EFFECT OF DIETARY SUPPLEMENTATION OF TURMERIC (*Curcuma longa*) POWDER ON THE PERFORMANCE OF VANARAJA BIRDS

Thesis

submitted to

NAGALAND UNIVERSITY

In partial fulfilment of requirements for the Degree

of

DOCTOR OF PHILOSOPHY

in

Livestock Production and Management

by

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2022

DECLARATION

I, Naorem Diana Devi, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree to any other University/Institute.

This is submitted to Nagaland University for the degree of Doctor of Philosophy in Livestock Production and Management.

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CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of dietary supplementation of turmeric (*Curcuma longa)* powderon the performance of Vanaraja birds"** submitted to Nagaland University in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy in Livestock Production and Management is the record of research work carried out by Miss Naorem Diana Devi, Registration No. Ph.D/LPM/00121 under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN LIVESTOCK PRODUCTION AND MANAGEMENT

This is to certify that the thesis entitled "Effect of dietary supplementation of turmeric (*Curcuma longa)* powder on the performance of Vanaraja birds" submitted by Miss Naorem Diana Devi, Admission No. Ph-238/17 Registration No. Ph.D/LPM/00121to the NAGALAND UNIVERSITY in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy in Livestock Production and Management has been examined by the Advisory Board and External Examiner on ………………………….

The performance of the student has been found **Satisfactory/Unsatisfactory.**

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ABSTRACT

The present research work entitled "**Effect of dietary supplementation of Turmeric (*Curcuma longa*) powder on the performance of Vanaraja bird**" was carried out with the objective to study the production performance, reproductive and egg quality traits, haematological and biochemical parameters and economics of rearing Vanaraja birds as influenced by dietary supplementation of turmeric powder. A total of 120 female Vanaraja birds of two months old were raised for a period of 365 days which were randomly divided into four treatment groups with T_1(control), T_2, T_3 and T_4 of 30 birds each with five replications per treatment and were subjected to four dietary levels of turmeric powder containing 0% , 0.5%, 0.75% and 1.5%, respectively . The birds were reared in cages under standard management practices. The final body weight (2948.06± 0.635 g/bird) was found to be significantly ($P<0.05$) higher in T_4 as compared to T_1 (2903.45± 0.502 g/bird). Overall body weight gain wasfound to increase ($P<0.05$) with the increase in the level of turmeric powder. Feed intake was significantly ($P<0.05$) lower at 1.5 % turmeric powder supplementation as compared to the control group. Better mean FCR of 63.11±10.10 was observed in the control group. Liveability was higher in turmeric supplemented group. Age at sexual maturity, egg weight at first egg, clutch size, hen- day egg production and hen- house egg production were found to be non-significant. Body weight at onset of egg production and total egg production was found to be significantly ($P<0.05$) higher in turmeric supplemented group T_4 and T_3, respectively. At 180 days, addition of turmeric at 1.5 per cent (T_4) had significantly ($P<0.05$) lowered yolk cholesterol, LDL, triglycerides and serum cholesterol. However, albumen index, haugh unit, yolk index, HDL, WBC and RBC were found to be unaffected by turmeric. Similarly, T_4 had significantly ($P<0.05$) lower yolk cholesterol, LDL, triglycerides and serum cholesterol at 242 days as compared to the control while yolk index, haugh unit, WBC, RBC and HDL were found to be non-significant. Higher ($P<0.05$) yolk index and WBC with significantly ($P<0.05$) lower yolk cholesterol, LDL, triglycerides and serum cholesterol was observed in T_4 at 365 days. However, albumen index, haugh unit, RBC and HDL were unaffected by turmeric supplementation. Higher net profit per bird and net profit per kg weight gain was observedin group T_3 followed by T_2, T_1 and the least in T_4group.

Overall, the turmeric powder supplementation at the rate of 0.75 (T_3) per cent resulted in better performance in terms of survivability, egg production and quality traits, haematological and biochemical values and net returns as compared to the control group. Therefore, on the basis of the above findings, use of turmeric powder at the rate of 0.75 per cent as feed additive can be recommended in poultry diet for better production performance and for producing quality poultry products for maximum return.

Key words: Body weight, egg production, blood parameters, net profit, turmeric powder.

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LIST OF ABBREVIATIONS

@	=	At the rate of
%	=	Per cent
ANOVA	=	Analysis of variance
COL	=	Cholesterol
df	=	Degree of freedom
FCR	=	Feed conversion ratio
Fig.	=	Figure
g/dl	=	Grams per decilitre
Hb	=	Haemoglobin
HDL	=	High density lipoprotein
i.e.	=	That is
Kg	=	Kilogram
LDL	=	Low density lipoprotein
mg/dl	=	Milligram per deciliter
nm	=	Nanometers
mmol/L	=	Millimoles per litre
PCV	=	Packed cell volume
RBC	=	Red blood cells
S.S	=	Sum of square
TP	=	Turmeric Powder
Viz.	=	Such as
WBC	=	White blood cells

CHAPTER 1

INTRODUCTION

INTRODUCTION

Poultry sector in India is rapidly growing and plays a very important role in the national economy. In terms of egg production, the country ranks third which is next to China and the United States with an annual production of 65.48 billion eggs, rising at an annual pace of 8 to 10% as opposed to agriculture, which is just 1.5 to 2%(Mehta and Nambiar, 2013). India ranks 6th in broiler production and is at the top of 5 chicken meat producing countries in the world. Poultry industry offers job to as many as 1.6 million people directly while the remaining 20% are engaged in its ancillary industriessuch as feed, pharmaceuticals, equipment and other services needed by the poultry sector(Ketharaj and Jeyakumar, 2009). As a result of government-initiated programmes on research and development poultry sector in India has advanced significantly over the past three decadesfrom small-scale backyard farming to a full-fledged commercial operation. The latest trends in poultry rearing practices and innovations for processed chicken meat, medications, feed additives, health goods, equipment, management, marketing and other technical support have made it feasible to increase the production of poultry meat and eggs.A significant economic sector in many nations is now the poultry sector.In 2019, the broiler and egg segment of the Indian poultry market had a value of INR 2,049 billion (International Market Analysis Research and Consulting Group, 2020).A significant proportion of non-edible agricultural and industrial by-products are used by poultry to produce high-quality, nutrient-rich, protein-rich product and helps in bridging the gap between the country's demand and supply of high-quality protein. The most affordable sources of animal proteins are eggs and poultry meat. Furthermore, one of the best fertiliser substitutes is poultry manure.

Feed cost continues to be the major expense item which accounts for 60-70 per cent of the total cost of production (Wilson and Beyer, 2002).Since the inception of the poultry industry, efforts have been undertaken to improve the feed efficiency and minimise production costs per unit through nutritional interventions. As a result, there has been an increase in the awareness and use of herbal feed additives in animal feeds to enhance productive and reproductive performance and improve the quality of the products resulting in reduced feed cost. People today are increasingly concerned about their health and the quality of the food they consume.Feed additives are non-nutritive substances such as antibiotic, enzyme, antioxidant, pellet-binder, antifungal, colored pigment and flavoring agent which are basically used in animal feeds to improve animal performance by speeding up growth, improving feed conversion efficiency, boosting immunity and reducing mortality. In animal farming there are several issues which have direct bearing on the efficiency and profitability and as such it demands attention more so in poultry, due to its fragility. Irrespective of the scale of operation, incidence of disease and infections and deterioration of the environment are frequent occurrences which leads to stressful conditionsresulting in poor utilization of feed and thereby significant losses. Due to the antibiotic resistance (Denli *et al.,* 2003) among pathogenic bacteriaand its residual effect (Yang *et al.,* 2009), the effectiveness of antimicrobial agents has lost its credibility and as such requires to be tackled rationally. Moreover, research has indicated a connection between the danger of zoonotic infections and the use of antibiotics that promote growth in livestock and poultry (Edens, 2003). Production of poultry was concentrated on maximising growth performance through increased growth rate and feed conversion efficiency. However, the genetic potential of the bird, the quality of the feed, the environment, and spread of diseases all play a significant role in how well the bird performs(Sugiharto, 2016).Use of plant phytogens is in vogue to replace antibiotic growth promoters. Prebiotics, probiotics, organic acids, enzymes, antioxidants are some of the effective antibiotic substitutes. Due to their wide range of positive effects, herbs and their extracts are known to be ideal options (Wenk, 2003 and Durrani *et al*., 2006). Docic and Bilkei (2003) stated that the plant extract, as substitution of antibiotic, positively affected feed intake, gain of body weight, utilization and improvement of microbial fermentation in the intestine.Turmeric, which includes bioactive secondary metabolites known as curcuminoids,has been used successfully as a suitable feed additive for poultry among other herbs and vitamins. A member of the Zingiberaceae family of plants, turmeric is a natural herb which thrives both in tropical and sub-tropical climates. Although turmeric is now grown in several South American (Peru and Bolivia) and Asian (Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, Philippines) nations, India continues to be the world's top producer, consumer and exporter(Shrishail *et al.,* 2013).Since the last decade, turmeric has increasingly been used in chicken feed due to its therapeutic properties (Khan *et al*., 2012).The use of turmeric and its extracts as a substitute for antibiotic growth promoters in the production of poultry has also been reported to be highly effective by Basak(2015).

