruit pulp extract of *Tamarindus indica* L. In this study, the methanol extract of *Tamarindus indica* L fruit pulp was investigated for its effects on the abundance of HepG2 cell lysate proteins. Cell lysate was extracted from HepG2 cells grown in the absence and presence of the methanol extract of *Tamarindus indica* L fruit pulp. Approximately 2500 spots were resolved using two-dimensional gel electrophoresis and the abundance of 20 cellular proteins was found to be significantly reduced. Among the proteins

of reduced abundance, fourteen, including six proteins involved in metabolism (including ethanolamine phosphate cytidylyltransferase), four mitochondrial proteins (including prohibitin and respiratory chain proteins), and four proteins involved in translation and splicing, were positively identified by mass spectrometry and database search. The identified HepG2 altered abundance proteins, when taken together and analyzed by Ingenuity Pathways Analysis (IPA) software, are suggestive of the effects of *Tamarindus indica* L fruit pulp extract on metabolism and inflammation, which are modulated by LXR/RXR. In conclusion, the methanol fruit pulp extract of *Tamarindus indica* L was shown to cause reduced abundance of HepG2 mitochondrial, metabolic, and regulatory proteins involved in oxidative phosphorylation, protein synthesis, and cellular metabolism.

Anu *et al.* (2014) conducted the study on the antimicrobial activities of the *Tamarind indica* pulp extract against gram-negative bacteria using disk diffusion method. The methanol crude extract obtained from it pulps were evaluated *in vitro* to determine their inhibition activities against human pathogenic microorganisms *Bacillus subtilis*. Preliminary phytochemical screening of methanol extract indicated the presence of alkaloids and tannins. The antibacterial activity was found 15.6 mm diameter of zone inhibition against *Bacillus subtilis*. They concluded that natural products present in tamarind pulp have potential of being used as antimicrobial agents for animals and/or plants protector against pathogenic microorganisms.

Atawodi *et al.* (2014) assessed the total polyphenols, flavonoids and antioxidant properties of different parts of *Tamarindus indica* Linn of Nigerian origin. Methanolic extracts of the leaves, stem bark, root bark, fruit pulp, fruit bark and seeds of *Tamarindus indica* Linn were analyzed for their total polyphenol contents, flavonoid

concentration and antioxidant activities in reference to Gallic acid equivalent (GAE), quercetin equivalent (QE) and Trolox equivalent (TE) respectively. The equivalent phenolics and flavonoids contents of the stem, fruit pulp and fruit bark (94±2.1 - 158±2.5 µg GAE /g and 27±1.0 - 39±0.7 µg QE /g respectively) were significantly (P = 0.05) higher than those of the seed, root and leaf (55±0.0 - 66±0.7 µg GAE /g and 21±0.7 - 17±1.0 µg QE /g respectively). The antioxidant activity of the stem, fruit pulp, fruit bark, seed, root and leaf were found to be 168±3.5, 143±3.5, 101±1.4, 83±3.5, 63±3.5 and 40±1.0 µg TE /g respectively. There was a strong positive correlation (r2 = 0.97) between the polyphenols contents and the *in vitro* antioxidant activity. These results suggest that different parts of T. indica possess high levels of polyphenols with significant antioxidant capacities to warrant further detailed studies on the possible roles of this property in their nutritional and health effects

Bibekananda *et al.* (2014) reviewed phytochemistry, pharmacology and traditional uses of *Tamarindus indica* L. Currently there have been an increased interest globally to identify plants and explore their therapeutic potential. As because drugs which obtained from nature pharmacologically potent and have low or no side effects for use in preventive medicine and the food industry. They represent a potential source of new compounds with different pharmacological activity. Traditional herbal medicines form an important part of the healthcare system of India. Ayurveda, supposed to be the oldest medical system in the world, provides potential leads to find active and therapeutically useful compounds from plants. Considering the growing interest in the field of plant drugs assessing different pharmacological activity. In this review we have discussed about the therapeutic potential and chemical constituents *Tamarindus indica*. It is available all over the country. *Tamarindus indica* is having some reported activities like antidiabetic, hypolipidemic, hepatoprotective

and antimicrobial properties. This plant is consumed by rural people as vegetable.

Gupta *et al.* (2014) evaluated antimicrobial activity of Tamarind (*Tamarindus indica*) and its potential as food bio-preservative Tamarind (*Tamarindus indica*) is used in Indian spices as a souring agent to provide the desired acidity in the various food recipes. The antimicrobial activity of tamarind extract (50% ethanol) was tested against ten bacterial strains (7 Gram-positive and 3 Gram-negative) and seven fungi known to cause food spoilage by agar well diffusion assays. The aqueous-ethanolic extract exhibited a broad spectrum of anti-bacterial activity inhibiting both the groups of bacteria. Tamarind extract was active against all the test Gram-positive bacteria isolates but was highly effective against *Staphylococcus aureus, Staphylococcus epidermidis, Bacillus subtilis* and *Listeria monocytogenes* with an inhibition zone of 18 mm, 19 mm, 16 mm and 16 mm, respectively. It also inhibited the growth of all Gram-negative bacteria isolates but produced an inhibition zone greater than 15 mm only in the case of *Pseudomonas aeruginosa, Pseudomonas sp. and Salmonella sp*. However, the extract was found to be ineffective against majority of test fungal species. Only *Aspergillus sp.* and *Penicillium sp*. were found to be partially sensitive to the extract. The phytochemical analysis of tamarind extract revealed the presence of tannins, terpenoids and citric acid. This study shows the potential for replacement of synthetic food grade preservatives with the use of natural extracts of tamarind.

Kuru (2014) studied *Tamarindus indica* and its health related effects. Tamarindus [*Tamarindus indica* L.], belongs to the family Leguminosae (Fabaceae), commonly known as Tamarind tree, is

one of the fruit spices that used as traditional medicine.Tamarind tree is found especially in the subcontinent, Africa, Pakistan Bangladesh, Nigeria and most of tropical countries. It is preferred to be used for abdominal pain, diarrhea and dysentery, some bacterial infections and parasitic infestations, wounds healing, constipation and inflation. It is rich source of most of the essential amino acids and phytochemicals and hence plant is reported to possess antidiabetics, antimicrobial, antivenomic, antioxidant, antimalarial, cardioprotective, hepatoprotective, antiasthmatic, laxative and hyperlipidemic activity. *T. indica* has ameliorative effects on many diseases. It can also be preferred as nutritional support for malnourished patient as it is cheap and easy to access.

Shridhar *et al.* (2014) investigated antioxidant activities of spray dried tamarind pulp powder as affected by carrier type and their addition rate. Spray dried tamarind pulp powder (TPP) was prepared by using three carrier agents maltodextrin (40, 50, 60%), gum arabic (40, 50, 60%) and whey protein concentrate (10, 20, 30%) and their total phenolic content and antioxidative properties (by DPPH, FRAP and ABTS assay). Total phenolic content of TPPs ranged from 59.45-131.33 mg of GAE / 100g. It was observed that phenolic content was protected at higher carrier agent addition rates. Values of Radical scavenging activity (% RSA), FRAP (mg of Ferrous sulphate equivalent / g) and total antioxidant activities (TAA) by ABTS assay of TPPs varied from 61.73 to 76.43, 56.81-311.63 and 0.071 - 0.15 mM of trolox equivalent / g of powder. FRAP values of TPPs ranged from and showed decrease in FRAP values with increase in the addition rate of the MD and GA. Antioxidant properties were positively correlated with total phenolic content of TPP.

Urszula *et al.* (2014) studied chemical, physico-chemical, technological, antioxidant and antibacterial properties of tamarind (*Tamarindus indica* L.). Powder extract (TPE) obtained from the fruit pulp, in view to its application in the food industry. Protein, fat, ash and total dietary fibre contents of TPE were 2.06, 3.03, 8.95 and 19.30 g/100 g dm, respectively. Furthermore, glucose and tartaric acid were presented in the largest amounts (155.65 and40.97 mg/g, respectively). DMSO tamarind extract contained the most phenolic (4.24 mg GAE/g) andflavonoids (127.16 mg RE/g) compounds. Methanolic extract of tamarind showed good antioxidant activity in DPPH assay (92.62% inhibition of radicals) and FRAP assay (2.46 mmol TE/g) assays. While, DMSO extract exhibited the best metal-ion chelating properties (73.68%). Besides, tamarind extracts possessed antibacterial activity against Gram-positive and Gram-negative bacteria. Results from this work suggest that TPE could be used as an ingredient of functional food as well as natural preservative in food industry.

Shinde *et al.* (2015) performed a systematic study to assess the efficacy of Dried Tamarind Pulp Powder (DTPP) with various inclusion levels in broiler poultry birds. Three hundred broiler chicks were equally divided into five groups as control (T0) and treatment T1 (0.25% DTPP), T2 (0.50% DTPP), T3 (1.00% DTPP) and T4 (1.50% DTPP). At the end of study, optimum feed intake, satisfactory body weight gain, significantly higher final live weight and improved FCR was observed. Hemoglobin, packed cell volume, TEC, TLC revealed no significant variation and were normal. Total serum protein, serum albumin, triglyceride, SGPT, SGOT, creatinine were normal without any significant variation. Significantly lowered total cholesterol, LDL), meat cholesterol, abdominal fat, higher HDL, carcass yield, dressing percent along with reduced cost of feeding

per kilogram live body weight (Rs. 49.01, 41.68, 44.27, 46.74 and 46.61) can were basal diet of broiler birds.

Sutrisna *et al*. (2015) conducted an experiment to examine the hypolipidemic effect of 70% ethanolic extract of *T. indica* L fruit flesh and rind and their chemical compounds. A total of 40 Wistar male rats were divided into 8 groups. group I was negative control (aquabidest); group II was positive control (Simvastatin 0.72 mg/gbw); groups III, IV, and V were treated by 70% ethanolic extract of the flesh fruit with doses of 200, 100, and 50 mg/kg bw, respectively; groups VI, VII, and VIII were treated by 70% ethanolic extract of the rind fruit with doses of 200, 100, and 50 mg/kg bw, respectively. The extract was given for 7 days after the third day. Measurement of plasma total cholesterol and triglyceride were carried out on days 0, 3, and 10. They found that the 70% ethanolic extract of T. indica L fruit rind and flesh with doses of 200, 100, and 50 mg/kg bw can reduce plasma total cholesterol and triglyceride significantly (P o 0.01). Chemical content of 70% ethanolic extract of *T. indica* L fruit rind and flesh by thin-layer chromatography examination are alkaloids, flavonoids, terpenoids, and phenolic. They concluded that the 70% ethanolic extract of *T. indica* L. fruit.

Amir *et al*. (2016) conducted an experiment to evaluate the hepatoprotective potential of aqueous extract of *Tamarindus indica* fruit against combination of two antitubercular drugs viz. Isoniazid and Rifampicin induced hepatotoxicity in rats. *In vitro* antioxidant activity of aqueous extract of *T. indica* by DPPH-HPLC method was found to be 81.48%. Treatment with aqueous extract of T. indica significantly reduced the elevated levels of biochemical markers such as SGOT, SGPT, ALP, bilirubin, TBARS and increased the albumin level as well antioxidant activities of SOD, CAT and GSH in intoxicated rats. The biochemical changes were supported by

histological observations. Results of this study clearly demonstrate that aqueous extract of *T. indica* fruit protects against anti-tuberculosis induced oxidative liver damage in rats and thus possess significant hepatoprotective activity. Further, they suggested that supplementation with this food extract might prove beneficial in the individuals on anti-TB drugs.

Materials and Methods

CHAPTER - III

MATERIAL AND METHODS

In order to achieve the objective of the present investigation, the experiment was planned to evaluate the response of layer bird to dietary supplemental Tamarind (*Tamarindus indica L*.) pulp powder with reference to its effect on serum as well as egg yolk cholesterol. In order to assess these parameters and other related parameters, various serum biochemical, physical parameters of egg and biochemical parameter of egg yolk were studied. Apart from this growth performance, weekly body weight changes, feed efficiency and egg production was also studied. The experiment was conducted at Jijamata Co-operative Layer Poultry Farm, Udgir and laboratory investigations were performed at Department of Animal Nutrition, College of Veterinary and Animal Sciences, Udgir, Dist. Latur. The experimental procedures and analytical techniques employed during the course of study are briefly discussed as under.

3.1 Experimental Layer Birds

For the present study 240 healthy 20th week old layer birds of 'BV-300' strain were used from M/s. Jijamata Co-operative Layer Poultry Farm, Udgir, Dist. Latur. Layer birds were divided into four groups of 60 birds each. Each group was divided into 3 replicates of 20 birds each.

3.2 Housing and Management

The experimental birds were maintained in California three tier cage system during entire trial period with similar managemental practices

except feeding treatment. All the experimental groups / replicates were kept in different cages keeping in view their group wise feeding treatments.

Fresh, clean and cool drinking water was provided to the experimental bird's *ad-libitum*. All the precautionary measures against diseases were taken throughout the experimental period

3.3 Preparation of Sample and Feeding Management

The fresh sample of tamarind fruit was procured from local market. The seed of tamarind fruit was separated with an intension to get pulp of fruit only. The clean pulp of tamarind fruit was kept for oven drying at 100^0 C for 24 hours. The oven dried sample was grounded for its further use. Every time the fresh ground sample was prepared before preparation of experimental diet for treatment groups.

As per the experimental program control group (T_0) was provided standard layer phase-I diet as per BIS-2007 specifications without any treatment. Treatment group (T1) was provided DTPP @250gm/100kg (0.25%) feed, T_2 with DTPP @500gm/100kg feed (0.5%) and T3 with DTPP @ 1000gm/100kg (1%). Feeding treatment was initiated from 21^{st} week and was continued till end of 36^{th} week without any changes.

Table- 1: Feeding Treatment adopted for experimental layer birds

	Treatment	**Number of replicates**	**No. of birds / group**

T_0	Control (Standard Layer phase-I Diet)	03	60
T_1	T_0 + DTPP @ 250gm per 100kg Feed	03	60
T_2	T_0 + DTPP @ 500gm per 100kg Feed	03	60
T_3	T_0 + DTPP @1000gm per 100kg Feed	03	60

Table- 2: Percent Ingredient Composition of Layer I phase Ration

Sr. No.	**Ingredient (%)**	**T_0**	**T_1**	**T_2**	**T_3**
1	**Maize (Ground)**	42	42	42	42
2	Jowar (Ground)	14	14	14	14
3	DORB	06	06	06	06
4	Sunflower meal	04	04	04	04
5	Soybean Meal	22	22	22	22
6	LSP	2.6	2.6	2.6	2.6
7	Shell Grit	7.5	7.5	7.5	7.5

8	Di-Calcium Phosphate	1.5	1.5	1.5	1.5
9	Salt	0.4	0.4	0.4	0.4
	Total	100	100	100	100
10	Dried Tamarind Pulp Powder (over and above)	00	0.25	0.50	1.00

Table-3: Proximate composition (% DMB) of dried pulp of Tamarind fruit

Nutrients	Composition (% DMB)
Dry Matter	84.8
Crude Protein	4.67
Crude Fiber	4.4
Ether Extract	2.2
Total Ash	2.0
Calcium	0.2

Phosphorus	0.40
Nitrogen Free Extract	86.73

Table- 4: Proximate composition (% DMB) of Layer Phase I ration

Nutrient	**T_0**	**T_1**	**T_2**	**T_3**
Dry matter	90.12	90.08	90.04	90.00
Crude Protein	17.85	17.86	17.87	17.89
ME/Kcal/kg (calculated)	2545.92	2545.92	2545.92	2545.92
Ether Extract	3.920	3.925	3.930	3.941
Crude Fiber	7.04	7.05	7.06	7.08
Total ash	5.700	5.704	5.739	5.759
Calcium	4.280	4.280	4.280	4.281
Phosphorus	0.723	0.723	0.720	0.722
Nitrogen free Extract	65.49	65.461	65.441	65.330

3.4 Parameter studies

3.4.1 Weekly body weight changes

The weekly live body weight of individual bird from each replicate was recorded on digital electronic weighing machine at morning hours. The schedule and procedure was properly maintained throughout the experimental period. The average weekly live body weight and body weight changes were calculated for all treatment groups during 20st to 36th week.

3.4.2 Feed efficiency per egg mass

The feed efficiency of experimental birds were calculated on the basis of feed consumed (gm) by experimental birds during week period and total egg mass produced (gm) by experimental birds during that specific period.

Following formula was adopted for calculation of feed efficiency at the end of respective week.

Feed efficiency = Feed consumed (gm) / Egg mass produced (gm)

3.4.3 Egg production:

The weekly egg production of each experimental group was recorded during 21st to 36th week period from the beginning of experimental period, each day the record of number of egg produced by

respective experimental group was maintained. The everyday data was summarized at the end of each week.

3.4.4 Serum Biochemical Parameters

The blood samples was collected at the beginning of experiment (20^{th} week), mid (28^{th} week) and end (36^{th} week) of experimental period. The specific volume of blood was collected from wing vein of representative experimental birds. The blood samples were subjected for centrifugation for separation of serum. Further the serum samples were maintained at - 20^{0}C until analyzed.

Serum samples were analyzed for total cholesterol, LDL, HDL, total protein, albumin, globulin and triglyceride. The biochemical estimations were performed using Cromtech Vet-biochemistry Semi – Auto Analyzer PUS-2018. The methodology and the set of reagents used in respect of each parameter was as per the recommendations of the manufacturer.

3.4.5 Egg parameters (Physical)

For the estimation of physical quality of eggs produced by experimental birds egg weight, shell thickness, yolk color, albumin index, yolk index and haugh unit were analyzed. The representative number of eggs were collected from respective experimental group at the beginning of experiment (20^{th} week), mid (28^{th} week) and end (36^{th} week).

Egg weight **:** Eggs were weighed on digital electronic weighing balance and data was recorded.

Shell thickness **:** The shell piece (devoid of shell membrane) from representative broken egg was collected. The

samples were collected comprising broad end, narrow end and middle and their thickness were measured using Screw gauge. The average of three pieces represented shell thickness.

Egg yolk colour **:** The yolk color was scored by matching (contrast) technique using DSM yolk colour fan. The colour intensity was denoted from 1 to 16 scale according to degree of yolk colour.

Albumen index **:** The height and diameter of egg albumen were obtained using Spherometer and Vernier Caliper respectively. Albumen index was calculated using following formula,

Albumen Index = Height of thick albumen / average width of thick albumen

Yolk index **:** The height (at centre) and diameter of the yolk was measured using Spherometer and Vernier Caliper. Yolk index was calculated as,

Yolk index = Height of yolk / width of yolk

Haugh unit **:** The height of albumen was recorded at two places (one near to yolk and other at the end of dense albumen) by using Spherometer and average was drawn. Haugh unit was calculated using following formula,

$$\text{Haugh Unit} = 100 \log (H + 7.57 - 1.7\, W^{0.37})$$

Where, H = Height of thick albumin (mm)
W = Weight of Egg (gm)

3.4.6 Egg Yolk Biochemical parameter

Egg yolk from representative eggs were processed for estimation of total cholesterol, triglyceride, LDL and HDL at beginning (20^{th} week), mid (28^{th} week) and end (36^{th} week) of experiment. Initially yolk was separated carefully from the albumin. One gram of yolk was placed into a centrifuge tube. Fifteen milliliters of chloroform: methanol (2:1 v/v) was added, blended on a vortex mixture, and allowed to extract for 12 h and extracted yolk samples were analyzed for cholesterol according to the colorimetric method. Sample of 0.5 ml extracted yolk was transferred into sterile tube containing 6 ml glacial acetic acid and mixed then, 4 ml ferric chloride reagent was added, shaken and let to cool. The estimations were done by using Cromtech Vet-biochemistry Semi – Auto Analyzer PUS-2018.