Turmeric contains 2.4 to 4% essential fatty acids, 6.3% crude protein, 5.1% crude fat, 69.4% carbs (Kermanshahi and Riasi, 2006), 13.1% moisture (Chattopadhyay *et al.,* 2004) and crude ash (Choudhury, 2019). The beneficial effects of turmeric is also due to its vitamin content containing 0.89% thiamine, 0.16% riboflavin, 2.30% naicine, 0.20% calcium, 0.63% phosphorus, 0.46% potassium and 0.05% iron (Ikpeama *et al.,* 2014). Turmeric has been used in poultry feed widely in a variety of dosages, concentrations and spans of time. It is reported that use of turmeric in poultry birds resulted in enhancement of haematological and biochemical markers, rise in antibody levels following vaccination, reduction in heat stress protection against the negative effects of aflatoxins when ingested and increase in various organs; antioxidant activity, reduction in the number of potentially harmful bacteria, such as *Escherichia coli*, in the ileal fluid of farm-raised laying hens(Guil-Guerrero *et al.,* 2017).

The hepato protector activities of curcumin could prevent the damage of liver cells (Aggarwal *et al*., 2007). The bioactive ingredients of turmeric promote healthy skin, eyes, and brain functioning in addition to aiding digestion. Its potent antiviral and antioxidant properties support the immune system's growth.

Turmeric, which is a commonly used spice is widely grown and thrives well under the prevailing climatic condition of the region. Use of locally available turmeric has great scope in the region which can benefit the poultry growers. Due to its therapeutic properties it can improve the birds performance, promote health and profitability in poultry production. The popularity of rearing birds such as Vanaraja is growing particularly among the local entrepreneurs and the rural community in the region. Considering the beneficial effects of turmeric, a detailed and systematic study on its optimum use in poultry diet was carried out not only to generate relevant data on the performance of the birds but also a basis to establish the optimum levels of inclusion in poultry diet for onward recommendation. Hence, the present study entitled "Effect of dietary supplementation of turmeric powder on the productive and reproductive performance of Vanaraja birds" was conducted with the following objectives:

OBJECTIVES:

1. To study the effect of dietary supplementation of turmeric powder on the productive traits of Vanaraja bird.
2. To study the reproductive traits of Vanaraja bird under the dietary supplementation of turmeric powder.

3. To study the effect of dietary supplementation of turmeric powder on the haematological and biochemical constituents of blood in Vanaraja bird.
4. To study the effect of dietary supplementation of turmeric powder on the economics of Vanaraja bird.

CHAPTER - 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Turmeric is a widely used spice which is known to have therapeutic and medicinal properties. Recognizing its importance as a potential alternative feed supplement to antibiotic growth promoter, several researchers have carried out trials to study its effect on the performance of poultry birds. Some of the important findings have been discussed below under the following heads.

2.1 Turmeric and its composition:

The World Health Organization declared turmeric and its yellow coloring agent (curcumin) as safe to be used in human food and animal feed (World Health Organisation, 1987).

Kapoor (1990) reported that turmeric contains proteins (6.3 %), fats (5.1 %), minerals (3.5 %), carbohydrates (69.4 %), and moisture (13.1 %). The essential oil (5.8 %) contains alpha-phellandrene (1 %), sabinene (0.6 %), cineol (1 %), borneol (0.5 %), zingiberene (25 %) and sesquiterpenes (53 %).

Turmeric is well known for its medicinal values and has been a recipe for the treatment of many diseases (Srimal, 1997).

The active ingredient curcumin has hepatoprotective properties and is claimed to enhance digestion and metabolism of nutrients(Pal *et al.*, 2001).

Demir *et al.* (2003) reported that turmeric and ginger as natural growth promoters can be used as an alternatives of common artificial growth promoters like antibiotics.

Inclusion of turmeric meal at the rate of not more than 50 g/kg is recommended in poultry ration to avoid induction of parenchymal and portal infiltration of mononuclear cells and hyperaemia of portal vessels (Al-Sultan and Gameel, 2004).

Curcumin is the active component of turmeric *(Curcuma Longa Linn*) and has biological and pharmacological activities (Chattopadhyay *et al*., 2004).

Based on human and animal studies, administration of curcumin upto 8000mg/day did not induce any toxic effect which suggests that turmeric may be safe and ideal to be used as feed additives in poultry (Ali*et al*., 2006).

Turmeric contains 2.4 to 4% essential fatty acids, 4.7 to 8.2 grammes of crude ash, 6.3% crude protein, 5.1% crude fat and 69.4% carbs (Kermanshahi and Riasi, 2006).

There are limited studies on the effects of turmeric powder supplementation in birds, specially laying hens (Radwan *et al*., 2008).

Curcuma longa is a perennial herb that belongs to the family of *Zingiberaceae* and is distributed throughout tropical and subtropical regions of the world (Beevers *et al*., 2011).

Due to its medicinal properties, the use of turmeric in poultry feed became extensive during the last decade (Khan *et al.,* 2012).

There is no documented publication till date that have reported harmful effects of turmeric meal in poultry diets when used at low to moderate concentrations (Nanung *et al.,* 2013).

Saraswati *et al.* (2013b) reported that chemical analysis of turmeric powder showed that it contained 7.97% curcumin.

The beneficial effects of turmeric is also due to its vitamin content containing 0.89% thiamine, 0.16% riboflavin, 2.30% niacin, 0.20% calcium, 0.63% phosphorus, 0.46% potassium and 0.05% iron (Ikpeama *et al.,* 2014).

Youssef *et al*. (2014) reported that turmeric contains 67.91% of carbohydrate, 2.46% fat, fibre 4.02%and protein 9.34%.

Turmeric and its extracts have been reported to be an effective alternative to antibiotic growth promoter in poultry production (Basak, 2015).

Curcumin has phytotherapeutic and functional nutritional use having potential nutraceutical effect on animal nutrition (Gunes *et al*., 2016 and Marathe *et al.,* 2016).

The variations in the effects of the addition of turmeric powder into laying hen diets among the different studies might be attributed to the differences in the concentration levels and periods of turmeric supplemented, age and strain of laying hens, turmeric sources, stability of active compounds, drying method, turmeric products, experimental methods used (Sherif, 2016).

Dalal and Kosti (2018) suggested that the active substances in the turmeric oil are curcuminoids, aromatic turmerones, alpha and beta turmerones and curlone. Curcuminoids have a wide spectrum of biological activities including antioxidant, antibacterial, antifungal, antiviral and anti-inflammatory property.

Olarotimi (2018) reported the beneficial properties of phytochemicals in turmeric as viable antimicrobial, antifungal, and antioxidant phytogenic feed additives capable of improving the utilization of dietary nutrients in birds and makes it a safer product.

Turmeric has chemical composition percentage of 88.85% dry matter (DM), 15.82% crude protein (CP), 3.72% ether extract (EE), 1.073% mineral matter (MM) and 7.79% crude fibre (CF) (Silva *et al*., 2018).

Effects of turmeric powder on

2.2 Productive traits

2.2.1 Body weight and body weight gain

Gowda *et al.* (2008) reported that body weight gain was not affected when birds were fed with diet containing 0.5 % of turmeric powder.

Radwan *et al.* (2008) reported that the addition of 0.5 or 1.0 % turmeric powder numerically increased the body weight gain as compared to hens fed basal diet.

Turmeric supplemented in layers diet was reported to enhance the body immune system of the birds against the harmful effects of Ochratoxin A infection on body weight gain. (Sawale *et al*., 2009).

Moeini *et al.* (2011) reported no significant differences in average daily gain and final live weight among the treatments when the layer birds were fed with diet supplemented with ginger rhizome powder (1 and 3 per cent) and turmeric rhizome powder (1 and 3 percent).

Al-Jaleel (2012) reported improved body weight gain at 1.0 and 1.5% turmeric supplementation without the effect on feed intake of broiler chickens.

Saraswati *et al.* (2013a) reported that supplementation of turmeric powder did not affect body weight gain and body fat deposition ($P>0.05$) of Japanese quail.

When broiler birds were subjected to four experimental diets containing 0%, 0.5%, 1.0% and 1.5% turmeric powder, Mondal *et al*. (2015) observed significant increase in mean body weight gain due to turmeric supplementation.

Arslan *et al.* (2017) reported that supplementation of turmeric powder at 1 and 1.5 % improved body weight gain of broiler.

Attiaa *et al.* (2017) reported that different level of turmeric supplementation did not affect the body weight.

Saikia *et al.* (2017) reported the overall mean body weight of Vanaraja birds at 2, 3, 4, 5 and 6 months of age as 797.13±2.73, 1293.16±4.51, 1743.01±5.06, 2087.28±6.26 and 2521.07±8.67g, respectively under traditional system of management.

Gumus *et al.* (2018) revealed that there were no statistically significant differences in terms of final body weight after the groups were fed as 0.5% sumac, 0.5% turmeric, and 0.25% sumac + 0.25% turmeric.

Ooi *et al.* (2018) showed that there was no significant difference (P>0.05) in the means of body weight gain among the treatment groups when medicinal herbs i.e. turmeric rhizome powder, Vietnamese coriander leaf powder and Dayak onion powder used as feed additives in laying hens.

Sulastri and Basri (2019) showed that the effect of organic feed containing cassava leaves, turmeric and ginger powder significantly increased live weight of Japanese quail.

Khodadadi *et al*. (2021) reported significantly higher final body weight in broilers as compared to the control due to turmeric supplementation at the rate of 200 and 500mg / kg of feed.

2.2.2 Feed intake and feed conversion ratio

Emadi *et al.* (2007) reported that birds fed with 1 % turmeric powder had lower feed consumption which resulted in reduction of egg production and egg mass compared with control diet.

Gowda *et al.* (2008) reported that FCR, average daily feed intake and body weight gain were not affected when broiler were fed with diet containing 0.5 % of turmeric powder.

Radwan *et al.* (2008) reported that the addition of 0.5 or 1.0 % turmeric powder numerically increased the feed intake as compared to hens fed basal diet.

Seo *et al.* (2008) suggested that curcumin in turmeric may have similar effect with insulin that regulates the homeostasis of blood glucose in the body and thus controls feed intake.

Curvelo *et al.* (2009) did not find any significant differences (P>0.05) in feed intake and feed conversion ratio when annato and turmeric were added to layer feed at 0.1 and 0.2 inclusion levels.

Gowda *et al.* (2009) reported that the inclusion of turmeric mixture at levels of 0.75% and 1% in the diets improved feed intake of broiler chicken.

Moorthy *et al.* (2009) found that there was no significant difference in feed consumption but the overall feed intake was numerically high in laying hens fed with turmeric as compared to other treatment groups.

Rahmatnejad *et al.* (2009) reported that there was no beneficial effect due to turmeric powder supplementation at 1.0 g/kg of feed in broiler chicken.

Turmeric supplemented in layers diet was found to enhance the body immune system of the birds against the harmful effects of Ochratoxin A infection and improved feed efficiency (Sawale *et al*., 2009).

Lagana *et al.* (2011) found that the addition of 0.2% turmeric into laying hen diets did not affect the feed consumption.

Moeini *et al.* (2011) observed that the average daily feed intake (ADFI) of laying hens increased significantly (P> 0.05) due to dietary supplementation of ginger rhizome powder (1 and 3 per cent) and turmeric rhizome powder (1 and 3 per cent).

Nouzarian *et al*. (2011) found that broiler birds exhibited better feed conversion ratio ($P < 0.05$) at 0.5 per cent turmeric powder during entire experimental periods than control group.

Akbarian *et al.* (2012) did not find beneficial effects of supplementing diets with turmeric meal at the rate of 0.5 g/kg.

Al-Jaleel (2012) reported improved FCR at 1.0 and 1.5% turmeric supplementation without the effect on feed intake of broiler chickens.

Park *et al.* (2012) reported that 2g/kg of turmeric powder decreased the feed conversion ratio (FCR) of laying hens.

Riasi *et al.* (2012) observed that hens fed diets containing 1.5 and 2 g kg-1 of TRP had lower feed intake than the other groups.

Saraswati *et al.* (2013b) reported that supplementation of turmeric powder did not affect feed intake and daily feed consumption ($P > 0.05$) of Japanese quail.

Bozkurt *et al.* (2014) found that hens fed diets containing 1.5 and 2 g/kg of turmeric powder had lower feed intake that the other groups.

Kilany and Mahmoud (2014) observed a decrease in the intake of feeds with turmeric and an even lower intake when the enzyme was added, with an improvement in feed efficiency of Japanese quail.

When broiler birds were subjected to four experimental diets containing 0%, 0.5%, 1.0% and 1.5% turmeric powder, Mondal *et al*. (2015) observed significant increase average feed efficiency due to turmeric supplementation.

Putra *et al.* (2015) found that inclusion of turmeric root at level of 2 % in the diet did not affect ($P<0.05$) feed intake significantly of Japanese quail when compared to the basal diet.

Rahardja *et al.* (2015) observed that feed intakes of the hen were significantly lowered when 4% turmeric powder supplemented, while there were no significant changes in water intakes.

Sheriff (2016) observed that laying hens fed with diet containing 0 and 2% level of turmeric powder exhibited better feed conversion ratio than those subjected to diets containing 4% turmeric during an 8 weeks trial period.

Wang *et al*. (2016) indicated that daily feed intake increased by addition of 100 and 200 mg/kg turmeric rhizome extract to broilers; but daily feed intake decreased by addition of 300 mg/kg.

Feed intake was significantly reduced while FCR was improved significantly when broilers were fed with turmeric supplemented diet containing 0.5, 1 and 2 g / kg of diet (Attiaa *et al*., 2017).

Arslan *et al.* (2017) reported that supplementation of turmeric powder at 0.5% and 1.5% reduced feed intake. All levels improved feed conversion efficiency but supplementation at the rate of 1.5% showed the best results in broiler birds.

Kanagaraju *et al.* (2017) revealed that the supplementation of turmeric powder in layer diets significantly ($P<0.05$) increased FCR.

Chauhan *et al.* (2018) reported no differences in feed intakes when turmeric was supplemented in layer birds.

Dalal and Kosti (2018) reported that turmeric stimulated feed intake and endogenous secretion and enhance production of laying hens.

Gumus *et al.* (2018) revealed that there were no statistically significant differences in terms of feed intake after the groups were fed according to the diets as 0.5% sumac, 0.5% turmeric, and 0.25% sumac + 0.25% turmeric. However, addition of turmeric reduced the feed conversion ratio of laying hens as compared with the control group.

Ooi *et al*. (2018) showed that there was no significant difference (P>0.05) in the means of overall feed intake and feed conversion efficiency among the treatment groups when medicinal herbs i.e. turmeric rhizome powder, Vietnamese coriander leaf powder and Dayak onion powder used as feed additives in laying hens.

Silva (2018) showed that the sorghum-based feeds with added turmeric levels did not affect layer bird's performance.

Godara and Singh (2019) reported that turmeric supplementation and feed restriction are beneficial for poultry production and improve the feed conversion ratio.

Sulastri and Basri (2019) showed that the effect of organic feed containing cassava leaves, turmeric and ginger powder is not significantly different on feed consumption and drinking consumption of Japanese quail.

Zadeh *et al.* (2022) found that the TP supplementation in laying hens significantly increased (P< 0.05) the feed conversion ratio while the feed intake remained unaffected.

2.2.3 Mortality/ liveability

Devegowda (1996) reported that the curcumin present in turmeric enhanced bird's performance by improving liveability and lowering mortality in poultry birds.

Al-Kassie *et al. (2011)* found that the feeding of turmeric rhizome powder in the poultry diet helped to improve the morbidity and mortality of broiler chickens.

Kanagaraju *et al.* (2017) revealed that the supplementation of turmeric powder in layer diets significantly ($P<0.05$) increased liveability.

Mortality per cent of Vanaraja bird under backyard system was recorded to be 11.7 (Singh *et al*., 2018).

2.3 Reproductive traits

Bhattacharya *et al*. (2005) reported that the age at sexual maturity and average egg size of Vanaraja chicken ranged from 172 to 185 days and between 46 and 55 g, respectively.

Age at sexual maturity of Vanaraja birds and egg weight at 40 weeks of age were found to be 164.79 days and 55.87g, respectively (Niranjan *et al.,* 2008).

Radwan *et al.* (2008) reported that supplementation of layer diets with turmeric meal at 5 g/Kg increased the percentage of hen day egg production.

Curvelo *et al.* (2009) did not find any significant differences ($P<0.05$) in average egg weight or egg production when annato and turmeric were added to layer feed at 0.1 and 0.2 inclusion levels.

Age at sexual maturity of Vanaraja birds was recorded to be 197.70 days (Haunshi *et al*., 2009).

There were no significant difference ($P>0.05$) in egg production and egg weight when laying hens were fed with fermented dry ginger (Incharoen and Yamauchi, 2009).

Moorthy *et al.* (2009) did not observe any significant effect on per cent hen day egg production of layers as a result of feeding diet supplemented with 0.1% of turmeric powder.

Awadein *et al.* (2010) observed that the sexual maturity of Mandarah hens was delayed when fed with 0.5% fenugreek as compared with the control group.

Lagana *et al.* (2011) found that the addition of 0.2% turmeric into laying hen diets did not affect the egg production.

Moeini *et al*. (2011) reported that egg weight was not affected by dietary supplementation of different levels of turmeric powder (P>0.05).