3.5 Statistical Analysis

The data recorded for each parameter was statistically analyzed as per Snedecor and Cochran (1994) and results were assessed to draw conclusion.

3.6 Analytical method

Feed ingredient used in the study were analyzed for proximate principles (A.O.A.C, 2012), calcium (Talapatra *et al*. 1940) and phosphorus contents.

Results and Discussion

CHAPTER – IV

RESULTS AND DISCUSSION

The present study was programed to evaluate the effect of supplementation of different levels of dried tamarind pulp powder (DTPP) through feed on serum and egg yolk cholesterol, HDL, LDL and triglyceride in layer poultry birds.

The effect was also studied in terms of weekly body weight changes, feed efficiency, egg production and egg quality parameters (physical). The serum biochemical parameters include total protein, albumin and globulin for evaluation of normal liver functioning.

In the previous chapter, observations of various research workers exhibited positive correlation between supplementation of tamarind pulp with serum as well as egg yolk cholesterol.

The data of individual parameter during 20^{th} to 36^{th} week was recorded periodically and statistically analyzed to draw appropriate conclusion.

4.1 Weekly body weight changes (g)

The average initial body weights (g) as well as weekly body weight changes from 20^{rth} to 36^{th} week are depicted in Table-5 and presented graphically in Graph-1.

The average initial body weight (g) of layer birds (20^{th} week) randomized in four experiment groups were 1282.67 ± 6.70, 1287.11 ± 5.39, 1272.67 ± 7.57 and 1288.11 ± 3.44 g in treatment group T_0, T_1, T_2 and T_3 respectively.

The data analysis of initial body weight among treatment group revealed no significant variation. The data also indicated that all the experimental birds randomized in various treatment groups were depicting normal body weights as per the specified standards for layer birds.

The Average values of live body weight (g) of experimental birds during 21st (1314.89 ± 4.66, 1313.44 ± 6.34, 1312.56 ± 3.50 and 1314.89 ± 2.07), 22nd (1359 ± 5.42, 1354.78 ± 2.64, 1357.89 ± 5.53 and 1357.56 ± 6.20), 23rd (1385.11 ± 4.55, 1381.33±2.15,1385.56±5.56 and 1387.78±5.13), 24th (1414.22±6.22, 1411.33±5.84, 1407.11±10.14 and 1416.78±5.67), 25th (1425.56±5.41, 1420±4.98, 1422.11±19.70 and 1431.56±4.92), 26th (1433.56±4.90,1432.56±5.66, 1437.22±4.40 and 1438±3.45), 27th (1447±4.37,1456.67±7.26,1450.78±4.31and 1448.89±4.05), 29th (1464.33±4.92, 1480±6.92, 1469.44±4.46 and 1462.89±4.31), 30th (1479.56±5.50, 1486.89±6.52, 1480.67±5.37 and 1473.11±5.06), 31st (1490.78±5.66, 1494.33±6.87, 1491.56±5.19 and 1480.33±6.35), 32th (1498.33±5.49 1500.67±5.13, 1499.67±5.45 and 1494.11±5.67), 33rd (1506.33±5.18, 1506.33±5.18, 1505.44±4.86 and 1504.67±5.48), 34th (1510.33±4.20, 1513.11±5.02, 1510.78±5.14 and 1510.44±4.88), 35th (1518±5.22, 1519±5.23, ±1515.44±4.83 and 1515.56±4.30) and 36th (1521.44±5.76, 1527.44±5.76, 1521.78±5.42 and 1522.67±4.10) for treatments T_0, T_1, T_2 and T_3 respectively.

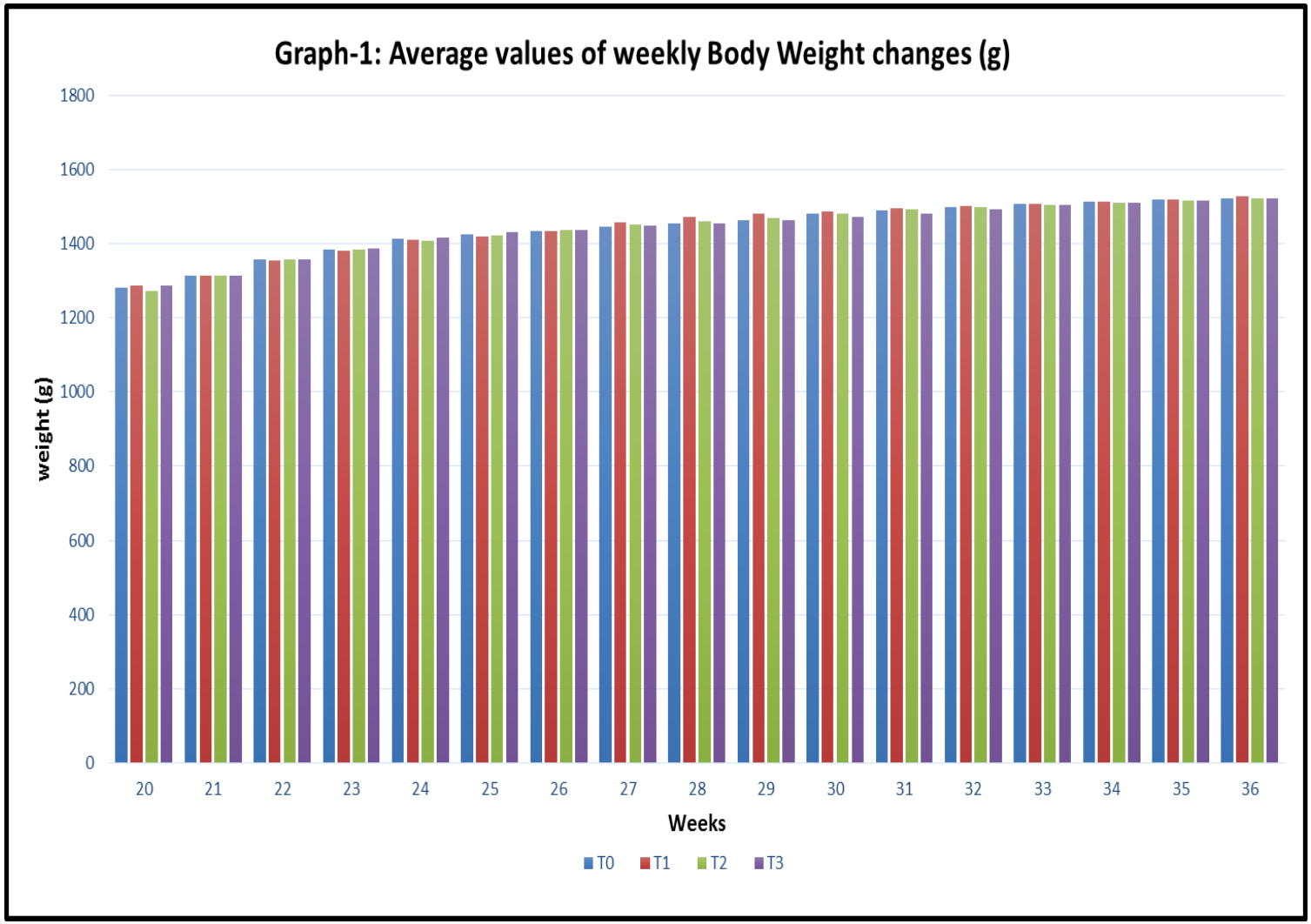
The statistical analysis of weekly body weight (g) of experimental birds from different treatment group has shown no significant variation during 21st to 36th week period except 28th (1453.33±4.57, 1470.78±7.22, 1459.89±4.56 and 1454.33±3.70) week.

The supplementation of DTPP at various levels for 16 weeks period resulted in maintaining proper body weight without any adverse effect. The observations revealed that supplementation of DTPP have maintained normal enzymatic secretion promoting proper digestion and feed efficiency. It was also reported that supplementation of tamarind improves gut health by maintaining favorable gut microorganisms and decreasing pathogenic microorganisms.

Table 5: Mean values of weekly body weight changes (g)

week	Treatment			
	T_0	T_1	T_2	T_3
20th	1282.67±6.70	1287.11±5.39	1272.67±7.57	1288.11±3.44
21st	1314.89±4.66	1313.44±6.34	1312.56±3.50	1314.89±2.07
22nd	1359.00±5.42	1354.78±2.64	1357.89±5.53	1357.56±6.20
23rd	1385.11±4.55	1381.33±2.15	1385.56±5.56	1387.78±5.13
24th	1414.22±6.22	1411.33±5.84	1407.11±10.14	1416.78±5.67
25th	1425.56±5.41	1420.00±4.98	1422.11±19.70	1431.56±4.92
26th	1433.56±4.90	1432.56±5.66	1437.22±4.40	1438.00±3.45
27th	1447.00±4.37	1456.67±7.26	1450.78±4.31	1448.89±4.05
28th	$1453.33±4.57^{b}$	$1470.78±7.22^{a}$	$1459.89±4.56^{ab}$	$1454.33±3.70^{b}$
29th	1464.33±4.92	1480.00±6.92	1469.44±4.46	1462.89±4.31
30th	1479.56±5.50	1486.89±6.52	1480.67±5.37	1473.11±5.06
31st	1490.78±5.66	1494.33±6.87	1491.56±5.19	1480.33±6.35
32nd	1498.33±5.49	1500.67±5.13	1499.67±5.45	1494.11±5.67
33rd	1506.33±5.18	1506.33±5.18	1505.44±4.86	1504.67±5.48
34th	1510.33±4.20	1513.11±5.02	1510.78±5.14	1510.44±4.88
35th	1518.00±5.22	1519.00±5.23	1515.44±4.83	1515.56±4.30
36th	1521.44±5.76	1527.44±5.76	1521.78±5.42	1522.67±4.10

Note: Mean with different superscript in column differs significantly ($P<0.01$).


Graph-1: Average values of weekly Body Weight changes (g)
1800
1600
1400
1200
1000
800
600
400
200
0
weight (g)
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Weeks
T0
T1
T2
T3

4.2 Feed efficiency per egg mass

The feed efficiency per egg mass of respective treatment group was calculated on the basis of weekly feed consumption and total egg mass produced during that particular week. The mean values of feed efficiency observed during respective weeks in different treatment groups are shown in Table- 6 and same is presented graphically in Graph- 2.

The mean values of feed efficiency per egg mass observed in various treatment during 21^{st} (11.43±0.03, 11.63±0.19, 11.57±0.03 and 11.45±0.03), 22^{nd} (6.1±0.05, 6.08±0.04, 6.2±0.16 and 5.98±0.06), 23^{rd} (4.43±0.05, 4.55±0.04, 4.55±0.16 and 4.4±0.06), 24^{th} (3.51±0.01, 3.57±0.01, 3.63±0.04 and 3.46±0.05), 25^{th} (3.25±0.01, 3.24±0.03, 3.23±0.03 and 3.3±0.06), 26^{th} (2.62±0.04, 3.63±1.03, 2.64±0.03and 2.73±0.16), 27^{th} (2.33±0.03, 2.28±0.04, 2.34±0.02 and 2.26±0.01), 28^{th} (2.11±0.01, 2.13±0.03, 2.19±0.03 and 2.15±0.02), 29^{th} (2.12±0.02, 2.11±0.03, 2.1±0.02 and 2.12±0.01), 30^{th} (2.22±0.07, 2.12±0.01, 2.17±0.01 and 2.09±0.01), 31^{st} (2.16±0.03, 2.17±0.04, 2.29±0.06 and 2.16±0.03), 32^{nd} (2.16±0.03, 2.15±0.03, 2.12±0.01 and 2.14±0.02), 33^{rd} (2.16±0.03, 2.14±0.01, 2.2±0.01 and 2.15±0.01), 34^{th} (2.2±0.01, 2.18±0.02, 2.18±0.02 and 2.19±0.02), 35^{th} (2.19±0.00, 2.16±0.01, 2.19±0.04 and 2.18±0.01) and 36^{th} (2.17±0.01, 2.16±0.01, 2.17±0.03 and 2.18±0.02) for treatments T_0, T_1, T_2 and T_3 respectively.

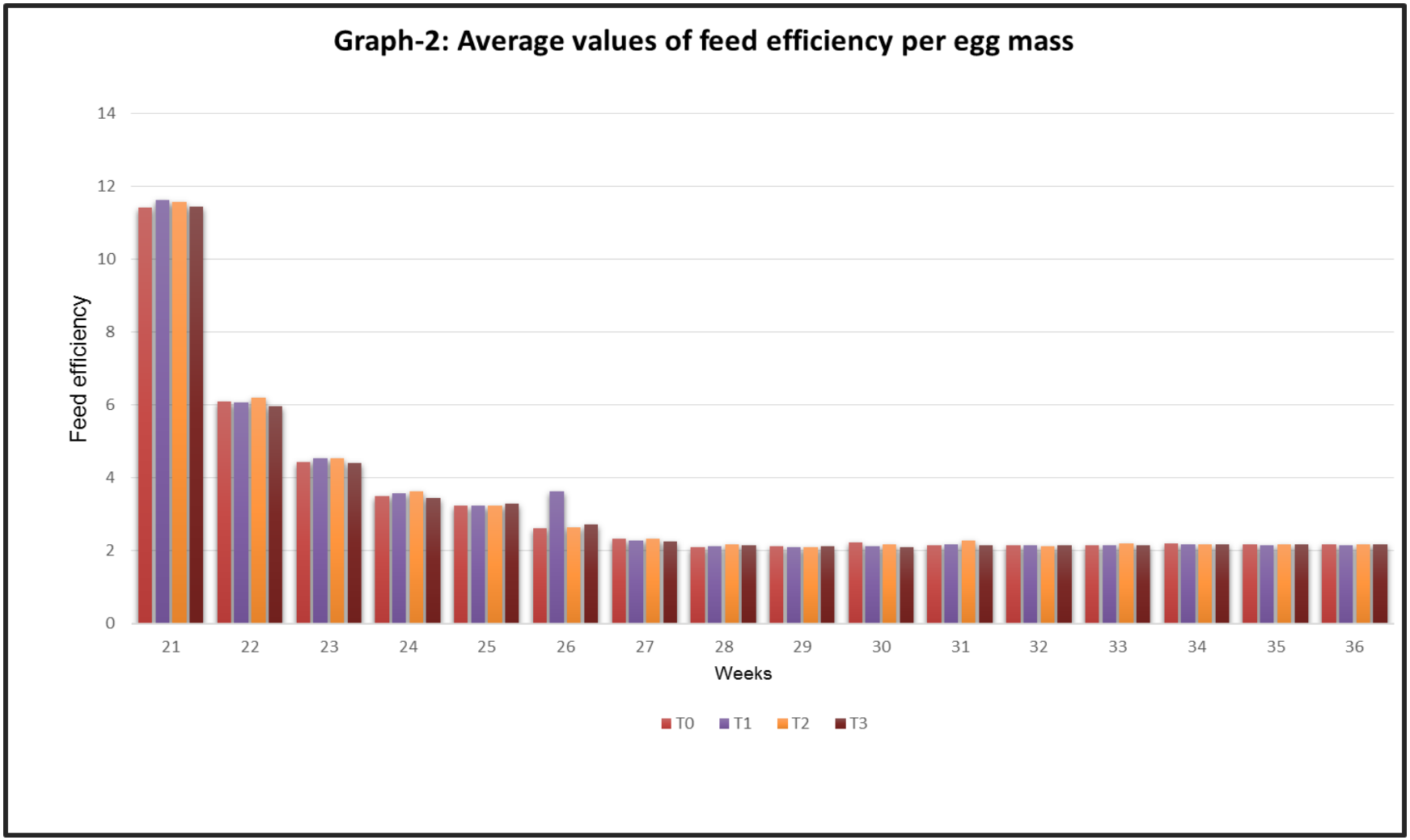
The statistical application to observed data revealed no significant variation among treatment groups. The observations revealed that there is no adverse effect of supplementation of DTPP at suggested levels. The experimental birds have maintained proper feed efficiency as per prevailing standards.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in feed efficiency after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

However Chowdhury *et al*., (2005) reported that supplementation of tamarind pulp at 2% level improved feed efficiency due to increase in egg mass production.

Table 6: Average values of Feed efficiency per egg mass

week	Treatment			
	T_0	T_1	T_2	T_3
21st	11.43±0.03	11.63±0.19	11.57±0.03	11.45±0.03
22nd	6.10±0.05	6.08±0.04	6.20±0.16	5.98±0.06
23rd	4.43±0.05	4.55±0.04	4.55±0.16	4.40±0.06
24th	3.51±0.01	3.57±0.01	3.63±0.04	3.46±0.05
25th	3.25±0.01	3.24±0.03	3.23±0.03	3.30±0.06
26th	2.62±0.04	3.63±1.03	2.64±0.03	2.73±0.16
27th	2.33±0.03	2.28±0.04	2.34±0.02	2.26±0.01
28th	2.11±0.01	2.13±0.03	2.19±0.03	2.15±0.02
29th	2.12±0.02	2.11±0.03	2.10±0.02	2.12±0.01
30th	2.22±0.07	2.12±0.01	2.17±0.01	2.09±0.01
31st	2.16±0.03	2.17±0.04	2.29±0.06	2.16±0.03
32nd	2.16±0.03	2.15±0.03	2.12±0.01	2.14±0.02
33rd	2.16±0.03	2.14±0.01	2.20±0.01	2.15±0.01
34th	2.20±0.01	2.18±0.02	2.18±0.02	2.19±0.02
35th	2.19±0.00	2.16±0.01	2.19±0.04	2.18±0.01
36th	2.17±0.01	2.16±0.01	2.17±0.03	2.18±0.02


Graph-2: Average values of feed efficiency per egg mass
Feed efficiency
14
12
10
8
6
4
2
0
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Weeks
T0
T1
T2
T3

4.3 Weekly Egg Production (%)

The average values of weekly egg production (%) observed in various experimental groups are shown in Table-7 and the same is presented graphically in Graph- 3.

The mean values of weekly egg production (%) observed in various treatment groups during 21st (26.4±0.64, 24.42±0.86, 25.9±0.71 and 26.32±0.33), 22nd (41.78±0.82, 42.69±0.30, 41.46±0.34 and 42.58±0.97), 23rd (57.18±1.14, 55.87±1.00, 56.33±1.23 and 56.32±0.49), 24th (64.76±1.74, 64.31±2.06, 65.12±1.64 and 65.52±0.87), 25th (68.43±1.60, 69.85±0.92, 69.46±1.33 and 68.45±0.33), 26th (85.02±2.18, 84.33±2.51, 84.69±0.63 and 86.26±0.54) 27th (91.36±0.62, 91.15±0.94, 90.67±1.03 and 91.33±2.00), 28th (94.26±1.20, 94.5±0.97, 95.26±0.79 and 95.66±0.74), 29th (96.53±0.68, 96.12±1.24, 97.90±1.36 and 96.57±0.29),30th (93.7±0.83, 94.24±0.58, 93.64±0.91 and 95.15±1.70), 31st (93.44±0.54, 94.04±0.79, 93.88±0.14 and 93.59±0.32), 32nd (94.32±1.26, 95.23±1.30, 96.29±0.53 and 95.74±0.84), 33rd (93.12±0.62, 94.05±0.94, 94.76±0.80 and 93.92±0.20, 34th (92.33±1.07, 92.14±1.01, 91.74±0.16 and 91.34±0.53), 35th (91.16±0.53, 92.04±1.03, 91.57±0.25 and 91.37±0.53) and 36th (91.34±0.53, 91.2±0.50, 91.64±0.81 and 91.24±0.43) week revealed no significant variation (P>0.05).