There were no significant differences (P>0.05) in egg production and egg weight due to supplementation of ginger root in laying hens (Zhao *et al.,* 2011).

Akbarian *et al.* (2012) did not find beneficial effects when diet was supplemented with turmeric meal at the rate of 0.5 g/kg of broiler feed.

Malekizadeh *et al.* (2012) reported that supplementation of turmeric meal in the diet at the rate of 10.0 or 30.0 g/kg did not influence egg production, egg weight and egg mass of laying hens.

Park *et al.* (2012) reported that birds that were subjected to 0.5% turmeric powder supplementation outperformed the others in egg production, egg weight and daily egg mass however, no differences in the egg shell strength, egg shell thickness and Haugh unit were observed among the treatments.

Riasi *et al*. (2012) reported that feeding of turmeric at 10.0 or 30.0 g/kg did not influence egg production, egg weight and egg mass of single comb white leghorn laying hens.

Saraswati *et al.* (2013a) reported that supplementation of turmeric powder, regardless of period of administration, increased ($P<0.05$)the total number of egg production until 9 months of age.

Bozkurt *et al.* (2014) reported that egg mass in the groups fed diet with turmeric powder were significantly ($P<0.05$)higher than that of the control.

Rahardja *et al*. (2015) reported that egg production was significantly increased and maintained at a higher level by turmeric powder supplementation up to 4% as compared with the control while the weight of eggs was unaffected.

Saraswati and Tana (2016) showed that administration of turmeric powder can accelerate the age of maturity of hens. Further, they reported that turmeric supplementation up to 4% did not affect egg weight of Japanese quail.

Sheriff (2016) described that increasing the turmeric level in layer diets resulted in significant reduction in egg mass.

Kanagaraju *et al.* (2017) reported that the supplementation of turmeric powder in layer diets significantly ($P<0.05$) increased hen day and hen housed egg production.

Saikia *et al.* (2017) studied the performance of Vanaraja bird under traditional system of farming and concluded that the mean age at first egg was 181.05±1.52days while the mean egg production up to 32, 40, 52 and 72 weeks of age was recorded as 32.13±0.11, 50.08±0.32, 89.29±1.02 and 181.12±1.53 numbers, respectively. Further, they recorded the mean egg weight at 32, 40 and 52 weeks of age as 47.31±0.21, 54.07±0.24, 58.32±0.26g, respectively.

Widjastuti *et al.* (2017) reported that the addition of turmeric meal *(Curcuma domestica, Val)* in layer ration had significant ($P<0.05$) effect on hen-day production and egg weight.

Gumus *et al*. (2018) reported that addition of turmeric increased egg production and egg weight compared with the control group.

Ooi *et al.* (2018) reported that dietary supplementation of 1% of turmeric rhizome powder, Vietnamese coriander leaf powder and Dayak onion powder in layer diet resulted in better performance in terms of hen-day egg production and egg weight associated with favourable intestinal environment without any adverse effect.

Age at sexual maturity , egg weight at onset and total egg production at 40 weeks of age of Vanaraja bird was reported to be 181.53±1.29 days and 43.07 ±0.75g / egg and 22.20± 0.88 numbers, respectively (Singh *et al.*, 2018).

Azou *et al.* (2019) reported significantly higher egg production when supplemented with turmeric powder on local laying hens.

Chakrabarti *et al*. (2020) reported the average age of sexual maturity, annual egg production and egg weight at 280 days of age of Vanaraja bird to be 172.36±2.23 days, 156.15±15.6 numbers and 55.85±5.53 g, respectively.

Zadeh *et al.* (2022) found that the turmeric powder supplementation in laying hens significantly ($P < 0.05$) reduced egg production, weight and mass throughout the experiment

2.4 Haematological and Biochemical constituents of blood

The conversion of cholesterol to bile acid by the action of curcumin, a path to eliminate cholesterol from the body could be the reason for lower cholesterol level in the turmeric supplemented group (Srinivasan and Sambaiah, 1991).

Curcumin modulates and speeds up the process of repair or regeneration of liver cells (Thaloor, 1999).

Al-Sultan (2003) reported that turmeric supplementation at 0.5 and 1.0 per cent increased both erythrocytic and total leukocytic count than control.

Decrease in serum triglycerides may be attributed to the inhibitory action of turmeric for secretion of liver triglyceride (Chattopadhyal *et al*., 2004).

Plasma cholesterol in birds increased considerably as a result of vitellogenesis and egg formation (Thrall *et al.,* 2004).

Turmeric contains curcumin compounds which can act as hepatoprotectors (Kohli *et al*., 2005).

Kermanshahi and Riasi (2006) reported decreased level of triglyceride, total cholesterol, LDL-cholesterol and increased the level of HDL-cholesterol in the blood of the laying hens when supplemented with 0.5-1.5 g/kg turmeric meal in layers diets.

Curcumin can stimulate the synthesis of LDL which causes the liver cells to take up more cholesterol from the body for the synthesis of bile acids, thereby causing a reduction in serum cholesterol receptors (Emadi *et al*., 2007).

Radwan *et al*. (2008) reported that turmeric powder supplementation at 1% level decreased total lipid, cholesterol, LDL-cholesterol and HDL-cholesterol without any statistically significant differences. They stated that the decrease of total lipid and cholesterol might be due to the effect of essential oil compounds present in the turmeric on lipid metabolism.

Curcumin stimulates bile production which is required in emulsification of lipid (Seo *et al*., 2008).

Zhongze *et al.* (2008) reported that inclusion of turmeric meal in poultry diets at 0.35 g/Kg stimulated the production of serum high-density lipoproteins (HDL), thereby reducing the total cholesterol, Low-density lipoproteins (LDL) and very low density lipoprotein (VLDL) concentrations in serum.

Curcumin can also increase the activity of lipoprotein lipase (Graham, 2009), which could be one of the possible mechanisms of the effects of curcumin on the reduction of blood triglyceride concentrations.

Kim and Kim (2010) reported that supplementation of 500 mg of turmeric per day for seven days significantly lowered lipid peroxidase, increased HDL-cholesterol, lowered total serum cholesterol.

Curcumin has a role to optimize liver function in lipid metabolism leading to increase in the performance of lipoproteins to control cholesterol, lipid and triglycerides levels in the tissues (Sengupta *et al.,* 2011).

Malekizadeh *et al.* (2012) observed that adding turmeric powder at 3% concentration in the diet of layer birds decreased ($P<0.05$) the serum total cholesterol, alanine amino transferase (ALT) and Aspartate amino transferase (AST).

Curcumin increased the excretion of cholesterol (Qinna *et al.*, 2012).

Riasi *et al*. (2012) reported that adding turmeric powder to older laying hen diets affected their serum triglyceride, total cholesterol, HDL and LDL-cholesterol.

Saraswati *et al.* (2013b) observed that the cholesterol level decreased from 177.4 mg/dl to 97 mg/dl with increase in turmeric levels and also significantly decreased serum triglyceride levels which reached 86.63 mg/dl in layer birds. Turmeric powder supplementation, regardless of period of supplementation, decreased ($P<0.05$) serum triglyceride and serum cholesterol concentration in quails.

Chauhan *et al.* (2014) observed significant reduction in LDL-cholesterol, triglycerides and improved HDL-cholesterol due to turmeric powder supplement. They suggested use of turmeric as an ingredient in laying hens diet for manipulating egg composition on fatty acids basis.

Naderi *et al.* (2014) observed that turmeric powder at the rate of 2.5 g/Kg and 7.5 g/Kg of the poultry diet significantly increased lymphocytes percentage compared with the control group.

Putra *et al.* (2015) observed that supplementation of turmeric powder up to 108 mg/day in Japanese quail diet had relatively higher serum HDL levels and lower LDL and triglycerides levels with increasing percentages of turmeric.

Fallah and Mirzaei (2016) observed that broilers receiving different levels of turmeric plus thyme powders had lower uric acid, total cholesterol, HDL, LDL and triglyceride concentrations compared to the control group.

Arslan *et al*. (2017) concluded that turmeric had the potential to improve cholesterol profile in broilers and its use at 1.5 per cent through feed was recommended for better results.

Guil-Guerrero *et al.* (2017)reported that use of turmeric in poultry birds resulted in enhancement of haematological and biochemical markers.

Kanagaraju *et al*. (2017) revealed that the supplementation of turmeric powder in layer diets significantly ($P<0.05$) decreased serum total cholesterol, VLDC, LDC, triglycerides but increased HDL cholesterol at 0.5 per cent level.

Dalal and Kosti (2018) reported that turmeric had positive effect on lowering blood triglycerides, total cholesterol and LDL-cholesterol. Turmeric also improved HDL-cholesterol. The decrease of total lipid and cholesterol may be due to the effect of essential oil compounds present in the turmeric on lipid metabolism.

Gumus *et al.* (2018) reported that the addition of sumac and turmeric supplementation had no significant effects on blood parameters of laying hens.