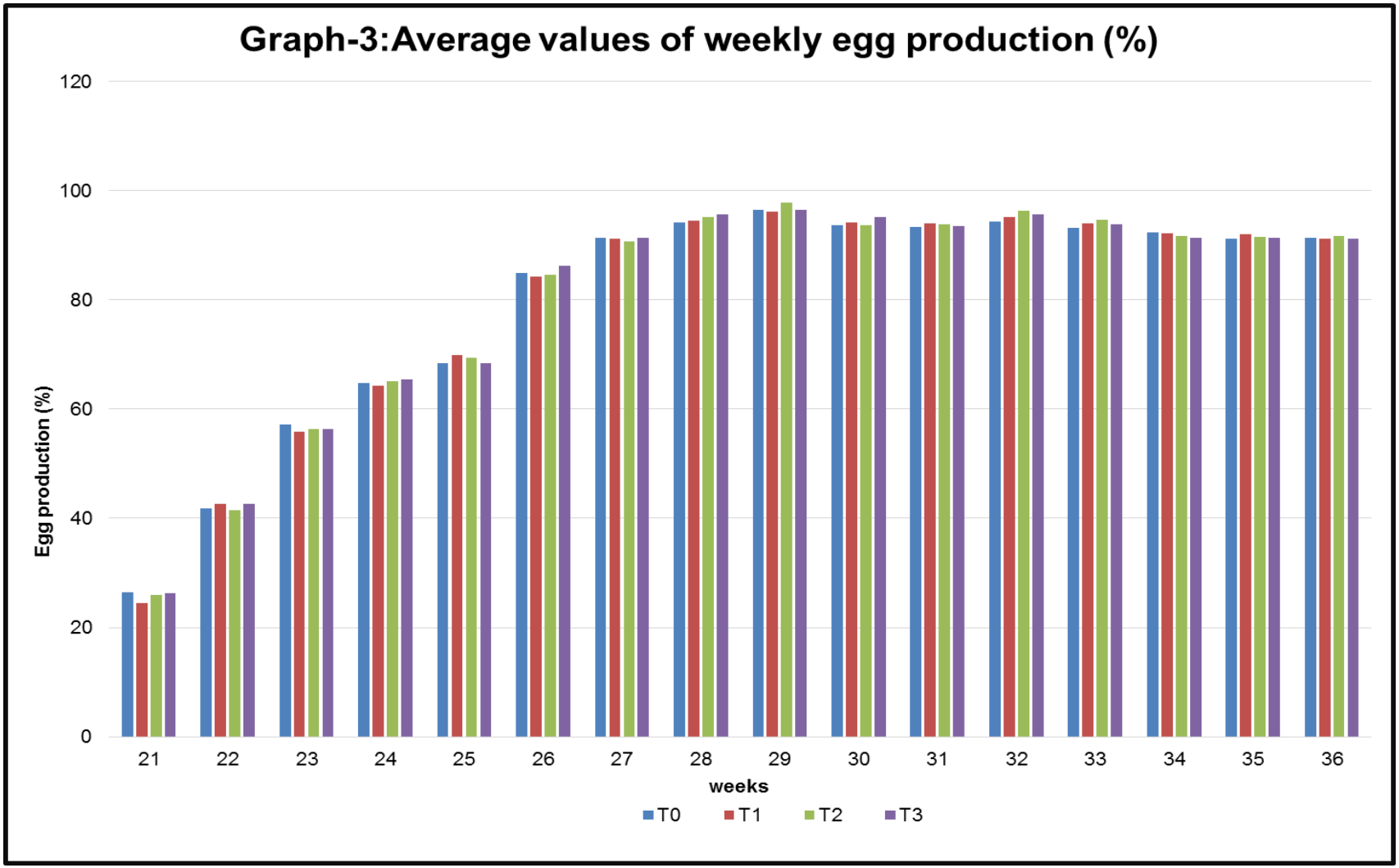
The supplementation of DTPP at various specified levels in experimental layer birds has shown no adverse effect on egg production. The observations of egg production are in accordance with standard production values.

Yingyuen *et al*. (2011) reported non-significant variation in egg production after feeding 0.4% tamarind in layer diet. However Chowdhury *et al*., (2005) reported that supplementation of tamarind pulp at 2% level improved egg production and egg mass with further decrease in the production performance with increasing level of tamarind up to 8 %.

In present study, the maximum level of DTPP was maintained at 1% which has shown no significant effect on egg production. This indicates that the inclusion level of tamarind pulp at the levels lower than 1% do not have positive affect on egg production.

Table 7: Mean values of weekly egg production (%)

Week	Treatment			
	T_0	T_1	T_2	T_3
21st	26.40±0.64	24.42±0.86	25.90±0.71	26.32±0.33
22nd	41.78±0.82	42.69±0.30	41.46±0.34	42.58±0.97
23rd	57.18±1.14	55.87±1.00	56.33±1.23	56.32±0.49
24th	64.76±1.74	64.31±2.06	65.12±1.64	65.52±0.87
25th	68.43±1.60	69.85±0.92	69.46±1.33	68.45±0.33
26th	85.02±2.18	84.33±2.51	84.69±0.63	86.26±0.54
27th	91.36±0.62	91.15±0.94	90.67±1.03	91.33±2.00
28th	94.26±1.20	94.50±0.97	95.26±0.79	95.66±0.74
29th	96.53±0.68	96.12±1.24	97.90±1.36	96.57±0.29
30th	93.70±0.83	94.24±0.58	93.64±0.91	95.15±1.70
31st	93.44±0.54	94.04±0.79	93.88±0.14	93.59±0.32
32nd	94.32±1.26	95.23±1.30	96.29±0.53	95.74±0.84
33rd	93.12±0.62	94.05±0.94	94.76±0.80	93.92±0.20
34th	92.33±1.07	92.14±1.01	91.74±0.16	91.34±0.53
35th	91.16±0.53	92.04±1.03	91.57±0.25	91.37±0.53
36th	91.34±0.53	91.20±0.50	91.64±0.81	91.24±0.43


Graph-3:Average values of weekly egg production (%)
120
100
80
60
40
20
0
Egg production (%)
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
weeks
T0
T1
T2
T3

4.4 Serum Biochemical parameters

4.4.1 Total Cholesterol (mg/dl)

The mean values of serum total cholesterol (mg/dl) observed in different treatment groups at 20th, 28th and 36th week of study are shown in Table-8 and same is presented graphically in Graph- 4.

The average initial values of total cholesterol (mg/dl) at 20th week were 164.3±5.64, 159.13±5.11, 160.38±3.61 and 161.71±4.23. The initial values of total cholesterol observed in different groups were physiologically normal and statistically non-significant.

As per the scheduled program, the values of total cholesterol (mg/dl) observed in different experimental groups at 28th week were 157.73±2.94, 125.96±1.67, 128.23±2.38 and 125.26±1.97. The statistical application to observed values denoted that the levels of serum total cholesterol among treatment groups T_1,T_2 and T_3 were significantly lower ($P<0.01$) than control group T_0.

After supplementation of DTPP in different experimental groups at the levels of 0.25%, 0.5% and1% for 8 weeks period the levels of serum total cholesterol was significantly reduced by 18 to 20 %.

The average values of total cholesterol (mg/dl) at 36th week were 155.1±3.04, 120.8±2.18, 119.48±2.03 and 117.08±1.57 in control group T_0

and treatment group T_1, T_2, and T_3 respectively. It was observed that significantly lower ($p<0.01$) cholesterol levels were recorded in all treatment group as compared to control T_0. After supplementation of DTPP in different treatment group at the levels of 0.25%, 0.5% and 1% for 16 weeks period the levels of serum total cholesterol was reduced by 25 to 28%.

Similar observations were reported by Chowdhury *et al*., (2005) with significantly reduced serum cholesterol levels in layer after supplementation of DTPP at 2% level.

Martinello *et al*., (2006) reported 50% reduction in total serum cholesterol after supplementation of Tamarindus indica L. fruit pulp extract (5%) in hamster.

Similar observations were also reported by Iftekhar *et al*., (2006) in humans, Jindal *et al*., (2011) in rats, Khairunnuur *et al*., (2011) in rats and Shinde *et al*., (2015) in broilers with significantly reduced serum total cholesterol levels after supplementation of DTPP/ tamarind pulp extract at different levels.

The observations of present study are in agreement with observations reported by various workers as mentioned above.

The possible mechanism of reducing serum total cholesterol might be due to production of cholic and deoxycholic bile acids from cholesterol. The excess of cholesterol is converted to their bile acids by hepatocytes and are conjugated with glycine and taurine. These acids enter in to the small intestine where they are absorbed and directed to the liver and

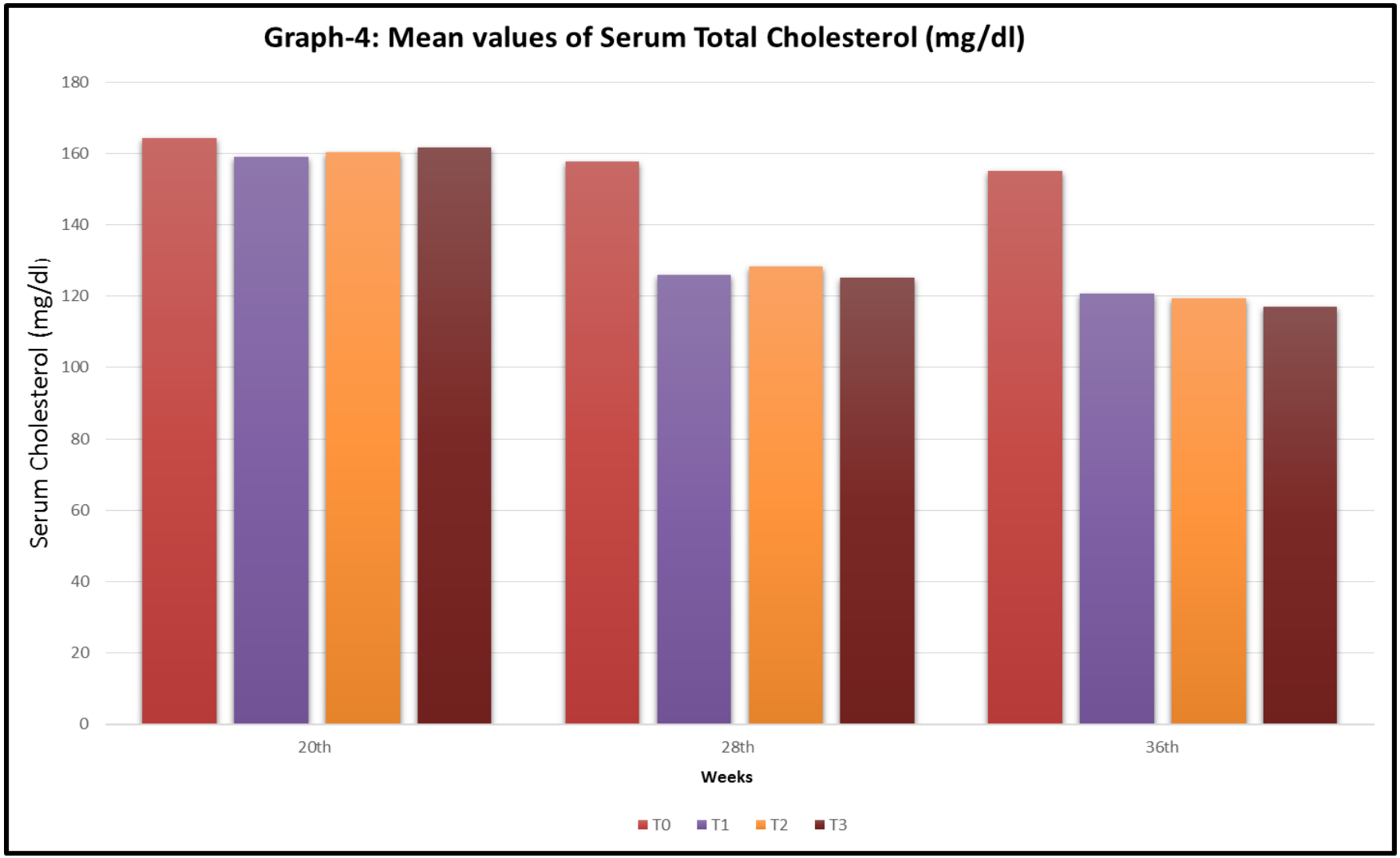
decrease in bile acid recycling would ultimately results in lowering in serum cholesterol concentration.

The suggested levels of dietary tamarind in present study might have reduced serum cholesterol concentration by increasing the +conversion of cholesterol to bile acids.

Table 8: Mean values of serum cholesterol (mg/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	164.3±5.64	159.13±5.11	160.38±3.61	161.71±4.23
28th	157.73±2.94[a]	125.96±1.67[b]	128.23±2.38[b]	125.26±1.97[b]
36th	155.1±3.04[a]	120.8±2.18[b]	119.48±2.03[b]	117.08±1.57[b]

Note: Mean with different superscript in column differs significantly (P<0.01).


Graph-4: Mean values of Serum Total Cholesterol (mg/dl)
Serum Cholesterol (mg/dl)
180
160
140
120
100
80
60
40
20
0
20th
28th
36th
Weeks
T0
T1
T2
T3

4.4.2 Serum HDL (mg/dl)

The mean values of serum HDL (mg/dl) observed in different experimental groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table-9 and presented graphically in Graph- 5.

The average initial values of serum HDL (mg/dl) at 20^{th} week were 30.24±4.51, 29.43±4.21, 31.38±3.98 and 31.5±4.16 in T_0, T1, T_2 and T_3 respectively. The initial values of serum HDL observed were physiologically normal and statistically non-significant.

The mean values of serum HDL (mg/dl) observed at 28^{th} week were 35.87±2.20, 50.02±2.85, 51.68±2.38 and 53.21±2.31 in control group T_0, T_1, T_2 and T_3 respectively. The statistical application the present data revealed significant variation ($P<0.01$) in serum HDL values with lowest in non-supplemented control group (T_0) followed by T_1, T_2 and T_3.

The post treatment results observed at the end (36^{th} week) revealed significant variation ($p<0.01$) with highest serum HDL level in treatment T_1 (56.34±2.55), followed by T_2 (55.45±2.55) and T_3 (55.65±1.93) and lowest in control group T_0 (38.99±2.95).

The supplementation of DTPP at various suggested levels in present study significantly increased serum HDL with 42 to 45 % in experimental group as compared to control.

Martinello *et al*., (2006) reported similar observations with increase in serum HDL levels up to 61% in hamster after supplementation of tamarind fruit pulp extract (5%). Similar observations were also reported by Jindal *et al*., (2011) and Khairunnuur *et al*., (2011) with significantly increased serum HDL levels in rats after supplementation of ethanolic extract (100mg/kg) and aqueous extract (50mg/kg) of tamarind pulp respectively.

The increase in serum HDL levels is supposed to be beneficial to host. In present study the observations are in agreement with other reported studies. The supplementation of DTPP at suggested levels significantly increased serum HDL levels as compare to control group. It might tamarind probably decreases LDL by decreasing the total amount of cholesterol in blood.

4.4.3 Serum LDL (mg/dl)

The mean values of serum LDL (mg/dl) observed in different experimental groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table -10 and same is presented graphically in Graph- 6.

The average initial values of serum LDL (mg/dl) at 20th week were 60.54±2.57, 61.98±3.38, 58.68±3.33 and 58.78±2.75 in T_0, T_1, T_2 and T_3 respectively. The initial values of serum LDL observed were physiologically normal and statistically non-significant.

The average values of serum LDL (mg/dl) observed at 28th week were 59.80±2.68, 39.48±2.90, 42.36±4.28 and 37.21±3.43 in T_0, T1, T_2 and T_3 respectively. The statistical application to present data revealed significant variation ($P<0.01$) in serum LDL values with highest in non-supplemented control group (T_0) followed by T_1, T_2 and T_3.

The post treatment results observed at the end (36th week) revealed significant variation ($P<0.01$) with lowest serum LDL level in treatment T_3 (34.85±4.11) followed T_1 (34.99±4.63) and T_2 (40.5±3.39) and highest in control T_0 (57.15±1.72).

The treatment group T_1, T_2 and T_3 has shown significantly ($P<0.01$) lower serum LDL values than control group T_0. The supplementation of DTPP at various suggested levels in present study significantly reduced serum LDL with 30 to 39% in experimental group as compared to control.

Iftekhar *et al*., (2006) reported similar observations in human model with significantly reduced serum LDL at dose of 15mg/kg body weight.

Similarly, Martinello *et al*., (2006) reported 73% reduction in serum LDL levels after supplementation of 5% tamarind pulp extract for 10 weeks in hamsters.

Similar observations were also reported by Khairunnuur *et al.,* (2011) and Chor Yin lin *et al*., (2013) with significantly reduced serum LDL levels after supplementation of tamarind pulp extract in rats and hamsters respectively.

The reduction in serum LDL levels might be due to epicatechins contents in Tamarindus indica (Luengthanaphol *et al*., 2004). The long term feeding of epicatechins believed to be beneficial for the suppression of high fat diet induced hypercholesteremia by modulating lipid metabolism.

Table 9: Mean values of Serum HDL (mg/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	30.24±4.51	29.43±4.21	31.38±3.98	31.50±4.16
28th	35.87±2.20^{b}	50.02±2.85^{a}	51.68±2.38^{a}	53.21±2.31^{a}
36th	38.99±2.95^{b}	56.34±2.55^{ab}	55.45±2.55^{a}	55.65±1.93^{a}

Note: Mean with different superscript in column differs significantly (P<0.01).

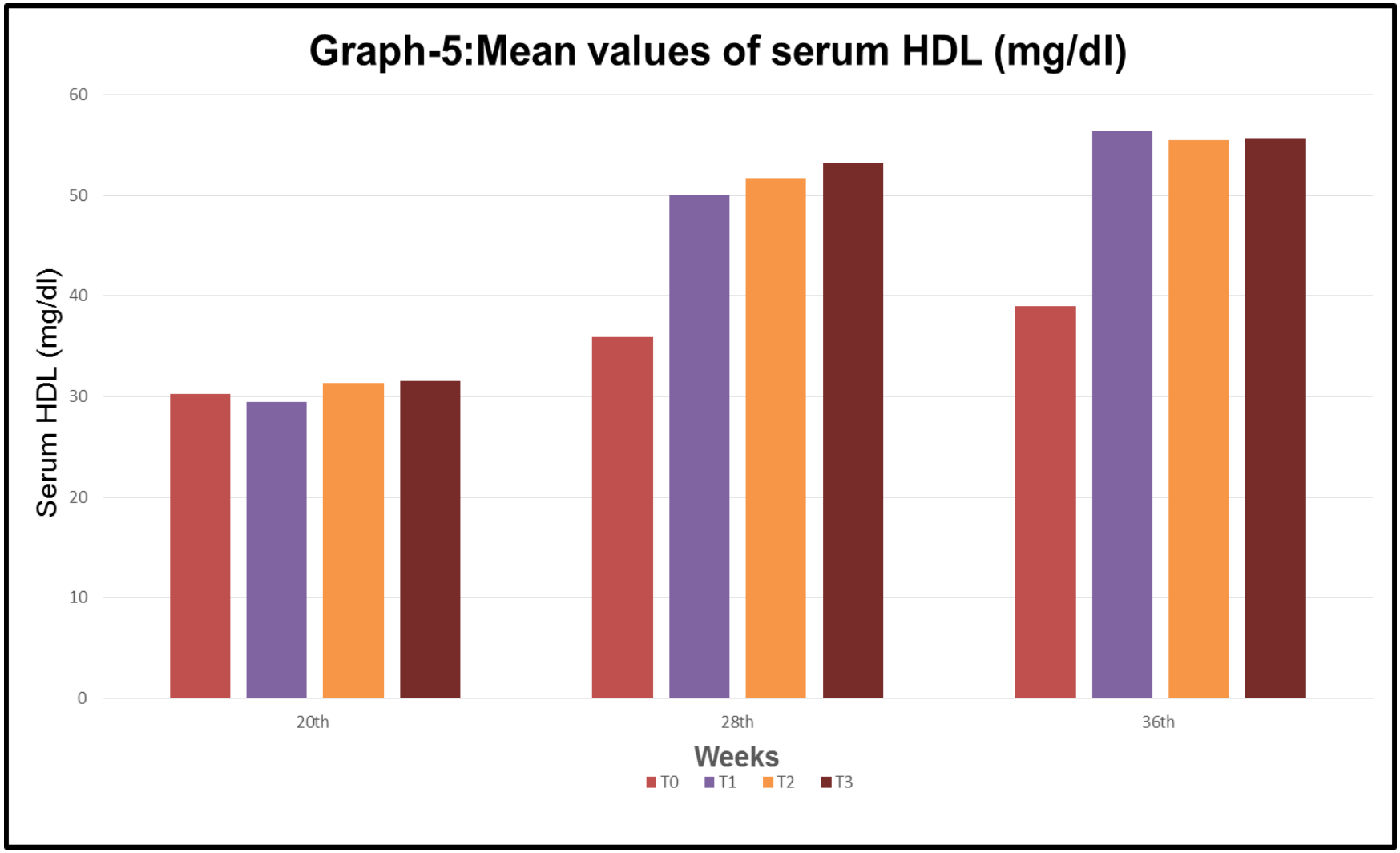
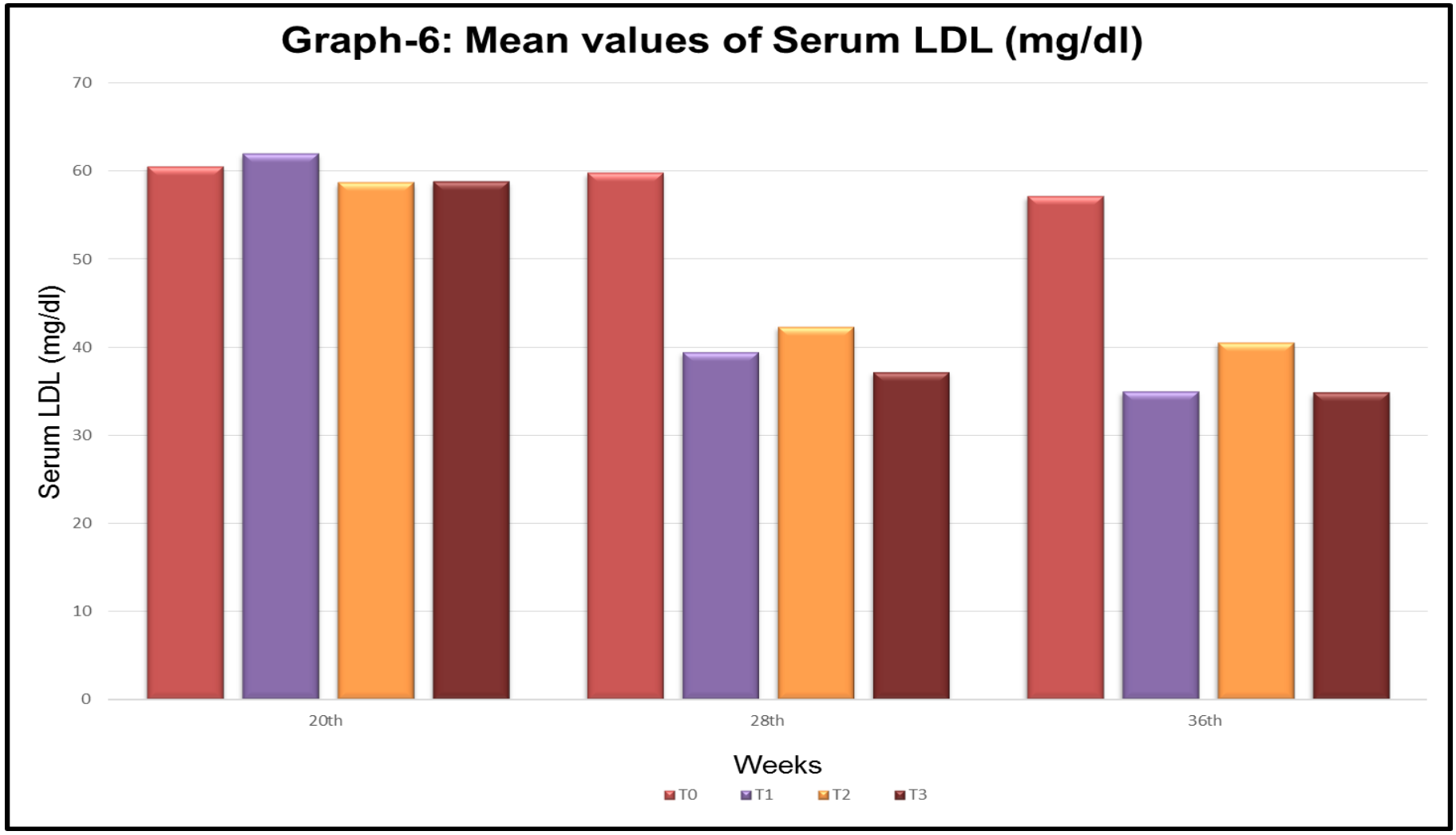

Graph-5:Mean values of serum HDL (mg/dl)
Serum HDL (mg/dl)
60
50
40
30
20
10
0
20th
28th
36th
Weeks
T0
T1
T2
T3

Table 10: Mean values of Serum LDL (mg/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	60.54±2.57	61.98±3.38	58.68±3.33	58.78±2.75
28th	59.80±2.67[a]	39.48±2.90[b]	42.36±4.28[b]	37.21±3.43[b]
36th	57.15±1.72[a]	34.99±4.63[b]	40.50±3.39[b]	34.85±4.11[b]

Note: Mean with different superscript in column differs significantly (P<0.01).


Graph-6: Mean values of Serum LDL (mg/dl)
70
60
50
40
30
20
10
0
Serum LDL (mg/dl)
20th
28th
36th
Weeks
T0
T1
T2
T3

4.4.4 Serum total protein (g/dl)

The mean values of serum total protein (g/dl) observed in different experimental groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table -11 and the same is presented graphically in Graph-7.

The average initial values of serum total protein (g/dl) at 20^{th} week were 4.55±0.09, 4.79±0.07, 4.62±0.15 and 4.99±0.20 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The values observed were within normal physiological range and were also statistically non-significant.

The average values of serum total protein (g/dl) at 28^{th} week were 4.57±0.12, 4.89±0.18, 4.62±0.15 and 4.63±0.23 in T_0, T_1, T_2 and T_3 respectively. The average values of serum total protein (g/dl) at 36^{th} week were 4.59±0.13, 4.77±0.18, 4.54±0.12 and 4.81±0.13 in T_0, T1, T_2 and T_3 respectively.

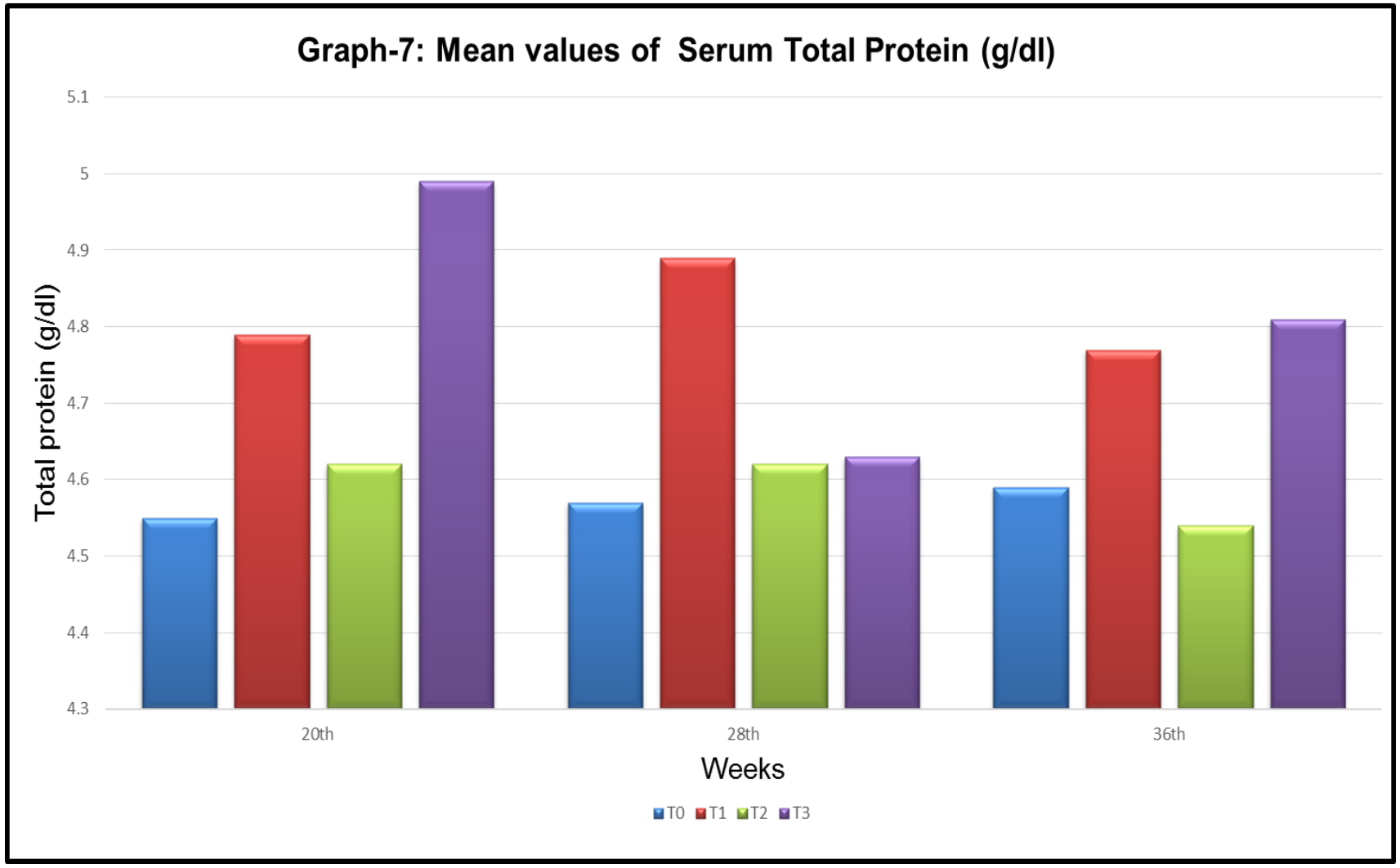
The average values of serum total protein observed during 28th and 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on serum total protein values indicating normal liver functioning of the experimental birds.

The values of total serum protein were also observed within normal physiological range as per standard specified values for layer birds.

Similar observations were also reported by Shinde *et al.,* (2015) in broiler poultry birds with non-significant effect of supplementation of DTPP at 0.25%, 0.5% 1% and 1.5%.

Table 11: Mean values of total serum protein (g/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	4.55±0.09	4.79±0.07	4.62±0.15	4.99±0.20
28th	4.57±0.12	4.89±0.18	4.62±0.15	4.63±0.23
36th	4.59±0.13	4.77±0.18	4.54±0.12	4.81±0.13


Graph-7: Mean values of Serum Total Protein (g/dl)
Total protein (g/dl)
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
4.3
20th
28th
36th
Weeks
T0 T1 T2 T3

4.4.5 Serum albumin (g/dl)

The mean values of serum albumin (g/dl) in different experimental groups at the 20th, 28th and 36th week are shown in Table -12 and same is presented graphically in Graph- 8.

The average initial values of serum albumin (g/dl) at 20th week were 2.23±0.08, 2.31±0.08, 2.25±0.06 and 2.27±0.06 in T_0, T_1, T_2 and T_3 respectively. The values observed were within normal physiological range and were also statistically non-significant.

The average values of serum albumin (g/dl) at 28th week were 2.24±0.23, 2.31±0.11, 2.26±0.06 and 2.29±0.08 in T_0, T_1, T_2 and T_3 respectively.

The average values of serum Albumin (g/dl) at 36th week were 2.21±0.05, 2.19±0.05, 2.5±0.13 and 2.42±0.15 in T_0, T_1, T_2 and T_3 respectively.

The average values of serum albumin observed during 28th and 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on serum albumin values indicating normal liver functioning of the experimental birds.

Similar observations were also reported by Shinde *et al*., (2015) in broiler poultry birds with non-significant effect of supplementation of DTPP at 0.25%, 0.5% 1% and 1.5%.

4.4.6 Mean values of globulin (g/dl)

The mean values of serum globulin (g/dl) in different groups at 20th, 28th and 36th week are shown in Table -13 and same is presented graphically in Graph- 9.

The average initial values of serum globulin (g/dl) at 20th week were 2.43±0.08, 2.66±0.17, 2.64±0.17 and 2.64±0.13 in T_0, T_1, T_2 and T_3 respectively. The values observed were within normal physiological range and were also statistically non-significant (P>0.05).

The average values of serum globulin (g/dl) at 28th week were 2.38±0.28, 2.48±0.21, 2.36±0.15 and 2.34±0.28 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average values of serum globulin (mg/dl) at 36th week were 2.38±0.15, 2.58±0.18, 2.04±0.11 and 2.39±0.17 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average values of serum globulin observed during 28th and 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected

on serum globulin values indication normal liver functioning of the experimental birds.

Similar observations were also reported by Shinde *et al.,* (2015) in broiler poultry birds with non-significant effect of supplementation of DTPP at 0.25%, 0.5%, 1% and 1.5%.

4.4.7 Serum Triglyceride (mg/dl)

The mean values of serum triglyceride (mg/dl) in different experimental groups at the 20^{th}, 28^{th} and 36^{th} week are shown in Table-14 and same is presented graphically in Graph- 10.

The average initial values of serum triglyceride (mg/dl) (20^{th} week) were 1605.11±63.62, 1657.44±113.19, 1581.33±89.03 and 1756.11±77.61 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The initial values of serum triglyceride were within normal physiological range and statistical application revealed no significant variation.

However significantly reduced serum triglyceride (mg/dl) levels were observed in treatment group T_3 (1246.67±21.06) followed by T_2 (1299.44±23.65) and T_1 (1342±55.33) as compare to control group T_0 (1707.33±87.91) at 28^{th} week.

The supplementation of DTPP at various suggested levels for 8 weeks in present study significantly reduced serum triglyceride with 22 to 28% in experimental group as compared to control.

The similar trends of reduction in serum triglyceride (mg/dl) levels was noticed during 36^{th} week with lowest serum triglyceride in treatment group T_3 (1200.67±25.91) followed by T_2 (1222.33±39.49), T_1 (1227.89±29.79) and highest in control group T_0 (1712.11±70.22).

The supplementation of DTPP at various suggested levels for 16 weeks in present study significantly reduced serum triglyceride with 29-31% in experimental group as compared to control.

The levels of serum triglyceride were significantly reduced due to supplement of DTPP at various level as suggested in the present study.

Similar observation were reported by Martinello *et al*., (2006) in hamster with 60% reduction in serum triglyceride levels after feeding of 5% dried tamarind pulp.

The serum triglyceride levels also reported to be reduced significantly after supplementation of 50 and 100 mg/kg ethanolic extract of Tamarindus indica pulp in rats (Jindal *et al*., 2011) and aqueous extract of Tamarindus indica at 50mg/kg in rats (Khairunnuur *et al.,* 2011).

It was also observed that the reduction in serum triglyceride levels is in accordance with reduction of serum cholesterol due to supplementation of DTPP.

The presence of various active principles in DTPP might be positively affected on lipid metabolism simultaneously leading to suppression of triglyceride production.

Table 12: Mean values of albumin (g/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	2.23±0.08	2.31±0.08	2.25±0.06	2.27±0.06
28th	2.24±0.23	2.31±0.11	2.26±0.06	2.29±0.08
36th	2.21±0.05	2.19±0.05	2.50±0.13	2.42±0.15

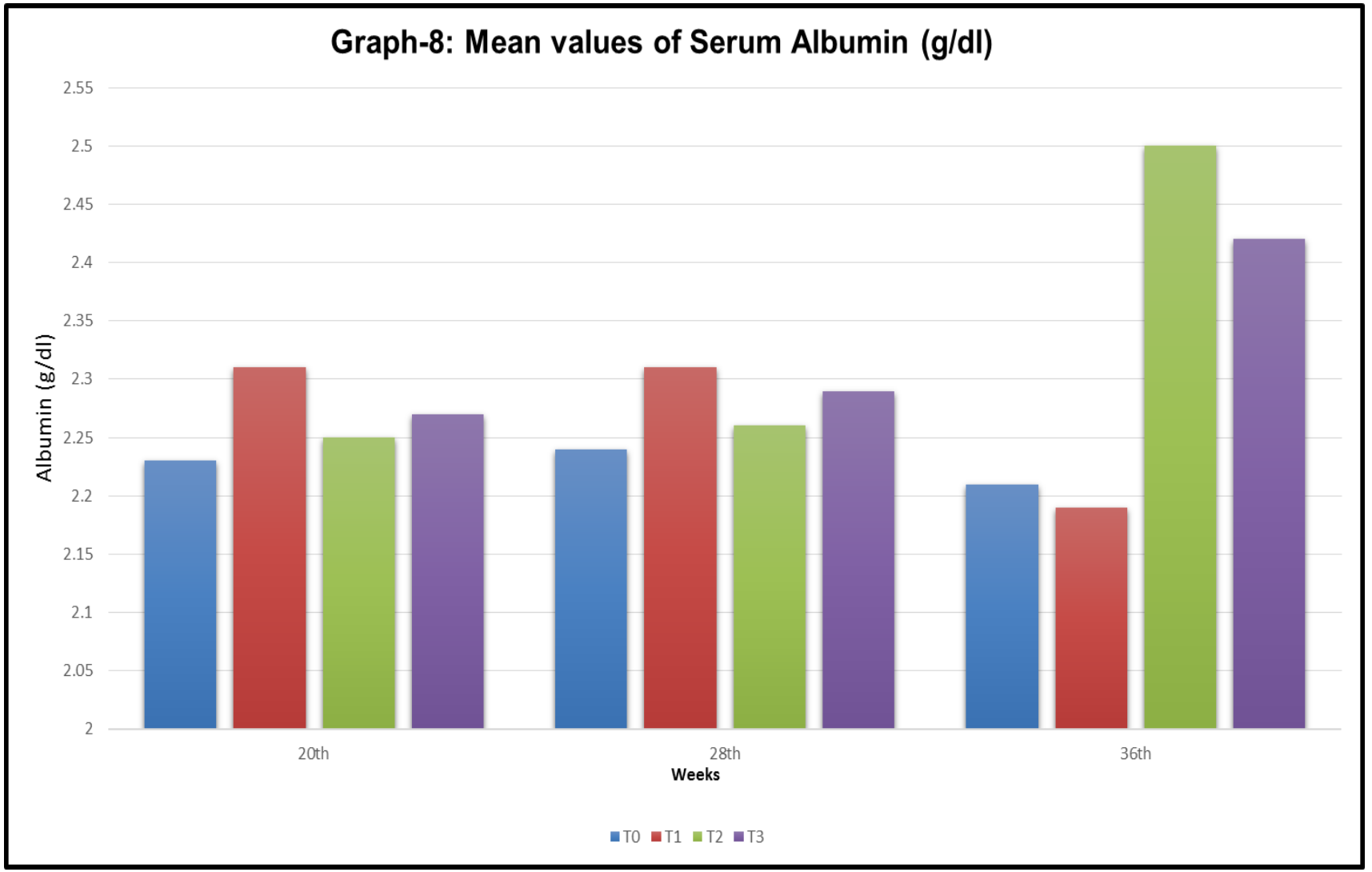

Graph-8: Mean values of Serum Albumin (g/dl)
Albumin (g/dl)
2.55
2.5
2.45
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
20th
28th
36th
Weeks
T0
T1
T2
T3