Nikola *et al*. (2018) observed that adding turmeric powder to older laying hen diets affected their serum triglyceride, total cholesterol, HDL and LDL-cholesterol, while the hens fed with standard feed had the higher triglyceride, total cholesterol, and LDL-cholesterol levels.

Silva *et al.* (2018) observed a decrease in blood cholesterol and triglycerides in all levels of added turmeric in laying hen diet.

Sulastri (2019) showed that the provision of special organic feed containing cassava leaves, turmeric and ginger powder was able to stabilize the cholesterol and HDL levels and reduce LDL levels in Japanese quail (*Coturnix japonica*).

Oluwafemi *et al*. (2021) showed that all the values of haematological parameters (Pack cell volume, haemoglobin, red blood cell, mean corpuscular volume, mean corpuscular heamoglobin, mean corpuscular haemoglobin concentration, white blood cells and its differentials) were significantly ($P<0.05$) increased with the increase in the level of turmeric oil in the diets of the bird.

Shende *et al.* (2021) reported non-significant ($P>0.05$) effect on haemato-biochemical parameters when turmeric was supplemented in birds diet.

Zadeh *et al*. (2022) reported that serum lipids levels, including triglyceride, cholesterol and very-low-density lipoprotein (VLDL) level reduced due to turmeric powder supplementation ($P< 0.05$) in laying hens.

Zhu *et al*. (2022) diet with 300 mg/kg herbal mixture which includes turmeric has a favourable effect in decreasing the lipid deposition and protecting liver injury by alleviating hepatic oxidant stress and inflammation in post-peak laying hens.

2.5 Egg quality traits

Narahari *et al*. (2003) did not observe any influence on egg quality traits when turmeric was supplemented in poultry diet.

Radwan *et al*. (2008) reported that yolk weight and yolk index were significantly higher in the treatment fed with 1.0% turmeric powder addition in the feed. The hens fed 1% turmeric significantly decreased the yolk total lipid. Hens fed 0.50 or 1.0% turmeric powder recorded the lowest values of yolk LDL-cholesterol and total cholesterol.

Curvelo *et al.* (2009) did not observed any influence on egg quality trait when annato and turmeric were added to layer feed at 0.1 and 0.2 inclusion levels.

Age at sexual maturity of Vanaraja birds was reported to be 197.70 days (Haunshi *et al.*, 2009)

Moorthy *et al.* (2009) have shown that different levels (0.0, 0.5, 1.0, 1.5 and 2.0g/kg of feed) of turmeric powder in laying hens nutrition had no significant effect on egg shell thickness, egg shell weight and eggs shell weight to egg weight ratio.

Kujero *et al.* (2012) had reported higher haugh unit at 1.5 % of turmeric supplementation and stated that the inclusion of turmeric in layer feed may have enhanced the egg quality as a result of higher haugh unit values.

Park *et al.* (2012) reported that haugh unit of group fed diet with turmeric was higher than that of control on the 14 day of storage ($P<0.05$). Also yolk index was found to be significantly higher in turmeric supplemented group.

Cholesterol in eggs was influenced by genetic factors, diet composition (Faitarone *et al.* 2013).

Saraswati *et al.*(2013b) analysed the supplementation of quail feed with turmeric powder (0, 13.5, 27 and 54 mg/quail/day) and observed an improvement in the internal and external quality of the eggs; the values of the response variables increased with increasing turmeric levels in the feed.

Rahardja *et al.* (2015) demonstrated that supplementation of turmeric powder up to 4% could improve and maintain egg production performance of the old laying hen at a higher level with a lower yolk cholesterol content.

Saraswati and Tana (2016) reported that the dietary supplementation of turmeric powder at 2 and 4% had no significant difference on haugh unit in laying hens as compared to control group.

Kanagaraju *et al.* (2017) reported that yolk cholesterol was significantly ($P<0.05$) reduced in birds provided with diet containing 0.5 and 1 % turmeric powder as compared to other treatment group (0.25 %) and control.

Widzatsu *et al*. (2017) reported non-significant ($P>0.05$) effect on yolk index, Haugh unit value when supplemented with turmeric powder in layer diet.

Ayed *et al.* (2018) reported that feed inclusion of 1 per cent garlic cloves and turmeric rhizome powder decreased egg yolk cholesterol concentration.

Chauhan *et al.* (2018) reported that dietary turmeric supplementation was effective in improving laying performance and internal egg qualities.

Gumus *et al.* (*2018*) reported that when layers were fed with 0.25% sumac + 0.25% turmeric-supplemented diet, yolk index was higher in number, but Haugh unit and albumen index were lower. Dietary addition of sumac and turmeric did not have any negative influence on performance and egg quality traits of laying hens.

Mousa *et al*. (2018) had also reported that there was significant ($P<0.05$) increase in albumen index when fed with turmeric supplemented diet.

Zadeh *et al.* (2022) reported that yolk percentage, height and index reduced when supplemented with turmeric in layer diet.

2.6 Economics

Eevuri and Putturu (2013) stated that herbal supplementation (turmeric) had positive influence on lowering the feed cost per unit of live weight gain of broiler.

Ramana *et al.* (2010) observed that raising Vanaraja breed was more profitable under backyard rearing system and could improve economic status of rural women by selling eggs and birds.

Islam *et al*. (2015) revealed that the benefit cost ratio of Vanaraja chicken is better than our local chicken under backyard system of rearing, which indicates that small scale Vanarajarearing is a profitable venture for farmwomen.

Kafi *et al.* (2017) observed that the cost of production and net return was being highly economical in treatment 0.75 per cent of turmeric in feed as compared to control groups.

Chauhan *et al.* (2018) reported that turmeric powder can be also used as a feed additive for the production of value-enhanced egg production with increased body weight hence reducing cost of feed for production per egg.

The benefit-cost ratio (gross return/ gross cost) of rearing Vanaraja birds under backyard condition was found to be 2.02 (Chakrabarti *et al*. 2020).

CHAPTER – 3

MATERALS AND METHODS

MATERIALS AND METHODS

Present study was carried out to study the growth performance, feed intake, feed conversion efficiency, mortality/liveability, reproductive traits, egg quality traits, haematological and biochemical constituents and relative economics of Vanaraja bird provided with turmeric powder supplemented diet following scientific and standard management practices.

3.1 Location of the study

The experiment was conducted in the poultry unit of the Instructional Livestock Farm of the Department of Livestock Production and Management, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland. The farm is located at 93.20^0E to 95.15^0E longitude and latitude between 25.6^0N at an elevation of 310 meter above mean sea level (MSL).The average annual rainfall ranges between175 to 250 cm.

3.2 MATERIALS

3.2.1 Experimental birds

A total of 120 numbers of Vanaraja pullets of uniform age (8 weeks) and size were used for the present study which were raised at the Institute’s farm. The birds were procured from ICAR Research Complex, Jharnapani, Nagaland.

3.2.2Experimental diet and Test materials

The birds were offered standard grower ration upto 18 weeks of age followed by layer finisher ration which were procured from reputed commercial feed supplier. The basal diet was supplemented with pure turmeric powder which was purchased from the local farmers.

3.3 Management of Experimental Stock

3.3.1Preparation of Rearing House

Before the start of the experiment, the rearing unit was swept, white washed and thoroughly cleaned and disinfected including all the equipment'ssuch as feeders, waterers and cages. In order to prevent infection, foot bath was filled with disinfectant which was replenished daily. Saw dust was spread on the floor below the cage area to collect the faeces which was changed every alternate day. The rearing unit was well lighted and ventilated. Strict sanitation and hygiene were maintained during the rearing period. The experimental birds were reared in layer cages individually throughout the trial period.

3.3.2Feed, Watering and Health

Measured quantity of feed was offered daily at 7.00 a.m. and 5.00 p.m. and the left-over feed, if any, was collected the next morning and the weigh back was recorded to assess the daily feed consumption of the birds. Fresh and clean water was provided on *ad libitum* basis. Birds were vaccinated against Ranikhet disease, infectious bursal disease and fowl pox as per the recommended vaccination schedule.

3.3.3 Experimental Design

The experiment was carried out as per Completely Randomized Block Design (CRD). One hundred and twenty (120) numbers of female Vanaraja birds of 8 weeks of age were randomly divided into four (4) different groups designated as T_1, T_2, T_3 and T_4 with thirty (30) chicks in each group having five replicates of six (6) birds each.

3.3.4Dietary Supplementation of Turmeric Powder

The birds were offered standard grower ration up to 18th weeks followed by layer ration which was supplemented with different levels of turmeric powder from the start of experiment till 52 weeks. Group T_1 served as control and was provided with just the basal diet while groups T_2, T_3 and T_4 were provided the same basal diet as in T_1 but supplemented with turmeric powder. Accurate quantity of turmeric powder was measured using a digital weighing balance and it was mixed properly with the feed. The details of dietary supplementation of turmeric powder are summarized in Table 3.1.