Table 13: Mean values of globulin (g/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	2.43±0.08	2.66±0.17	2.64±0.17	2.64±0.13
28th	2.38±0.28	2.48±0.21	2.36±0.15	2.34±0.28
36th	2.38±0.15	2.58±0.18	2.04±0.11	2.39±0.17

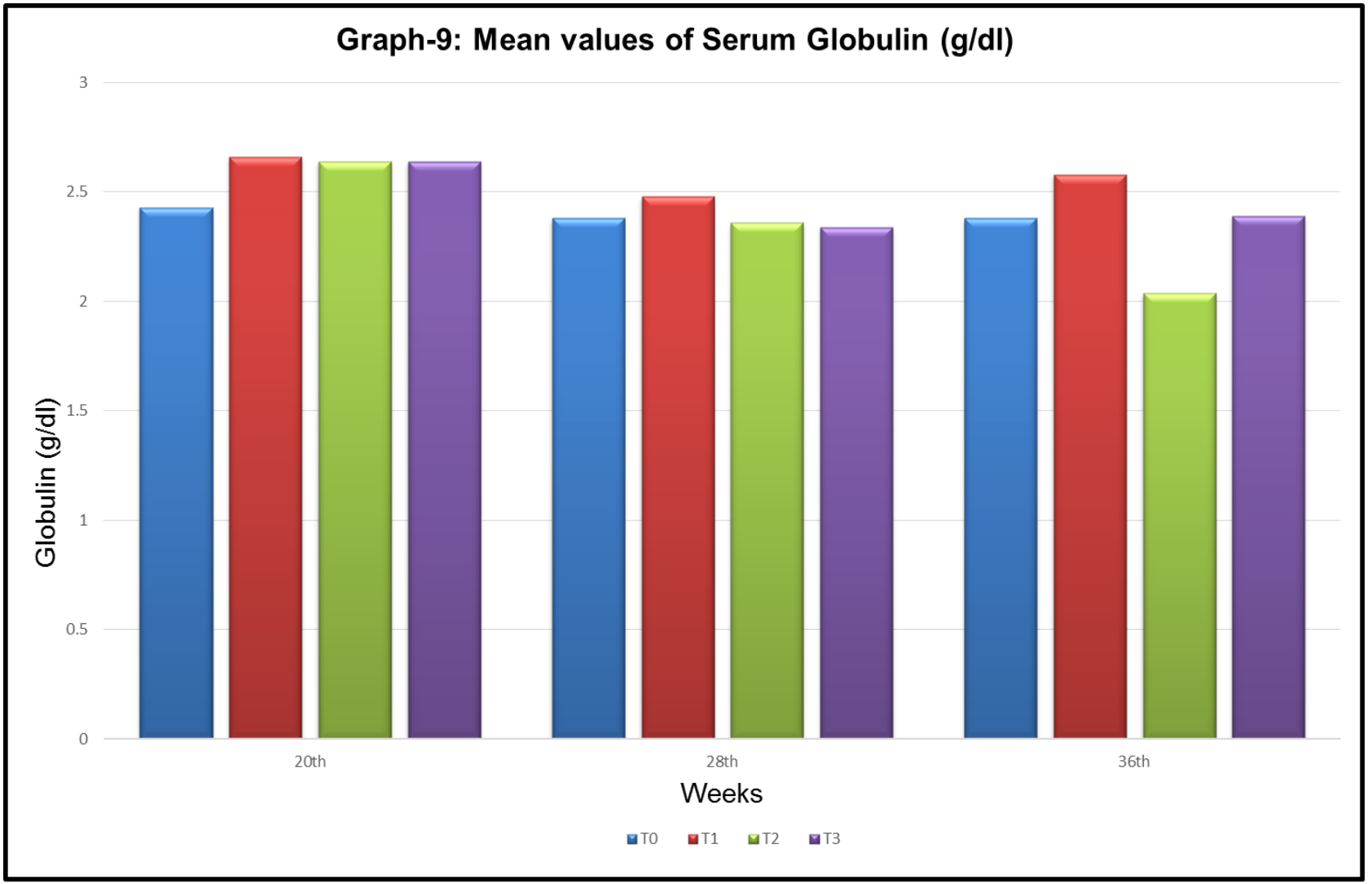
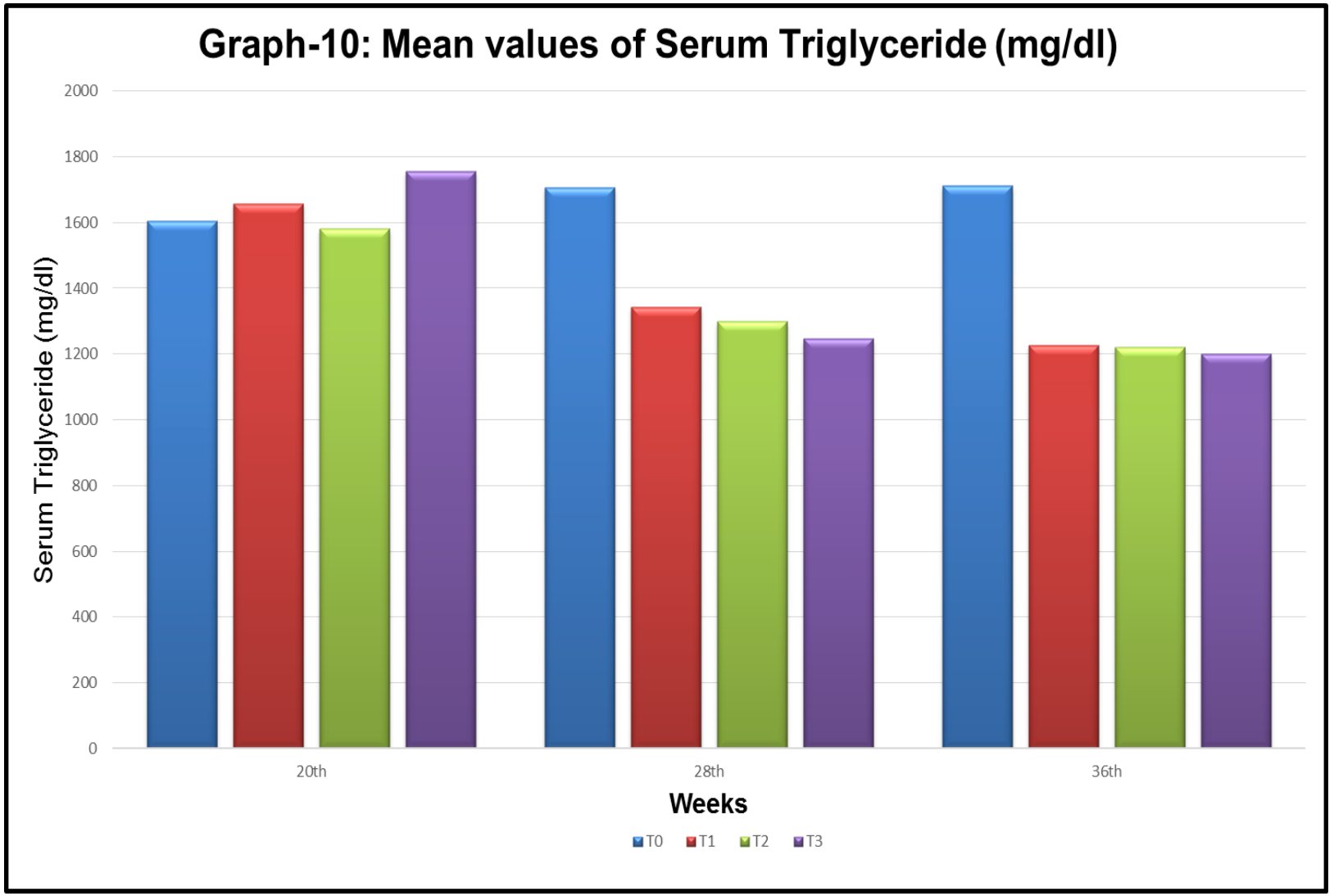

Graph-9: Mean values of Serum Globulin (g/dl)
3
2.5
2
1.5
1
0.5
0
Globulin (g/dl)
20th
28th
36th
Weeks
T0
T1
T2
T3

Table 14: Mean values of serum triglyceride (mg/dl)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	1605.11±63.62	1657.44±113.19	1581.33±89.03	1756.11±77.61
28th	1707.33±87.91[a]	1342±55.33[b]	1299.44±23.65[b]	1246.67±21.06[b]
36th	1712.11±70.22[a]	1227.89±29.79[b]	1222.33±39.49[b]	1200.67±25.91[b]

Note: Mean with different superscript in column differs significantly (P<0.01).


Graph-10: Mean values of Serum Triglyceride (mg/dl)
Serum Triglyceride (mg/dl)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
20th
28th
36th
Weeks
T0
T1
T2
T3

4.5 Egg Parameters (Physical)

4.5.1 Egg Weight (g)

The mean values of egg weight (g) observed in different groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table-15 and same is presented graphically in Graph- 11.

The average values of egg weight (g) at 20^{th} week were 33.91±1.31, 34.49±0.75, 34.3±0.86, and 33.44±0.81 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of egg weight (g) were within range of normal standards values and statistical application revealed no significant variation.

The average values of egg weight (g) at 28^{th} week were 55.57±0.72, 55.8±0.55, 55.89±0.58 and 55.64±0.65 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

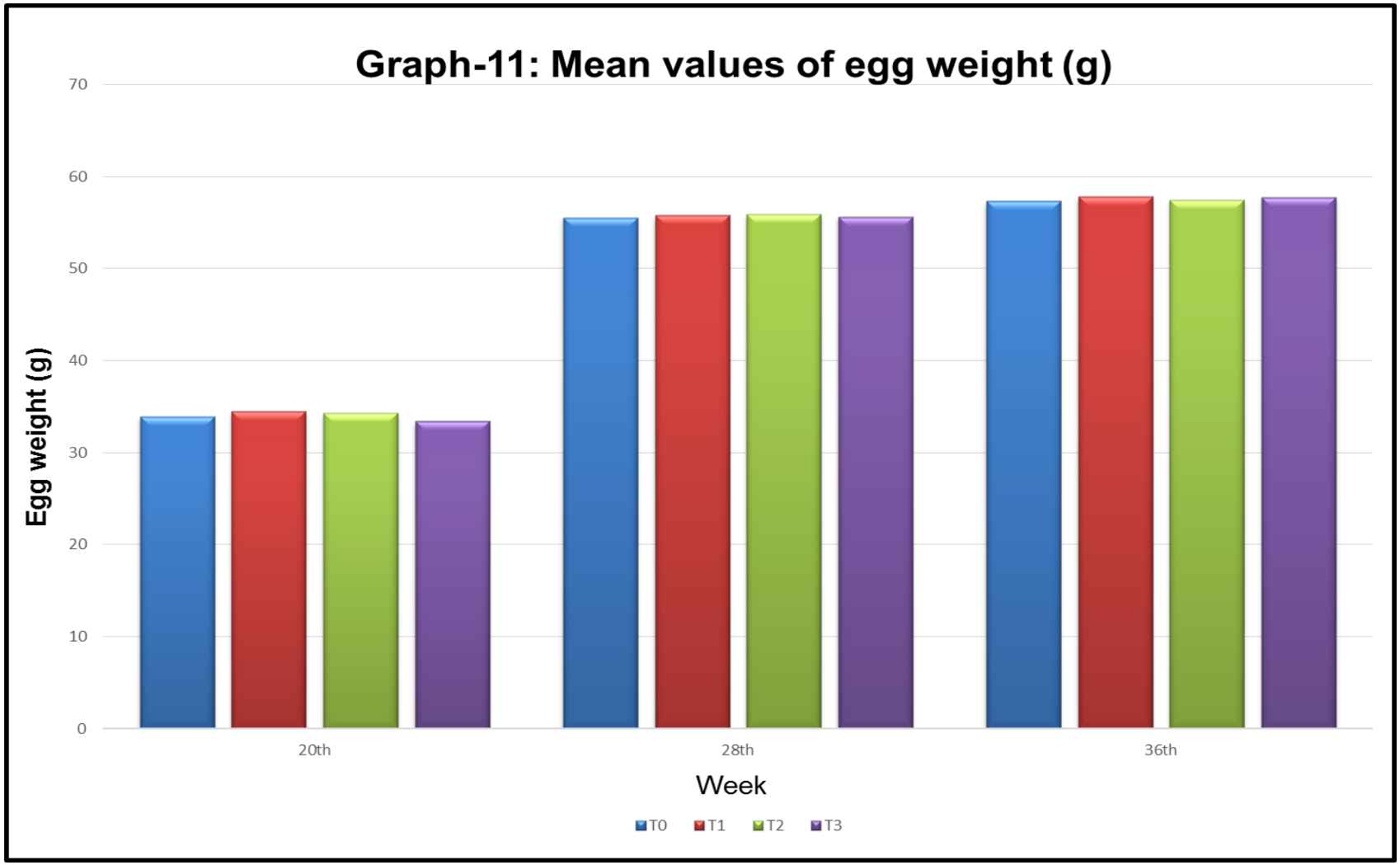
The average values of egg weight (g) at 36^{th} week were 57.34±0.69, 57.82±0.23, 57.48±0.23 and 57.77±0.28 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average value of egg weight (g) observed during 28^{th} and 36^{th} week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on egg weight.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in egg weight after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 15: Mean values of egg weight (g)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	33.91±1.31	34.49±0.75	34.3±0.86	33.44±0.81
28th	55.57±0.72	55.8±0.55	55.89±0.58	55.64±0.65
36th	57.34±0.69	57.82±0.23	57.48±0.23	57.77±0.28


Graph-11: Mean values of egg weight (g)
70
60
50
40
30
20
10
0
Egg weight (g)
20th
28th
36th
Week
T0
T1
T2
T3

4.5.2 Shell thickness (mm)

The mean values of shell thickness (mm) observed in different groups at 20th, 28th and 36th week are shown in Table-16 and same is presented graphically in Graph- 12.

The average values of shell thickness (mm) at 20th week were 0.38±0.0, 0.37±0.01, 0.38±0.0 and 0.37±0.0 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of shell thickness (mm) were within range of normal standards values and statistical application revealed no significant variation.

The average values of shell thickness (mm) at 28th week were 0.43±0.01, 0.43±0.02, 0.42±0.01 and 0.41±0.01 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

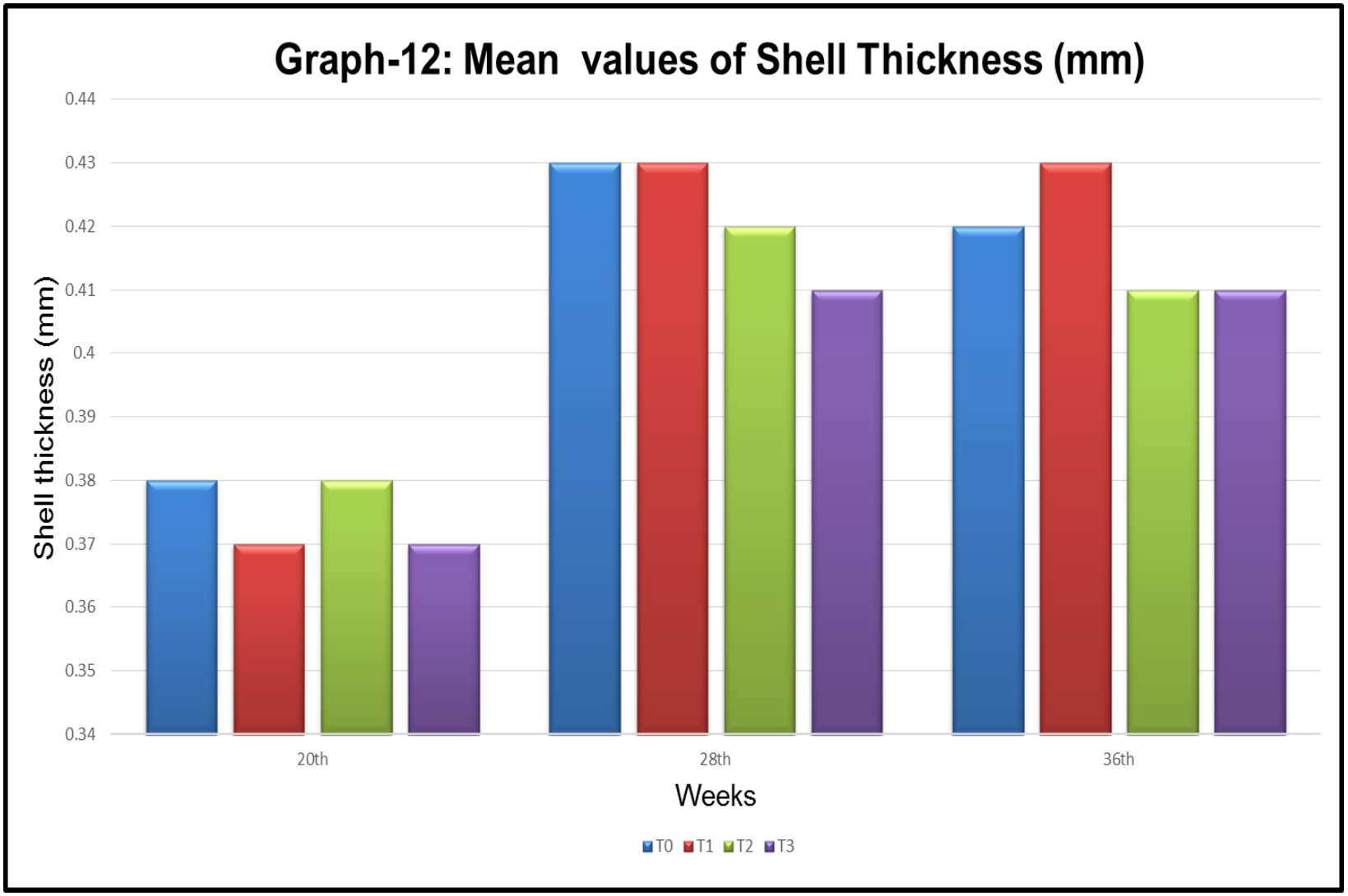
The average values of shell thickness (mm) at 36th week were 0.42±0.01, 0.43±0.02, 0.41±0.01 and 0.41±0.01 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average value of egg shell thickness (mm) observed during 28th and 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on shell thickness.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in shell thickness (mm) after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 16: Mean values of shell thickness (mm)

Week	Treatment			
	T_0	T_1	T_2	T_3
20th	0.38±0.0	0.37±0.01	0.38±0.0	0.37±0.0
28th	0.43±0.01	0.43±0.02	0.42±0.01	0.41±0.01
36th	0.42±0.01	0.43±0.02	0.41±0.01	0.41±0.01


Graph-12: Mean values of Shell Thickness (mm)
Shell thickness (mm)
0.44
0.43
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
20th
28th
36th
Weeks
T0 T1 T2 T3

4.5.3 Yolk colour

The mean values of yolk colour observed in different groups at 20th, 28th and 36th week are shown in Table -17 and same is presented graphically in Graph- 13.