Table 3.1: Details of Dietary Supplementation of Turmeric Powder

Experimental Group	Level of turmeric supplementation
T_1	Basal diet
T_2	Basal diet + Turmeric powder at the rate of 0.5per cent
T_3	Basal diet + Turmeric powder at the rate of 0.75 per cent
T_4	Basal diet + Turmeric powder at the rate of 1.5per cent

3.5 Experimental Procedure

3.5.1 Body Weight and Weight gain

Initial body weight of the pullets was recorded on the first day of the experiment and thereafter the body weight was recorded on fortnightly basis which was taken in the morning hours prior to feeding them and the weight was recorded in grams. Gain in weight was calculated by subtracting the weight of previous week from the preceding week. A digital weighing balance having a maximum capacity of 10 kg was used to weigh the birds during the entire experiment period.

3.5.2 Feed Intake and Feed Conversion Ratio

The amount of feed supplied to the birds was recorded daily and the feed residue, if any, was recorded the next morning to find out the exact amount of feed consumed by birds per day and the left over feed was subtracted from the total amount of feed supplied the previous day to get the exact quantity of feed consumed by the birds per day. From these data, theaverage and fortnightly feed consumption was calculated for each bird in each group and expressed in grams. The feed conversion ratio (FCR) of different experimental groups was calculated by adopting the following formula:

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Quantity of feed consumed (g)}}{\text{Body weight gain (g)}}$$

3.5.3 Mortality/Liveability

Mortality was observed throughout the period of experiment and recorded and the mortality per cent was calculated by using the following formula:

$$\text{Mortality (per cent)} = \frac{\text{Total birds died}}{\text{Total live birds}} \times 100$$

Liveability per cent was calculated by subtracting the number of mortality from 100.

3.6 Reproductive Traits

3.6.1 Age at Sexual Maturity

Production of the egg started when the birds attain sexual maturity. Age at first egg was considered as sexual maturity. Collection of eggs was done thrice a day, in the morning, afternoon and evening. After recording the collected eggs were filled in the egg trays and stored at room temperature.

3.6.2 Body weight at 1st egg, age at first eggand Egg weight at 1st laying

On the day when the birds laid the first egg body weight of the particular bird was recorded. Age at first egg was calculated by counting the number of days starting from day old to the day of first egg while egg weight was measured by using a digital weighing balance of 500g capacity.

3.6.3 Clutch size, persistency of laying and total egg production

A clutch is a group of eggs laid by a hen on consecutive days which is followed by a rest period of about a day or more. Daily egg production was recorded to calculate the total egg production while the persistency of laying was recorded by calculating the hen day egg production and hen housed egg production using the following formula.

$$HDEP = \frac{\text{Total no. of egg laid during a given time}}{\text{Total hens days during the period}} \times 100$$

$$HHEP = \frac{\text{Total numbers of egg laid during a given time}}{\text{Number of hens housed at the beginning of the laying period}}$$

3.6.4 Egg quality traits

The purpose of this study was to determine the quality of the eggs. For this, five eggs were randomly taken from each treatment. The main parameters which were used to determine the quality of the eggs during the experiment were albumen index, haugh unit, yolk index and yolk cholesterol. For the measurement of yolk height and albumen height, an instrument called spherometer was used and for measuring length and diameter of yolk and albumen, Vernier calliper was used.

3.6.4.1 Albumen index

Albumen index was calculated by following the standard formula:

$$AI = \frac{\text{Albumen height (mm)}}{\text{Albumen length (mm)} + \text{Albumen width (mm)}} \times 100$$

Albumen index (AI) is related to albumen height, albumen length and albumen width.

3.6.4.2 Yolk index

The yolk index, defined as the ratio of yolk height over yolk diameter, provides indication on the freshness of the egg. Eggs with yolk index above 0.38 are considered as extra fresh. Those ranging from 0.28 to 0.38 are fresh and those below 0.28 are considered regular. The yolk index will decrease during storage, although less when eggs are kept under refrigeration. Yolk index was calculated by using the following standard formula given by Romanoff and Romanoff (1949):

$$YI = \frac{\text{YH (mm)}}{\text{YD (mm)}} \times 100$$

Where, YI= yolk index, YH= height of the yolk and YD= diameter of the yolk.

3.6.4.3 Haugh unit

Haugh unit indicates egg quality as conceived by Dr. Raymond Haugh in 1937.The height of the thick albumen surrounding the yolk, combined with the egg weight determines the haugh unit score. The haugh unit score was calculated by adopting the following formula:

$$HU=100*\log (H-1.7W^{0.37}+7.6)$$

Where, H is the height of the albumen (mm) and W is the weight of the egg in gram.

The haugh unit values range from 0 to 130 and can be ranked as below:

AA: 72 or more (firm), A: 71 or 60 (reasonably firm), B: 59- 31 (Weak and watery). The higher haugh unit score the better the quality of egg.

3.6.4.4 Yolk cholesterol

Yolk Cholesterol was examined by following a rapid technique for extraction of yolk cholesterol as per the method described by Washburn and Nix (1973).

Procedures

1. Onegram sample of yolk was mixed with 15 ml. of 2:1 chloroform-methanol and shaken 12 times by hand.
2. 5 ml. of distilled water was added and the sample was shaken again for 12 times by hand.
3. After thorough mixing, the sample was centrifuged at 2500 r.p.m. for 10 minutes.
4. The aqueous-methanol layer was removed by suction and discarded.
5. The chloroform layer was filtered through fiberglass filter paper into a test tube, stoppered
6. The volume obtained was recorded and stored at -5° C.

For cholesterol assay standard kit was procured from DIATEK healthcare Pvt. Ltd.Composition of the reagent in the cholesterol standard kit is given in Table 3.2 and protocol for cholesterol analysis is given in Table 3.3

End Point Method:

The solution was mixed and incubated for 5 minutes at 37^{o}C. The absorbance was read for Standard (S) and Test (T) against Blank (B) with 510 nm.

Cholesterol mg/g yolk concentration was estimated by Zlatkis method (Zlatkis *et al.,* 1953).

Table 3.2 Composition of the reagent in the cholesterol standard kit

Reagent 1 (R1)	2 x 25 ml
Good's buffer (pH 6.7)	50 mmol/l
Phenol	5mmol/l
4AA	0.3 mmol/l
Cholesterol esterase	> 200 U/l
Cholesterol oxidase	> 50 U/l
Peroxidase	> 3 kU/l

Cholesterol Standard: 200 mg/dl.

Table 3.3 Protocol for cholesterol analysis

	Blank	Standard	Test
Cholesterol reagent (1)	2.5ml	2.5ml	2.5ml
Cholesterol standard	-	0.0125 µl	-
Sample	-	-	0.0125 µl

Cholesterol (mg/g yolk) = Absorbance of Test×200×V/Absorbance of standard ×100×W

3.7Haematological / biochemical studies

3.7.1 Collection of blood sample

To study the blood parameters, blood samples were collected via wing vein from five randomly selected birds from each treatment at four months intervals. Two ml of blood was collected from each bird using sterile disposable syringe and was discharged immediately into sterilized heparin tube for examinations of all the hematological and biological constituents using standard laboratory procedures. Serum was prepared by following standard protocol. Plasma was separated and stored at-20°C. However, for estimation ofRBC and WBC fresh whole blood was used.

Plate 1Productive traits evaluation and vaccination of the bird

Plate 2 Haematological and Biochemical evaluation

Plate 3Egg quality traits evaluation

3.7.2 Red blood cells count

Red blood cells (RBCs) or erythroid cells are the most common type of blood cells and its main function is to deliver oxygen to all the parts of the body tissues.

The analysis was done using an improved Neubauer Haemocytometer as per the method described by Sastry (1985):

Procedure

1. Blood sample was drawn up to0.5 mark in RBC tube which was indicated by the red colour bead in the bulb of the pipette.

2. The same pipette with the RBC diluting fluid (Hayem's fluid) was filled up to the mark 101.

3. The blood and the diluting fluid in the pipette were mixed together by rotating (horizontally) the pipette between the palms.

4. After proper mixing, the diluted blood was allowed to flow on to the counting chamber of the haemacytometer by holding the pipette at an angle of 45º till the counting chamber was completely filled.

5. The cells were allowed to settle down in the chamber for 3-4 minutes and then the chamber was observed under the microscope to calculate Red cells.

6. The cells counted from the five squares of the central area were added and multiplied by 10,000 and expressed in cubic millimetres.

3.7.3 Total white blood cells (WBCs) count

White blood cells (WBCs) also called as leucocytes or leukocytes are the cells of the immune system that protects and fights against infectious diseases and foreign invaders.

Procedure

1. Blood sample was drawn up to 0.5 mark in WBC pipette
2. Immediately WBC diluting fluid was drawn up to 101 mark.
3. The blood and the diluting fluid in the pipette were mixed together by rotating (horizontally) the pipette between the palms.
4. After proper mixing, the diluted blood was allowed to flow on to the counting chamber of the haemocytometer by holding the pipette at an angle of 45º till the counting chamber was completely filled.
5. The cells were allowed to settle down in the chamber for 3-4 minutes and then the chamber was observed under the microscope to calculate WBC cells.
6. WBC was counted in the 9 large squares and the figure obtained was multiplied by 2000 and was expressed in cubic millimetres.