The average values of yolk colour at 20th week were 9.89±0.26, 9.89±0.20, 9.78±0.28 and 9±0.44 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of yolk colour were within range of normal standards values and statistical application revealed no significant variation.

The average values of yolk colour at 28th week were 10.11±0.20, 10.11±0.26, 10.67±0.29 and 10.33±0.44 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

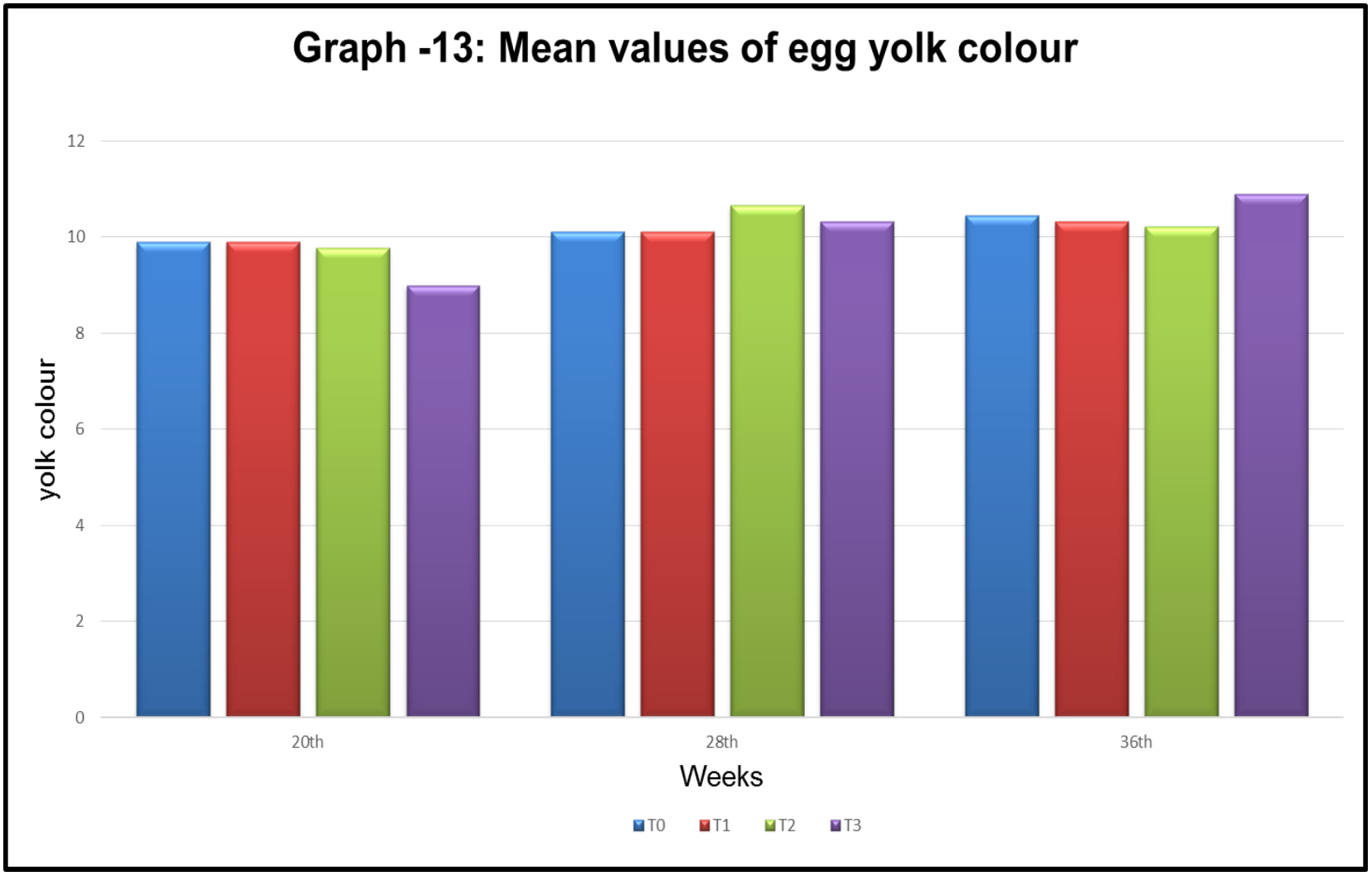
The average values of yolk colour at 36th week were 10.44±0.20, 10.33±0.26, 10.22±0.29 and 10.89±0.44 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average value of egg yolk colour observed during 28th and 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on yolk colour.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in yolk colour after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 17: Mean values of Yolk colour

week	Treatment			
	T_0	T_1	T_2	T_3
20th	9.89±0.26	9.89±0.20	9.78±0.28	9±0.44
28th	10.11±0.20	10.11±0.26	10.67±0.29	10.33±0.44
36th	10.44±0.20	10.33±0.26	10.22±0.29	10.89±0.44


Graph -13: Mean values of egg yolk colour
12
10
8
6
4
2
0
yolk colour
20th
28th
36th
Weeks
T0
T1
T2
T3

4.5.4 Albumen index

The mean values of albumen index observed in different groups at 20^{th}, 28^{th} and 36^{th} weeks are shown in Table -18 and same is presented graphically in Graph- 14.

The average initial values of albumen index at 20^{th} week were 0.09±0.003, 0.10±0.003, 0.10±0.003 and 0.09±0.003 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of albumen index were within range of normal standard values and statistical application revealed no significant variation.

The average values of albumen index at 28^{th} week were 0.10±0.004, 0.10±0.005, 0.10±0.005 and 0.10±0.004 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

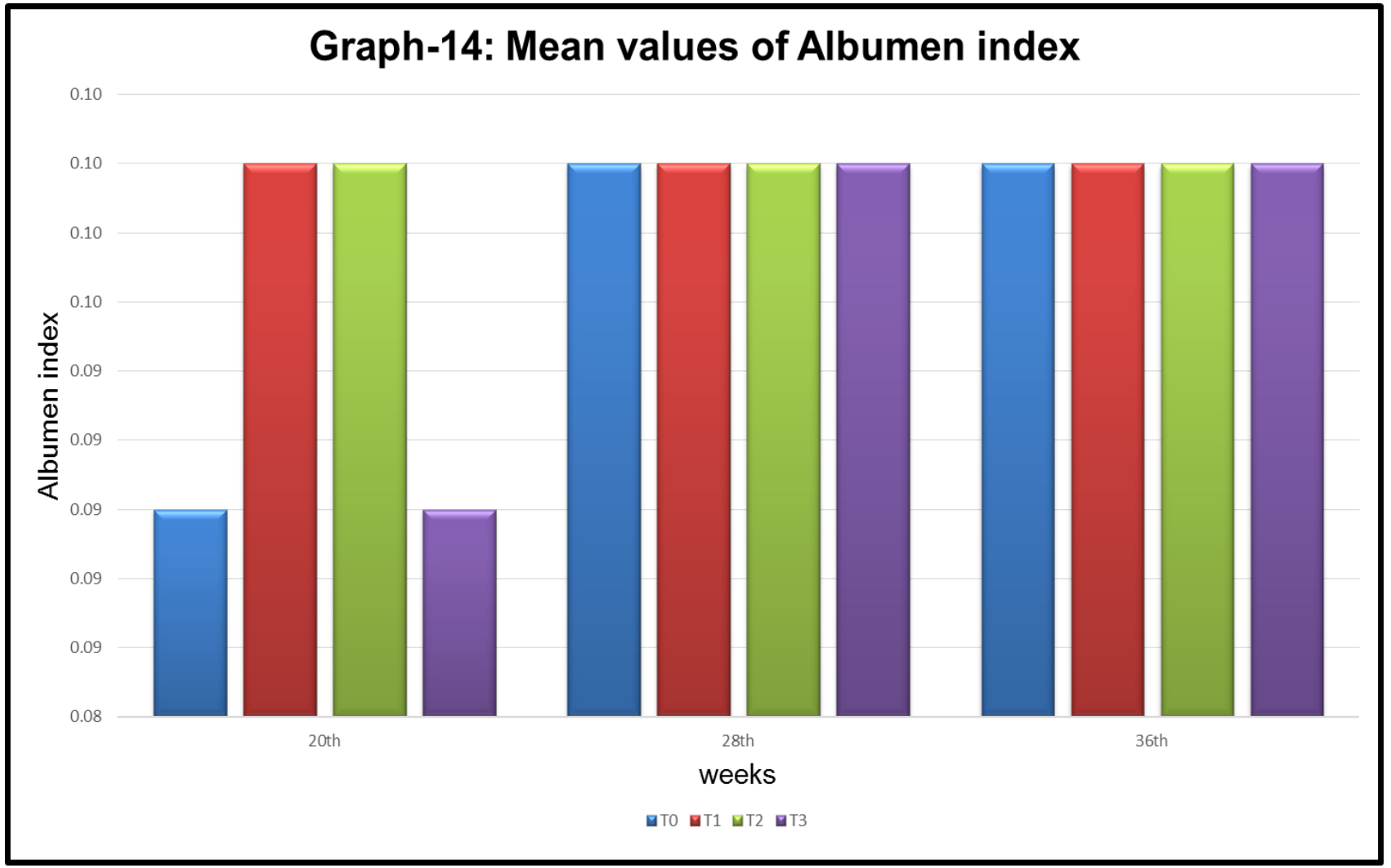
The average values of albumen index at 36^{th} week were 0.10±0.005, 0.10±0.002, 0.10±0.003 and 0.10±0.004 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average values of albumen index observed during 28^{th} and 36^{th} week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on albumen index.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in albumen index after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 18: Mean values of Albumen index

week	Treatment			
	T_0	T_1	T_2	T_3
20th	0.09±0.003	0.10±0.003	0.10±0.003	0.09±0.003
28th	0.10±0.004	0.10±0.005	0.10±0.005	0.10±0.004
36th	0.10±0.005	0.10±0.002	0.10±0.003	0.10±0.004


Graph-14: Mean values of Albumen index
Albumen index
0.10
0.10
0.10
0.10
0.09
0.09
0.09
0.09
0.09
0.08
20th
28th
36th
weeks
T0
T1
T2
T3

4.5.5 Yolk index

The mean values of yolk index observed in different groups at 20th, 28th and 36th week are shown in Table -19 and same is presented graphically in Graph- 15.

The average values of yolk index at 20th week were 0.41±0.023, 0.44±0.018, 0.44±0.019 and 0.46±0.013 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of yolk index were within range of normal standards values and statistical application revealed no significant variation.

The average values of yolk index at 28th week were 0.38±0.004, 0.39±0.008, 0.38±0.009 and 0.37±0.009 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average values of yolk index at 36th week were 0.38±0.003, 0.37±0.017, 0.37±0.015 and 0.39±0.007 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

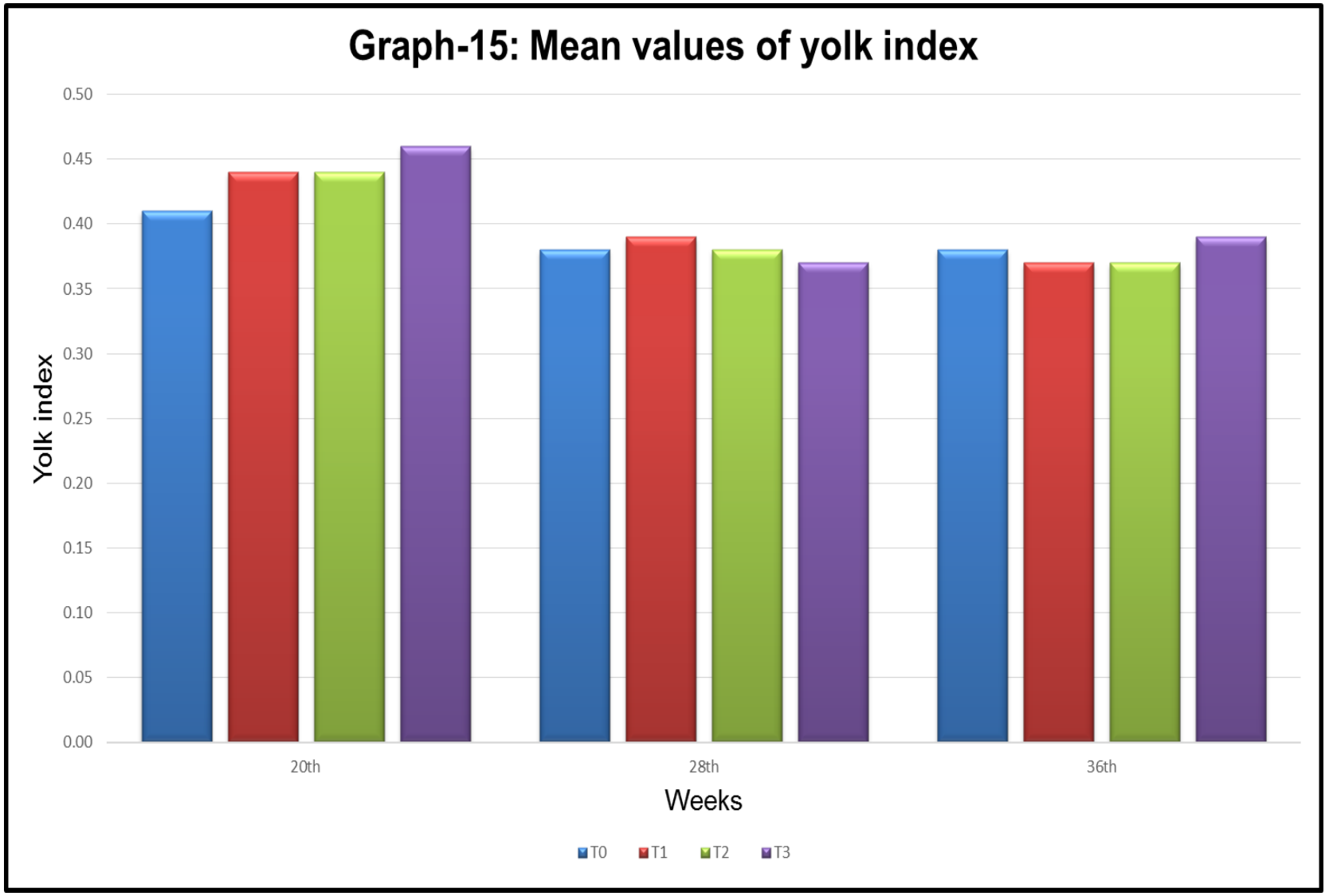
The average values of yolk index observed during 28th to 36th week were statistically non-significant. The supplementation of DTPP at

suggested levels in present study do not significantly or adversely affected on yolk index.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in yolk index after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 19: Mean values of yolk index

week	**Treatment**			
	T_0	**T_1**	**T_2**	**T_3**
20th	0.41±0.023	0.44±0.018	0.44±0.019	0.46±0.013
28th	0.38±0.004	0.39±0.008	0.38±0.009	0.37±0.009
36th	0.38±0.003	0.37±0.017	0.37±0.015	0.39±0.007


Graph-15: Mean values of yolk index
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Yolk index
20th
28th
36th
Weeks
T0
T1
T2
T3

4.5.6 Haugh unit

The mean values of haugh unit observed in different experimental groups at 20th, 28th and 36th week are shown in Table-20 and same is presented graphically in Graph-16.

The average values of haugh unit at 20th week were 88.40±1.67, 90.56±1.40, 91.10±0.97 and 90.57±0.69 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of haugh unit were within range of normal standards values and statistical application revealed no significant variation.

The average values of haugh unit at 28th week were 85.62±1.21, 84.92±1.55, 87.21±1.62 and 87.83±1.78 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

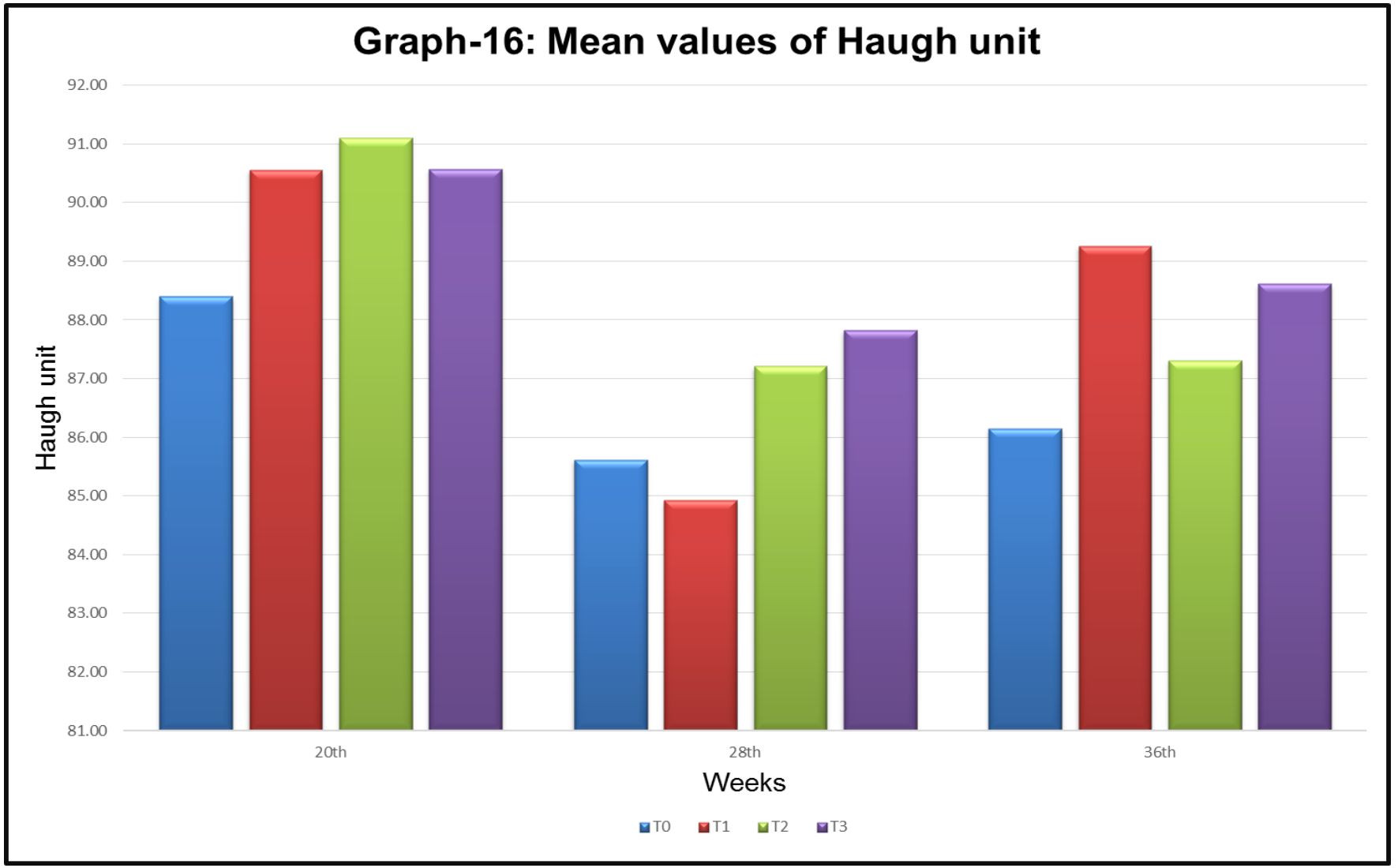
The average values of haugh unit at 36th week were 86.15±1.47, 89.26±0.78, 87.31±1.54 and 88.61±0.84 in control group T_0 and treatment group T_1, T_2 and T_3 respectively.

The average values of haugh unit observed during 28th to 36th week were statistically non-significant. The supplementation of DTPP at suggested levels in present study do not significantly or adversely affected on haugh unit.

Yingyuen *et al*., (2011) reported similar observations with no significant variation in haugh unit after supplementation of 0.4% tamarind in layer diet fed during 18th to 34th week.

Table 20: Mean values of Haugh unit

week	Treatment			
	T_0	T_1	T_2	T_3
20th	88.40±1.67	90.56±1.40	91.10±0.97	90.57±0.69
28th	85.62±1.21	84.92±1.55	87.21±1.62	87.83±1.78
36th	86.15±1.47	89.26±0.78	87.31±1.54	88.61±0.84


Graph-16: Mean values of Haugh unit
92.00
91.00
90.00
89.00
88.00
87.00
86.00
85.00
84.00
83.00
82.00
81.00
Haugh unit
20th
28th
36th
Weeks
T0
T1
T2
T3

4.6 Egg parameter (Biochemical)

4.6.1 Egg yolk cholesterol (mg/g)

The mean values of egg yolk cholesterol (mg/g) observed in different treatment groups at 20^{th}, 28^{th} and 36^{th} week of study are shown in Table-21 and same is presented graphically in Graph-17.

The average initial values of egg yolk cholesterol (mg/g) at 20^{th} week were 17.29±1.14, 18.15±1.75, 17.73±1.29 and 18.89±1.13. The initial values of yolk cholesterol observed in different groups were physiologically normal and statistically non-significant.

As per the scheduled study program the values of egg yolk cholesterol (mg/g) observed in different experimental groups at 28^{th} week were 17.87±0.17, 15.53±0.68, 15.92±0.80 and 15.71±0.66. The statistical application to observed values denoted that the levels of yolk cholesterol among treatment groups T_1, T_2 and T_3 were significantly lower ($P<0.05$) than control group T_0. After supplementation of DTPP in different experimental groups at the levels of 0.25%, 0.5% and1% for 8 weeks period the levels of yolk cholesterol was reduced by 11 to 14 %.

The average values of yolk cholesterol (mg/g) at 36^{th} week were 17.58±0.70, 15.19±0.72, 15.33±0.39 and 15.54±0.56 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. It was observed that significantly lower ($p<0.05$) cholesterol levels were recorded in all

treatment group as compared to control T_0. After supplementation of DTPP in different treatment group at the levels of 0.25%, 0.5% and 1% for 16 weeks period the levels of yolk cholesterol was reduced by 12 to 14%.

In present study, it was noted that serum cholesterol level were significantly reduced by 25 to 28 % after supplementation of DTPP for 16 weeks at different suggested levels.

Chowdhury *et al*., (2005) reported that egg yolk cholesterol concentrations was not affected by dietary tamarind however, serum cholesterol concentration were decreased quadratically at the level of 2, 4, 6 and 8% dietary tamarind fed for six weeks in layer poultry birds.

Yingyuen *et al.,* (2011) reported significantly lower egg yolk cholesterol levels in layer poultry birds after supplementation of 0.4% Tamarindus indica for sixteen weeks period. The observation recorded in present study are in agreement with Yingyuen *et al*., (2011).

It was reported that the composition of egg yolk fatty acid is reflection of fatty acid synthesis by liver of laying hen considering amount of egg yolk fatty acid provided by adipose tissue is about 20% (Grimes *et al*., 1996).

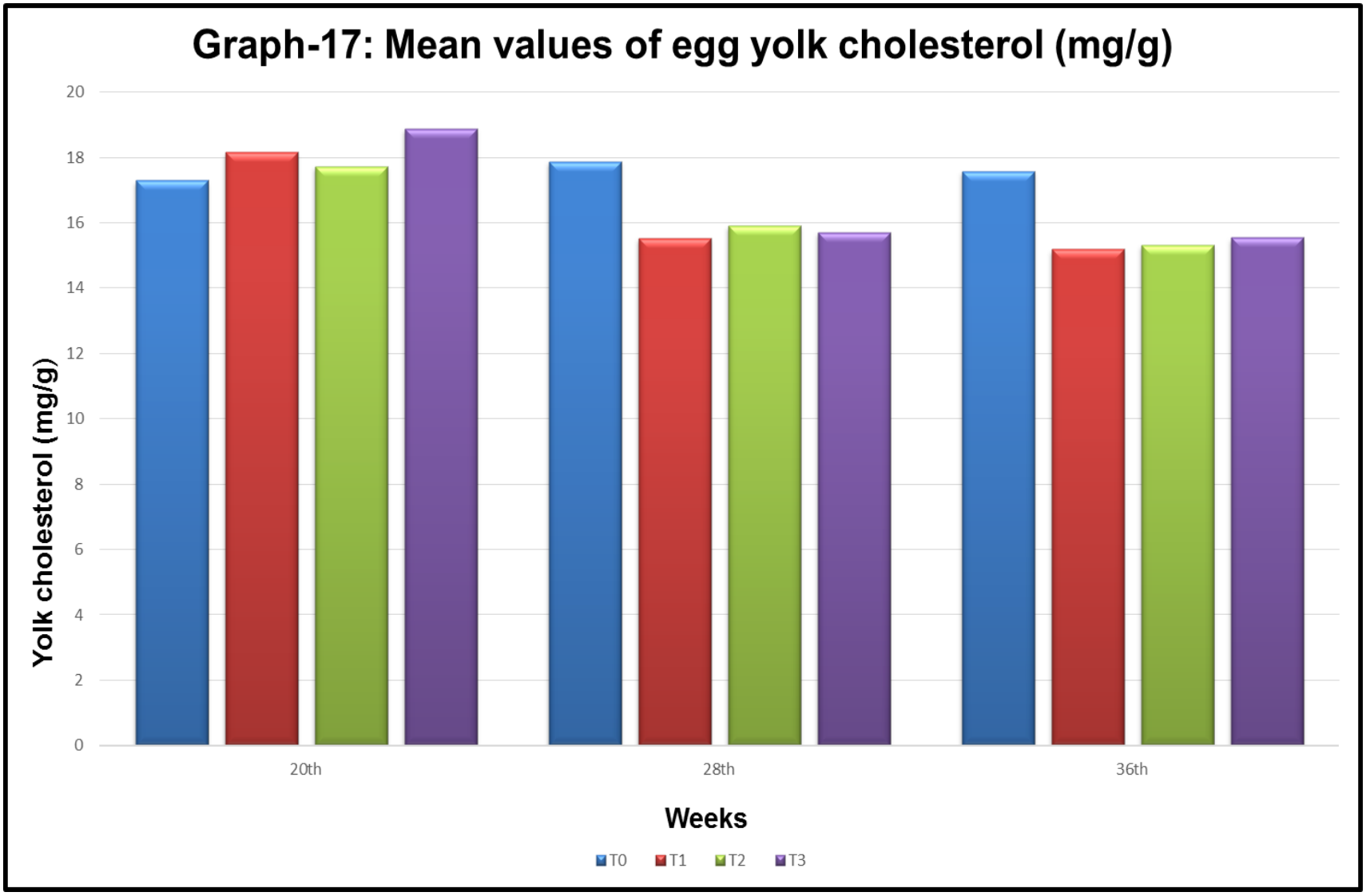
The reduction in egg yolk cholesterol could be due to suppression of lipogenic enzymes as indicated by pronounced decrease in m-RNA abundance and enzyme synthesis (Tomilson *et al*., 1988).

Since most of the yolk cholesterol is synthesized in liver, decreased hepatic cholesterol and fatty acid synthesis due to suppression of hepatic lipogenic enzymes might have reduced the incorporation of cholesterol and its esters in to yolk precursor with resultant reduction in yolk cholesterol level.

Table 21: Mean values of egg yolk cholesterol (mg/g)

week	Treatment			
	T_0	T_1	T_2	T_3
20th	17.29±1.14	18.15±1.75	17.73±1.29	18.89±1.13
28th	17.87±0.17[a]	15.53±0.68[b]	15.92±0.80[b]	15.71±0.66[b]
36th	17.58±0.70[a]	15.19±0.72[b]	15.33±0.39[b]	15.54±0.56[b]

Note: Mean with different superscript in column differs significantly ($P<0.05$).


Graph-17: Mean values of egg yolk cholesterol (mg/g)
Yolk cholesterol (mg/g)
20
18
16
14
12
10
8
6
4
2
0
20th
28th
36th
Weeks
T0
T1
T2
T3

4.6. 2 Egg yolk HDL (mg/g)

The mean values of egg yolk HDL (mg/g) observed in different experimental groups at 20th, 28th and 36th week are shown in Table- 22 and same is presented graphically in Graph- 18.

The average initial values of egg yolk HDL at 20th week were 9.38±0.70, 9.62±1.21, 9.83±1.05 and 9.91±0.77 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of egg yolk HDL observed in different groups were physiologically normal and statistically non-significant.

The average values of egg yolk HDL at 28th week were 9.93±0.42, 11.25±0.57, 10.56±0.46 and 10.43±0.60 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The statistical application to observed values revealed no significant variation among treatment groups.

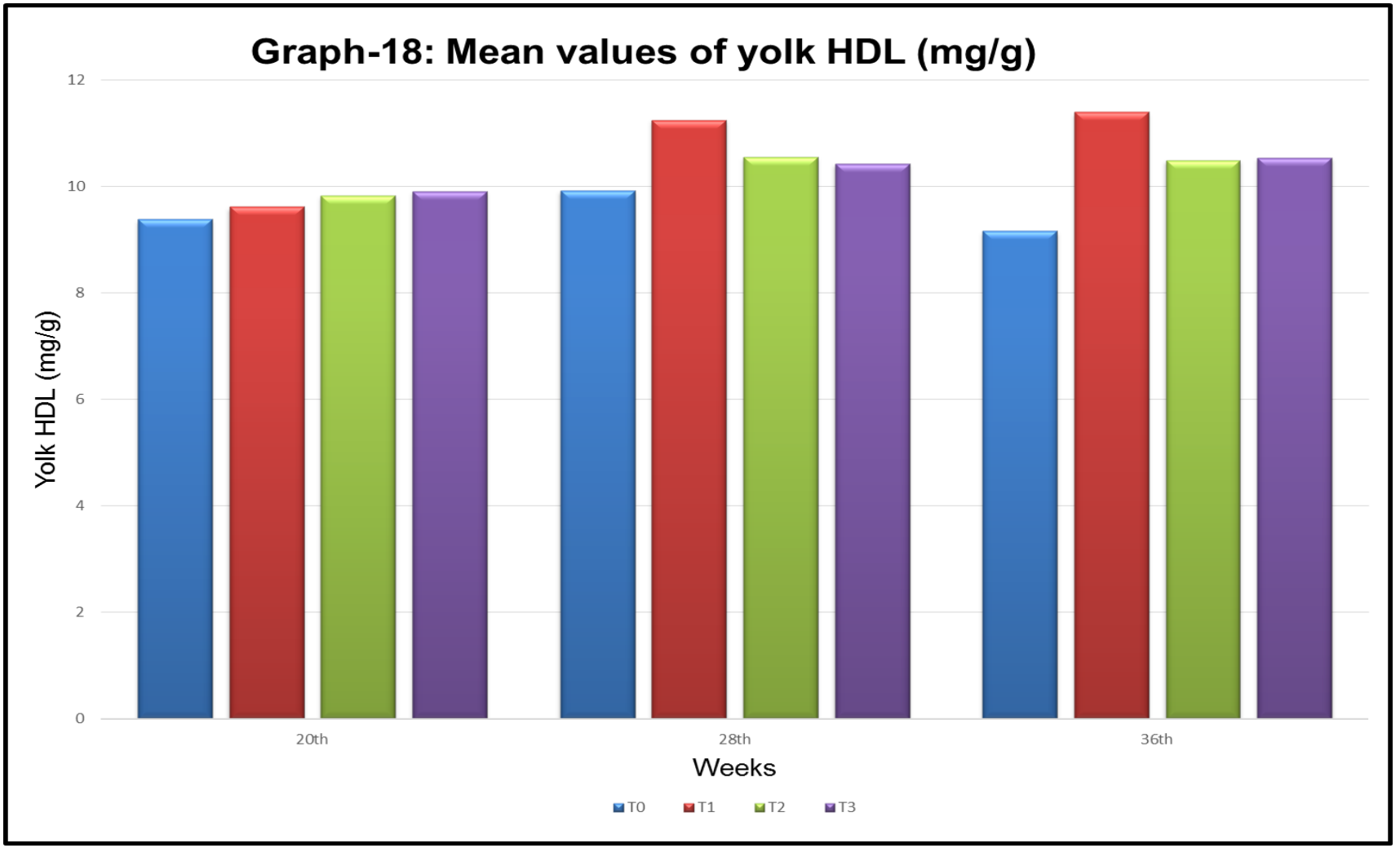
The average values of egg yolk HDL at 36th week were 9.16±0.51, 11.40±0.73, 10.49±1.11 and 10.54±0.51 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The values of egg yolk HDL observed at 36th week were statistically non-significant.

In present study the supplementation of DTPP at suggested levels for 16 weeks significantly increased serum HDL levels by 42 to 45 %. However dietary supplementation could not reflect similar observation in case of egg yolk HDL.

Although the values of egg yolk HDL were statistically non-significant but numerically remarkable improvement in the HDL levels were observed.

Table 22: Mean values of yolk HDL (mg/g)

week	Treatment			
	T_0	T_1	T_2	T_3
20th	9.38±0.70	9.62±1.21	9.83±1.05	9.91±0.77
28th	9.93±0.42	11.25±0.57	10.56±0.46	10.43±0.60
36th	9.16±0.51	11.4±0.73	10.49±1.11	10.54±0.51


Graph-18: Mean values of yolk HDL (mg/g)
Yolk HDL (mg/g)
12
10
8
6
4
2
0
20th
28th
36th
Weeks
T0
T1
T2
T3

4.6.3 Egg yolk LDL (mg/g)

The mean values of egg yolk LDL (mg/g) observed in different experimental groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table -23 and same is presented graphically in Graph- 19.

The average initial values of egg yolk LDL (mg/g) at 20^{th} week were 6.12±0.57, 6.58±0.62, 6.6±0.31 and 6.28±0.38 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The initial values of egg yolk LDL observed in different groups were physiologically normal and statistically non-significant.

The average values of egg yolk LDL (mg/g) at 28^{th} week were 6.33±0.53, 5.96±0.39, 5.99±0.54 and 5.82±0.29 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The statistical application to observed values revealed no significant variation among treatment groups.

The average values of egg yolk LDL (mg/g) at 36^{th} week were 6.46±0.56, 5.49±0.15, 5.93±0.29 and 5.41±0.25 in control group T_0 and treatment group T_1, T_2 and T_3 respectively. The values of egg yolk LDL observed at 36^{th} week were statistically non-significant.

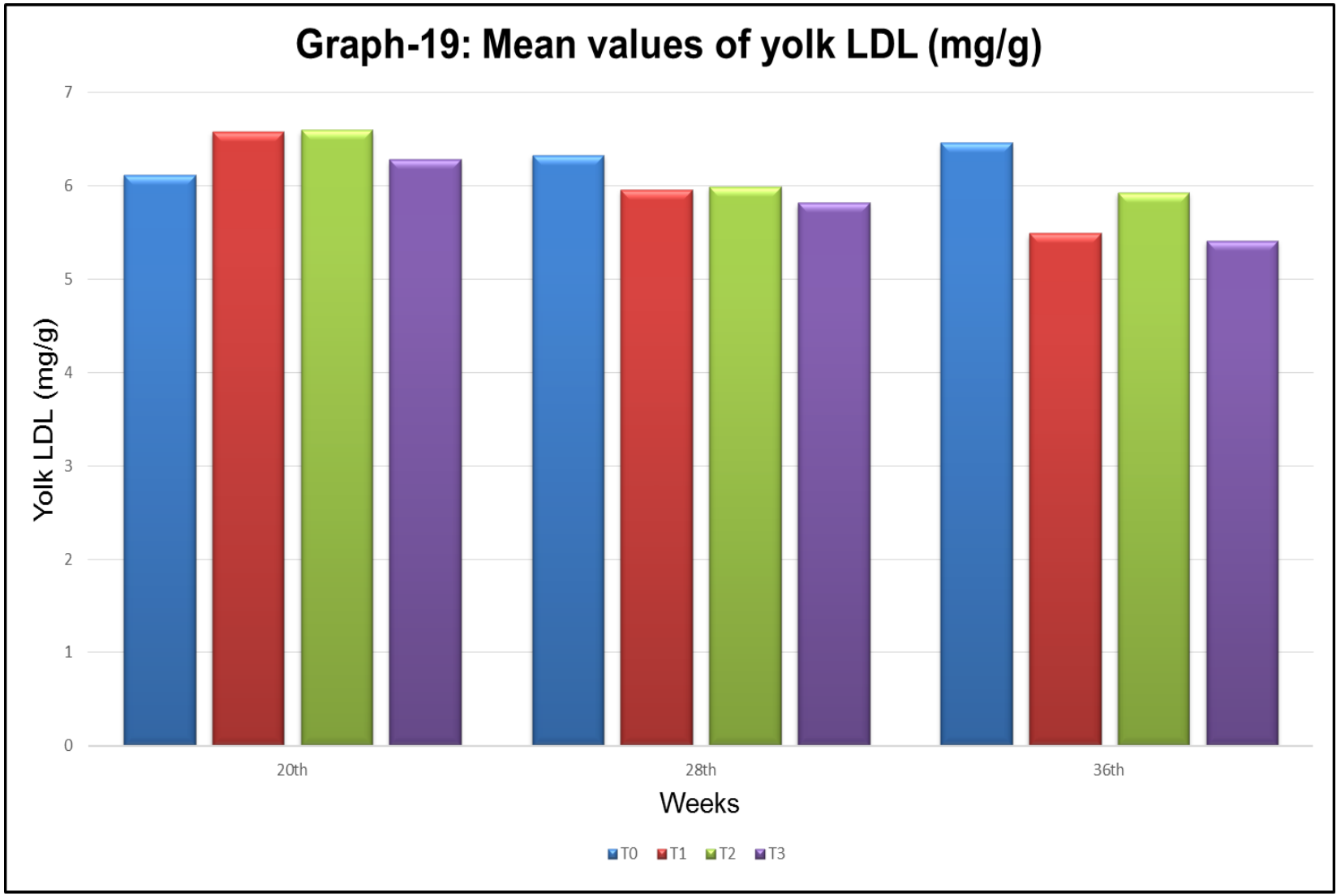
In present study the supplementation of DTPP at suggested levels for 16 weeks significantly decreased serum LDL levels by 30 to 39 %.

However dietary supplementation could not reflect similar observation in case of egg yolk LDL.

Although the values of egg yolk LDL were statistically non-significant but numerically remarkable reduction in the LDL levels were observed.

Table 23: Mean values of yolk LDL (mg/g)

week	Treatment			
	T_0	T_1	T_2	T_3
20th	6.12±0.57	6.58±0.62	6.6±0.31	6.28±0.38
28th	6.33±0.53	5.96±0.39	5.99±0.54	5.82±0.29
36th	6.46±0.56	5.49±0.15	5.93±0.29	5.41±0.25


Graph-19: Mean values of yolk LDL (mg/g)
Yolk LDL (mg/g)
7
6
5
4
3
2
1
0
20th
28th
36th
Weeks
T0
T1
T2
T3

4.6.4 Egg yolk Triglyceride (mg/g)

The mean values of egg yolk triglyceride (mg/g) observed in different experimental groups at 20^{th}, 28^{th} and 36^{th} week are shown in Table -24 and same is presented graphically in Graph- 20.