3.7.4 Lipid profile measurements

Total serum cholesterol (TC), triglycerides (TG) and high density lipoprotein (HDL) and low density lipoprotein (LDL) were determined by using biochemical analysis kits from DIATEK HEALTH care Pvt. Ltd.

3.7.4.1Determination of serum cholesterol

Cholesterol is a type of body fat or lipid. Cells in the liver produce it and release it into the blood stream. Cholesterol plays a vital role in many bodily processes such as making hormones, building cellular membranes and producing bile acids to digest fatty foods.

Total serum cholesterol concentration was estimated by following the standard protocol and expressed in mg/dl.

Procedure

1. Each test tubewas marked as per the sample numbers with one test tube marked as S (standard).
2. 1ml of reagent (R1) was taken in all the sample test tubes.
3. In all the sample test tubes 1ml of reagent (R1) was taken.
4. 10 µl of the cholesterol standard was added in the test tube which marked as S (standard).
5. In the sample test tubes, 10µl of all the sample serum was added, mixed and incubated at room temperature (25^{o}-30^{o} C) for 10 minutes.
6. In a spectrophotometer after adjusting the optical density at 0 by using distilled water and reagent (R1) as blank, the absorbance of this solution was measured at 510 nm. The reading was recorded accordingly.
7. The values obtained were calculated as per the following formula and expressed in mg/dl.

$$\text{Cholesterol} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 200$$

3.7.4.2Determination of triglycerides

Triglycerides are also lipids that circulate in the blood. Triglycerides concentration was expressed in mg/dl.

Procedure

1. Each test tube was marked as per the sample numbers with one test tube marked as S (standard).
2. In all the sample test tubes, 1ml of reagent (R1) was taken.
3. 10 µl of the standard was added in the test tube marked for standard.
4. 10µl of serum was added in the sample test tubes, mixed and incubated at room temperature (25-30^{o} C) for 10 minutes.

5. In a spectrophotometer after adjusting the optical density at 0 by mixing distilled water and reagent (R1) as blank, the absorbance of this solution was measured at 510nm. The reading was accordingly recorded.
6. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{Triglycerides} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 200$$

3.7.4.3Determination of highdensity lipoprotein (HDL)

High density lipoprotein or good cholesterol absorbs cholesterol and carries it back to the liver. High density lipoprotein concentration was expressed in mg/dl.

Procedure

1. Each test tube was marked as per the sample numbers with two other test tubes marked as B (blank) and S (standard).
2. In all the test tubes except S, 450µl of reagent (R1) was taken.
3. In the test tube marked for standard 6 µl of the calibrator was added.
4. 6 µl of serum was addedin the sample test tubes, mixed and incubated at 37^{o}C for 5 minutes.
5. After 5 minutes, all test tubes except S 150 µl of reagent (2) was added, mixed and incubated for 5 minutes at 37^{o}C.
6. In a spectrophotometer after adjusting the optical density at 0 by using distilled water as blank,the absorbance of this solution was measured at 600nm. The reading was accordingly recorded.
7. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{HDL} = \frac{\text{Absorbance of test - Absorbance of blank}}{\text{Absorbance of standard - Absorbance of blank}} \times \text{Caliberator concentration}$$

3.7.4.4Determination of low density lipoprotein (LDL)

Low density lipoprotein sometimes called bad cholesterol, makes up most of the body's cholesterol. Low density lipoprotein concentration was expressed in mg/dl.

Procedure

1. Each test tube was marked as per the sample numbers and two other test tubes marked as B (blank) and S(standard).
2. In all the test tubes except S, 450µl of reagent (R1) was taken.
3. In the test tube marked for standard 6 µl of the calibrator was added.
4. 6 µl of serum was added in the sample test tubes mixed and incubated at 37^{o}C for 5 minutes.
5. After 5 minutes all test tubes except S, 150 µl of reagent (2) was added mixed and incubated for 5 minutes at 37^{o}C.
6. In a spectrophotometer after adjusting the optical density at 0 by using distilled water as blank, the absorbance of this solution was measured at 600nm. The reading was accordingly recorded.
7. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{HDL} = \frac{\text{Absorbance of test - Absorbance of blank}}{\text{Absorbance of standard - Absorbance of blank}} \times \text{Caliberator concentration}$$

3.8Economics of Feeding Turmeric powder

The economics of feeding diet supplemented with turmeric powder was calculated on the basis of overall cost of inputs, *i.e.* the cost of chicks, feeds, test material, labour, medicines and other miscellaneous cost. Final live weight of the bird, gain in weight and egg production was considered for calculating the gross return per bird and net profit per kg gain in weight

3.9Statistical Analysis

The experimental data collected was subjected to statistical analysis in order to draw a valid interpretation and to see the effect of dietary supplementation of turmeric powder at different levels on various parameters in a completely randomized design as described by Gomez and Gomez (1984). The overall level of statistical significance was defined as $P<0.05$. The significance of the result was evaluated using Analysis of variance (ANOVA) in WASP.

CHAPTER – 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was carried out with 120 numbers of two months old female Vanaraja pullets which were reared till they attained 52 weeks of age. The birds were subjected to four dietary treatments containing 0, 0.5, 0.75 and 1.5 per cent of turmeric powder. Data on body weight, gain in body weight, feed consumption, feed conversion efficiency, mortality, liveability, egg quality traits, haematological and biochemical parameters and economy of feeding were recorded and analysed statistically and are presented in tables and illustrated by graphs in order to give a quick visual access to the salient findings. The findings from the present study are discussed in this chapter under the following heads.

4.1 Productive traits

4.1.1 Body weight

The observation on variation in body weight in different treatment groups during the trial period of 365 days are presented in Table 4.1.1. The mean body weight of different experimental groups at fortnightly interval up to the end of 365 days has been graphically plotted in Fig 4.1.1. The statistical analysis of the average body weight at different fortnight is given in Appendix A(Body weight).

Table 4.1.1 Average body weight (g/bird) of Vanaraja birds in different treatment groups

Fortnight	Treatment				C.D Value (0.05)
	T_1	T_2	T_3	T_4	
0	1365.32	1366.60	1366.12	1364.40	NS
1st	1710.00	1711.73	1717.26	1721.93	5.356
2nd	1949.40^{b}	1962.32^{a}	1955.46^{b}	1964.06^{a}	6.502
3rd	2147.20^{c}	2148.99^{c}	2157.58^{b}	2176.11^{a}	4.883
4th	2313.13^{c}	2317.80^{b}	2322.06^{a}	2324.20^{a}	2.803
5th	2430.53^{c}	2436.93^{b}	2438.10^{b}	2440.80^{a}	2.256
6th	2474.80^{d}	2482.86^{c}	2489.80^{b}	2494.934^{a}	1.458
7th	2499.40^{c}	2502.86^{b}	2504.79^{b}	2513.46^{a}	2.967
8th	2550.60^{d}	2560.20^{c}	2583.26^{b}	2593.93^{a}	2.641
9th	2601.06^{d}	2635.53^{c}	2640.20^{b}	2644.26^{a}	2.229
10th	2630.53^{d}	2647.26^{c}	2655.93^{b}	2660.73^{a}	1.595
11th	2641.74^{d}	2656.73^{c}	2663.46^{b}	2665.20^{a}	1.591
12th	2657.66^{b}	2660.40^{b}	2686.13^{a}	2695.00^{a}	1.517
13th	2690.73^{d}	2706.13^{c}	2716.53^{b}	2725.20^{a}	1.500
14th	2710.00^{d}	2726.53^{c}	2740.20^{b}	2751.13^{a}	1.844
15th	2743.13^{d}	2750.40^{c}	2763.52^{b}	2768.46^{a}	1.311
16th	2751.13^{d}	2762.26^{c}	2776.33^{b}	2794.80^{a}	1.881
17th	2771.93^{d}	2788.00^{c}	2800.60^{b}	2821.53^{a}	1.554
18th	2809.00^{d}	2824.40^{c}	2840.27^{b}	2850.00^{a}	1.761
19th	2829.20^{d}	2860.00^{c}	2876.33^{b}	2897.86^{a}	2.563
20th	2859.31^{d}	2890.20^{c}	2900.20^{b}	2921.13^{a}	2.506
21st	2889.20^{d}	2912.66^{c}	2928.46^{b}	2941.13^{a}	1.967
22nd	2903.45^{d} ± 0.502	2916.13^{c} ±0.343	2934.66^{b} ±0.527	2948.06^{a} ±0.635	1.534

a, b, c,d
Means bearing different superscripts in a row differ significantly (P<0.05)