The average initial values of egg yolk triglyceride (mg/g) at 20^{th} week were 129.67±3.93, 130.26±4.12, 133.82±6.85 and 126.91±5.30 in control group T_0 and treatment group $T_{1,}$ T_2 and T_3 respectively. The initial values of egg yolk triglyceride observed in different groups were physiologically normal and statistically non-significant.

The average values of egg yolk triglyceride (mg/g) at 28^{th} week were 129.17±3.87, 120.37±2.48, 121.99±1.46 and 122.44±4.26 in control group T_0 and treatment group $T_{1,}$ T_2 and T_3 respectively. The statistical application to observed values revealed no significant variation among treatment groups.

The average values of egg yolk triglyceride (mg/g) at 36^{th} week were 128.87±5.56, 115.07±2.68, 117.71±2.66 and 116.34±2.99 in control group T_0 and treatment group $T_{1,}$ T_2 and T_3 respectively. The values of egg yolk triglyceride observed at 36^{th} week were statistically non-significant.

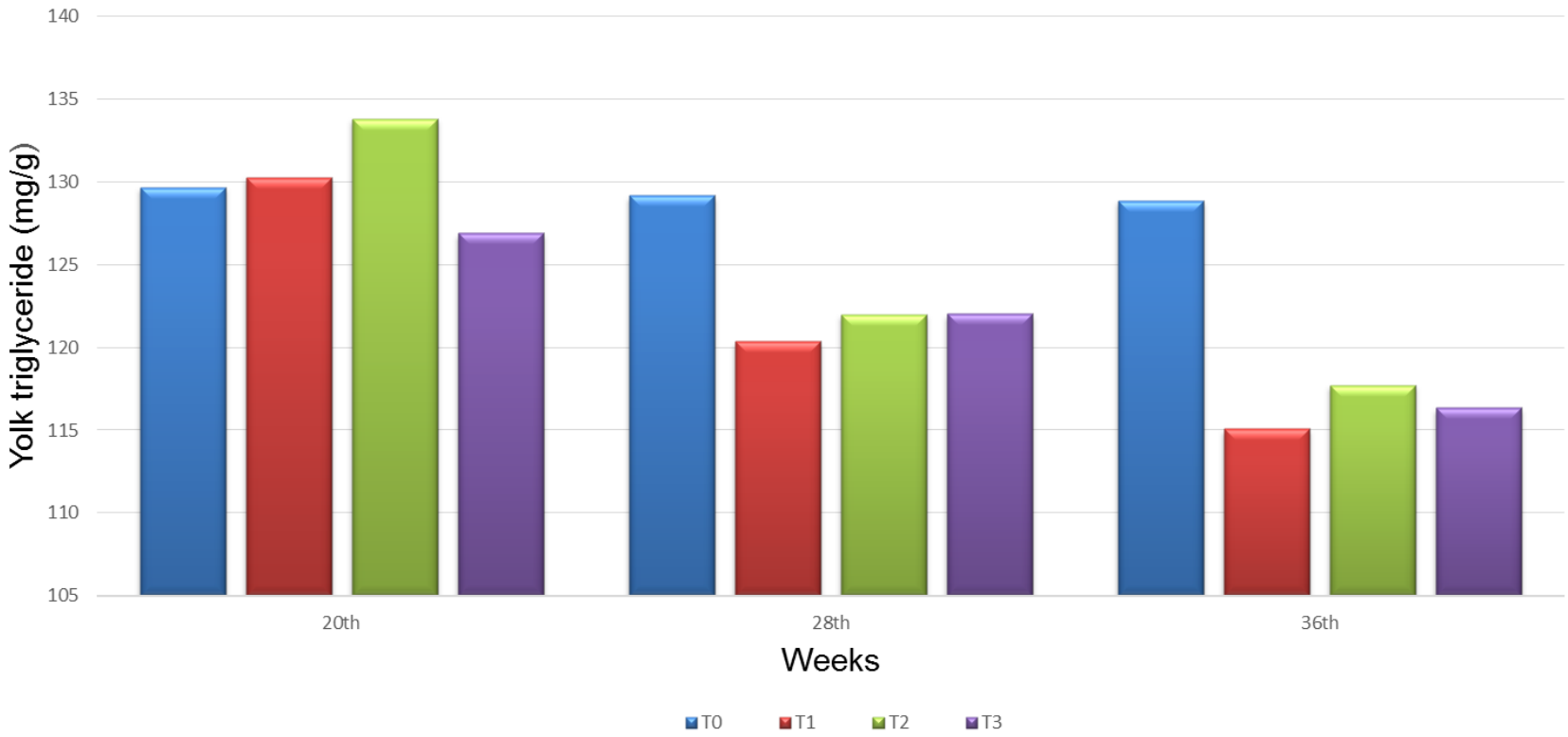
In present study the supplementation of DTPP at suggested levels for 16 weeks significantly decreased serum triglyceride levels by 29 to 31 %. However dietary supplementation could not reflect similar observation in case of egg yolk triglyceride.

Yingyuen *et al.,* (2011) reported significantly lower egg yolk triglyceride levels due to supplementation of 0.4% tamarind for 16 week period in layer poultry birds. Although the values of egg yolk triglyceride were statistically non-significant but numerically remarkable reduction in the triglyceride levels were observed.

Table 24: Mean values of egg yolk triglyceride (mg/g)

week	Treatment			
	T_0	T_1	T_2	T_3
20th	129.67±3.93	130.26±4.12	133.82±6.85	126.91±5.30
28th	129.17±3.87	120.37±2.48	121.99±1.46	122.44±4.26
36th	128.87±5.56	115.07±2.68	117.71±2.66	116.34±2.99

Graph-20:Average yolk triglyceride (mg/g)



Summary and Conclusions

CHAPTER – V
SUMMARY AND CONCLUSION

The present study exhibits the effect of supplementation of different levels of dried tamarind pulp powder (DTPP) through feed on serum and egg yolk cholesterol, HDL, LDL and triglyceride in layer poultry birds. The effect was also examined in terms of weekly body weight changes, feed efficiency, egg production and egg quality parameters (physical), so as to asses any adverse effect. The serum biochemical parameters were also included assessing total serum protein, albumin and globulin for evaluation of normal liver function.

Two hundred and forty healthy 20 weeks old layer birds of 'BV-300' strain were used. Layer birds were divided into four groups of 60 birds each. Each group was further divided into 3 replicates of 20 birds each. Group I (T_o) was treated as control fed with basal diet without dried tamarind pulp powder. Group II (T_1) was treatment group with dried tamarind pulp powder 250g/100kg feed, Group III (T_2) @ 500g/100kg and Group IV (T_3) @ 1000g /100kg.

The initial live body weights at 20^{th} (1282.67±6.70, 1287.11±5.39, 1272.67±7.57 and 1288.11±3.44) as well as weekly during 21^{st} to 36^{th} revealed no significant variation among treatment and control group (except 28^{th} week).

Initially at 21^{st} week, feed efficiency per egg mass was 11.43±0.03, 11.63±0.19, 11.57±0.03 and 11.45±0.03 with no significant variation and similar trend was observed till the end of trial up to 36^{th} week (2.17±0.01, 2.16±0.01, 2.17±0.03 and 2.18±0.0).

Egg production noted at the end of trial (36th week) was 91.34±0.53, 91.2±0.50, 91.64±0.81 and 91.24±0.43 with no significant variation (P>0.05) among various experimental groups. Similar observations were noted weekly from 21st to 35th week.

The levels of serum total cholesterol (mg/dl) at 20th week (164.3±5.64, 159.13±5.11, 160.38±3.61, 161.71±4.23) were non-significant. However, at 28th (157.73±2.94, 125.96±1.67, 128.23±2.38, 125.26±1.97) and 36th (155.1±3.04, 120.8±2.18, 119.48±2.03, 117.08±1.57) week were significantly different. About 25 to 28 % reduction in total serum cholesterol was observed after supplementation of DTPP for 16 weeks period.

Significantly increased (42 to 45%) serum HDL (mg/dl) was observed at 28th (35.87±2.20, 50.20±2.85, 51.68±2.38 and 53.21±2.31) and 36th (38.99±2.95, 56.34±2.55, 55.45±2.55 and 55.65±1.93) week of experiment. Similarly, significantly reduced (30-39%) serum LDL was observed at 36th (57.15±1.72, 34.99±4.63, 40.5±3.39 and 34.85±4.11) week.

The average serum total protein (g/dl) (4.59±0.13, 4.77±0.18, 4.54±0.12, 4.81±0.13), serum albumin (g/dl) (2.21±0.05, 2.19±0.05, 2.5±0.13 and 2.42±0.15) and serum globulin (g/dl) (2.38±0.15, 2.58±0.18, 2.04±0.11, 2.39±0.17) observed at the end of trial (36th week) was physiologically normal and statistically non-significant in all experimental groups.

The levels of serum triglyceride (mg/dl) were significantly reduced by 29-31% at 36th week with lowest in treatment group T_3 (1200.67±25.91) followed by T_2 (1222.33±39.49), T_1 (1227.89±29.79) and highest in control group T_0 (1712.11±70.22).

Egg weight (g) (57.34±0.69, 57.82±0.23, 57.48±0.23, 57.77±0.28), shell thickness (mm) (0.42±0.01, 0.43±0.02, 0.41±0.01, 0.41±0.01), yolk colour (10.44±0.20, 10.33±0.26, 10.22±0.29, 10.89±0.44), albumen index (0.10±0.005, 0.10±0.002, 0.10±0.003, 0.10±0.004), yolk index (0.38±0.003, 0.37±0.017, 0.37±0.015, 0.39±0.007) and haugh unit (86.15±1.47, 89.28±0.78, 87.31±1.54, 88.61±0.84) were normal and were not affected by treatment.

Egg yolk cholesterol (mg/g) was significantly reduced by 12 to 14% (17.58±0.70, 15.19±0.72, 15.33±0.39, 15.54±0.56) while no significant changes in yolk HDL (mg/g) (9.16±0.51, 11.4±0.73, 10.49±1.11, 10.54±0.51), yolk LDL (mg/g) (6.46±0.56, 5.49±0.15, 5.93±0.29, 5.41±0.25) and yolk triglyceride (mg/g) (128.87±5.56, 115.07±2.68, 117.71±2.66, 116.34±2.99) were noted.

The present study concludes that egg yolk cholesterol can be reduced by 12 to 14% by supplementation of DTPP between 0.25 to 1.00 % for 16 weeks period in layer birds without adversely affecting on feed efficiency, egg production, serum biochemistry and other egg quality parameters.

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Vitae

Vitae

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He participated in National Service Scheme (N.S.S.) and Inter university games (Ashwamedh), and in ICAR games also participated in various social activities during his graduation studies.

Thesis Abstract

THESIS ABSTRACT

a) Title of the thesis (in Capital letters) : UTILIZATION OF TAMARIND (*Tamarindus indica L.*) PULP AS FEED SUPPLEMENT IN LAYER CHICKEN.

b) Full name of student : Mr. Biradar Parikshit Baburao

c) Name and address of Major Advisor : Dr. A. B. Kanduri
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d) Degree to be awarded : M.V.Sc

e) Year of award of degree : 2016

f) Major subject : Animal Nutrition

g) Total number of pages in the thesis : 87

h) Number of words in the abstract : 299

i) Signature of Student :

j) Signature, Name and address of Forwarding authority (HOD/SH) :

ABSTRACT

The efficacy study of Dried Tamarind Pulp Powder (DTTP) was performed on two hundred and forty 20 week old layer birds (BV-300) randomly divided into four groups T_0 (control), T_1 (0.25%), T_2 (0.5%) and T_3(1.00%) for 16 weeks period (20 to 36 week). The live body weights (1521.44±5.76, 1527.44±5.76, 1521.78±5.42, 1522.67±4.10), feed efficiency per egg mass (2.17±0.01, 2.16±0.01, 2.17±0.03 , 2.18±0.0) and egg production (91.34±0.53, 91.2±0.50, 91.64±0.81, 91.24±0.43) was normal and did not affected by treatment. Significantly decreased (25 to 28%) serum total cholesterol (mg/dl) (155.1±3.04, 120.8±2.18, 119.48±2.03, 117.08±1.57), remarkable increase (42 to 45%) in serum HDL (mg/dl) (38.99±2.95, 56.34±2.55, 55.45±2.55 and 55.65±1.93), reduced (30-39%), reduced serum LDL (57.15±1.72, 34.99±4.63, 40.5±3.39 and 34.85±4.11) and significantly decreased (29-31%) serum triglyceride (mg/dl) (1712.11±70.22, 1227.89±29.79, 1222.33±39.49, 1200.67±25.91) along with physiologically normal serum total protein (g/dl) (4.59±0.13, 4.77±0.18, 4.54±0.12, 4.81±0.13), serum albumin (g/dl) (2.21±0.05, 2.19±0.05, 2.5±0.13, 2.42±0.15) and serum globulin (g/dl) (2.38±0.15, 2.58±0.18, 2.04±0.11, 2.39±0.17) can be achieved after supplementation of DTPP for 16 weeks period. Egg weight (g) (57.34±0.69, 57.82±0.23, 57.48±0.23, 57.77±0.28), shell thickness (mm) (0.42±0.01, 0.43±0.02, 0.41±0.01, 0.41±0.01), yolk colour (10.44±0.20, 10.33±0.26, 10.22±0.29, 10.89±0.44), albumen index (0.10±0.005, 0.10±0.002, 0.10±0.003, 0.10±0.004), yolk index (0.38±0.003, 0.37±0.017, 0.37±0.015, 0.39±0.007) and haugh unit (86.15±1.47, 89.28±0.78, 87.31±1.54, 88.61±0.84) were normal and did not affected by treatment. Egg yolk cholesterol (mg/g) was significantly reduced by 12 to 14% (17.58±0.70, 15.19±0.72, 15.33±0.39, 15.54±0.56) while no significant changes in yolk HDL (mg/g) (9.16±0.51, 11.4±0.73, 10.49±1.11, 10.54±0.51), yolk LDL (mg/g) (6.46±0.56, 5.49±0.15, 5.93±0.29, 5.41±0.25) and yolk triglyceride (mg/g) (128.87±5.56, 115.07±2.68, 117.71±2.66, 116.34±2.99) was noted. The present study concludes that egg yolk cholesterol can be reduced by 12 to 14% by supplementation of DTPP between 0.25 to 1.00 % for 16 weeks period in layer birds without adversely affecting on feed efficiency, egg production, serum biochemistry and other egg quality parameters.

प्रबंध सारांश

१)प्रबंध शिर्षक : **"अंडी देणाऱ्या कोंबड्यांच्याखाद्यामध्ये चिंचेचा पूरक खाद्य म्हणून केलेला वापर"**

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५) पदवीदानाचे वर्ष : 2016

६) मुख्य विषय : पशु आहारशास्त्र

७) प्रबंधाची एकूण पाने : ८७

८) सारांशचे एकूण शब्द : ३२५

९) विद्यार्थ्यांची स्वाक्षरी :

१०) विभाग प्रमुख : (नाव ,पत्ता व स्वाक्षरी)

"अंडी देणाऱ्या कोंबड्यांच्या खाद्यामध्ये चिंचेचा पूरक खाद्य म्हणून केलेला वापर"

प्रस्तुत संशोधनात अंडी देणाऱ्या कोंबड्याच्या खाद्यामध्ये वाळवून भुकटी केलेल्या चिंचेचा वापर केल्याने होणाऱ्या परिणामाचा अभ्यास करण्यात आला. प्रस्तुत संशोधनासाठी 20 आठवड्याच्या एकूण 240 कोंबड्या चार गटामध्ये समान विभागण्यात आल्या. पहिला गट (T_0) राखीव असून त्यामध्ये केवळ मूळ खाद्याचा वापर करण्यात आला. दुसऱ्या (T_1), तिसऱ्या (T_2) व चौथ्या (T_3) गटामध्ये अनुक्रमे 0.25%, 0.50% व 1.00% वाळवून भुकटी केलेल्या चिंचेचा वापर करण्यात आला. संशोधनाअंती कोंबड्याचे वजन (ग्रॅम) (1521.44, 1527.44, 1521.78, 1522.67), खाद्याचे अंड्यात रूपांतराचे गुणोत्तर (2.17, 2.16, 2.17, 2.18) व अंडी उत्पादन (%) (91.34, 91.20, 91.64, 91.24) समाधानकारक असून कोणत्याही प्रकारचा दुष्परिणाम आढळून आले नाही. रक्त तरल कोलेस्टेरॉल (मिलिग्रॅम / डेसिलिटर) (155.10, 120.80, 119.48, 117.08) च्या प्रमाणात लाक्षणिक घट (25-28%) झाल्याचे दिसून आले. रक्त तरल एच डी एल (मिलिग्रॅम/ डेसिलिटर) (38.99, 56.34, 55.45, 55.65) च्या मध्ये उल्लेखनीय वाढ (42-45%) झाली. रक्त तरल एल डी एल (मिलिग्रॅम / डेसिलिटर) (57.15, 34.99, 40.50, 34.85) च्या प्रमाणात लाक्षणिक घट (30-39) दिसून आले. रक्त तरल ट्रायग्लीसराईड (मिलिग्रॅम/ डेसिलिटर) (1712.11, 1227.89, 1222.33, 1200.67) च्या प्रमाणात लाक्षणिक घट (29-31%) झाली. याबरोबरच रक्त तरल प्रथिने (ग्रॅम/ डेसिलिटर) (4.59, 4.77, 4.54, 4.81), रक्त तरल अल्बुमिन (ग्रॅम/ डेसिलिटर) (2.21, 2.19, 2.50, 2.42) व रक्त तरल ग्लोबुलीन (ग्रॅम/ डेसिलिटर)(2.38, 2.58, 2.04, 2.39) समाधानकारक आढळून आले. अंड्या चे वजन (ग्रॅम) (57.34, 57.82, 57.48, 57.77), अंड्याच्या कवचाची जाडी (मिलीमीटर) (0.42, 0.43, 0.41, 0.410) अंड्याच्या पिवळ्या बलकचा रंग (10.44, 10.33, 10.22, 10.89) अल्बुमिन निर्देशांक (0.10, 0.10, 0.10, 0.10), पिवळा बलक निर्देशांक (0.38, 0.37, 0.37, 0.39) व हॉग एकक (86.15, 89.28, 87.31, 88.61) प्रचलित मानकनुसार समाधानकारक आढळले.. अंड्यातील पिवळ्या बलकातील कोलेस्टेरॉल (मिलिग्रॅम/ग्रॅम) (17.58, 15.19, 15.33, 15.54) च्या प्रमाणात लाक्षणिक घट (12-14%) झाल्याचे दिसून आले. तर अंड्यातील पिवळ्या बलकातील एच डी एल (मिलिग्रॅम / ग्रॅम) (9.16, 11.40, 10.49, 10.54), एल डी एल (मिलिग्रॅम/ग्रॅम) (6.46, 5.49, 5.93, 5.41) व ट्रायग्लीसराईड (मिलिग्रॅम/ग्रॅम) (128.87, 115.07, 117.71, 116.34) मध्ये कोणताही लाक्षणिक बदल झाल्याचे दिसून आले नाही. प्रस्तुत अभ्यासातून असे दिसून आले की, अंडी देणाऱ्या कोंबड्यांमध्ये 0.25-1.00% वाळवून भुकटी केलेल्या चिंचेचा पूरक खाद्य म्हणून

वापर केल्यास अंड्यातील पिवळ्या बलकातील कोलेस्टेरॉलच्या प्रमाणात 12 ते 14% घट होऊ शकतो.