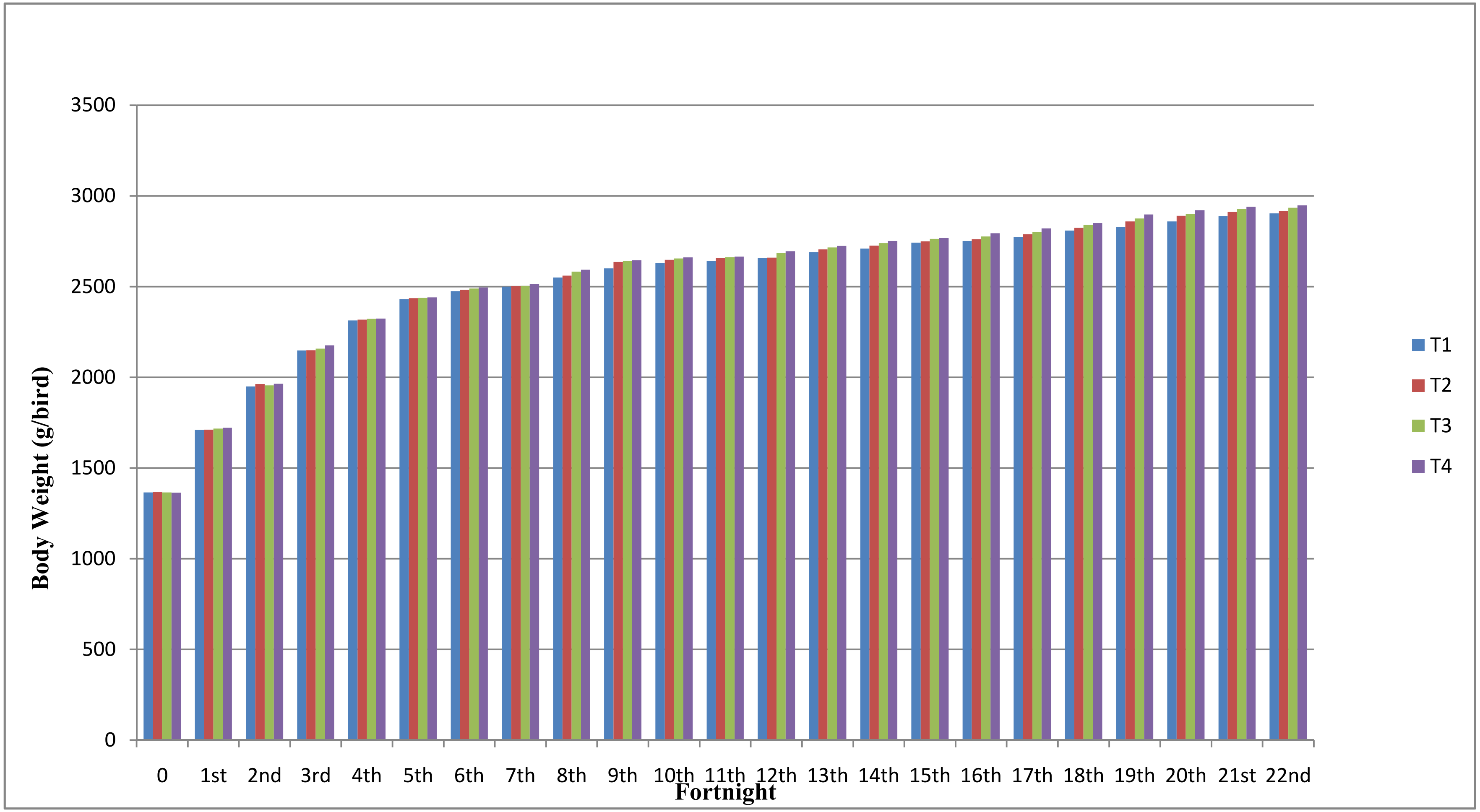

Fig 4.1.1 Body weight (g/bird/) of Vanaraja birds in different treatment groups

As per Table 4.1.1, Initial body weight of Vanaraja birds for different treatment groups i.e. T_1, T_2, T_3 and T_4 at 0 day was recorded as 1365.32, 1366.60, 1366.12 and 1364.40, respectively. Corresponding final body weight recorded at the end of 22nd fortnight for different treatment groups was 2903.45 ±0.502, 2916.13 ±0.343, 2934.66 ±0.527 and 2948.06 ±0.635. Analysis of variance revealed that there was significant ($P<0.05$) difference infinal body weight amongst the treatment groups and the body weight was found to be significantly higher inT_4 followed by T_3,T_2 and least in T_1. These results were in agreement with the findings of Sulastri and Basri (2019) who had reported significantly higher body weight in laying birds supplemented with turmeric powder. These imply that the bioactive compound present in turmeric might have enhanced the digestion,metabolic processes and nutrient utilisation for growthas also reported by Olarotimi (2018).On the other hand, Moeini*et al.* (2011)andAttiaa*et al*. (2017) reported non-significant differencesin final body due to supplementation of additives such as ginger and turmeric. The contradictory findings could be due to the variations in bird strains, agro- climatic differences, quality of feed and level of turmeric used.

4.1.2 Gain in Body Weight

Theaverage fortnightly gain in body weight, overall total body weight gain and overall mean gain in weight for different treatment groups are given in Table 4.1.2 and their mean statistical analysis are presented in Appendix- B (Body weight gain). The pattern ofgrowth and total average gain in weight during the experimental period are plotted graphically in Fig 4.1.2.

Table 4.1.2 Average gain in body weight (g/bird) of Vanaraja birds in different treatment groups

Fortnight	Treatment				C.D Value (0.05)
	T1	T2	T3	T4	
1st	344.68	345.13	351.13	337.53	5.554
2nd	239.40	250.59	238.20	242.13	NS
3rd	197.80^{c}	186.66^{d}	202.12^{b}	212.04^{a}	3.745
4th	165.93^{a}	168.80^{a}	164.48^{a}	148.08^{b}	6.762
5th	117.40	119.13	116.03	116.60	NS
6th	44.266^{c}	45.93^{c}	51.70^{b}	54.13^{a}	2.142
7th	24.60^{a}	20.00^{b}	14.99^{c}	18.53^{bc}	3.952
8th	51.20^{c}	57.33^{b}	78.47^{a}	80.46^{a}	3.547
9th	50.46^{c}	75.33^{a}	56.93^{b}	50.33^{c}	3.620
10th	29.46^{a}	11.73^{c}	15.73^{b}	16.46^{b}	2.702
11th	11.20^{a}	9.46^{b}	7.53^{c}	4.46^{d}	1.493
12th	15.92^{c}	3.66^{d}	22.66^{b}	30.80^{a}	2.556
13th	33.06^{b}	45.73^{a}	30.4^{c}	30.20^{c}	1.737
14th	19.26^{b}	20.40^{b}	23.66^{a}	25.93^{a}	2.672
15th	31.13^{a}	23.86^{b}	23.32^{b}	17.33^{c}	1.783
16th	10.00^{b}	11.86^{b}	12.80^{b}	24.33^{a}	2.920
17th	20.8^{b}	25.73^{a}	24.26^{a}	26.73^{a}	2.664
18th	37.06^{a}	36.40^{b}	39.67^{b}	28.46^{c}	2.589
19th	20.20^{c}	35.60^{b}	36.06^{b}	47.86^{a}	2.473
20th	30.11^{a}	30.20^{a}	23.86^{b}	23.26^{b}	3.076
21st	29.89^{a}	22.46^{b}	28.26^{a}	20.00^{b}	3.342
22nd	14.25^{a} ±1.00	3.46^{c} ±0.50	6.20^{bc} ±0.80	6.93^{b} ±1.30	2.849
Overall weight gain	1538.13^{d}±1.16	1549.53^{c} ±0.76	1568.54^{b} ±0.74	1583.66^{a} ±1.03	2.828

a, b, c, d

Means bearing different superscripts in a row differ significantly (P<0.05)

As per Table 4.1.2, the average gain in body weight from 1st fortnight to 22nd fortnight for the treatment groups i.e. $T_{1,}$ $T_{2,}$ T_3 and T_4 was in the range of 10.00 to 344.68, 3.46 to 345.13, 6.20 to 351.13 and 4.46 to 337.53 g/fortnight/bird, respectively. Overallbody weight gain from day old till the 22nd fortnight for the different treatment groups i.e. $T_{1,}$ $T_{2,}$ T_3 and T_4 was 1538.13± 1.16, 1549.53± 0.76, 1568.54 ±0.74 and 1583.66± 1.03g/fortnight/bird, respectively.

As per statistical analysis supplementation of turmeric powder had significant effect on the overall weight gain. It was found to increase ($P<0.05$) with the increase in the level of turmeric powder. The positive effect of bioactive compounds in turmeric might have enhanced the growth of the birds as was also reported by Ikpeama *et al.* (2014) and Olarotimi(2018). Contrary to the present findings, researchers such as Saraswati *et al.* (2013a) and Ooi *et al*. (2018)have reported non-significant effect on body weight gain due to turmeric supplementation. Differences in the findings could be due to the quality of feed, level and type of turmeric used, variation in bird strain, location of the study and agro-climatic conditions.

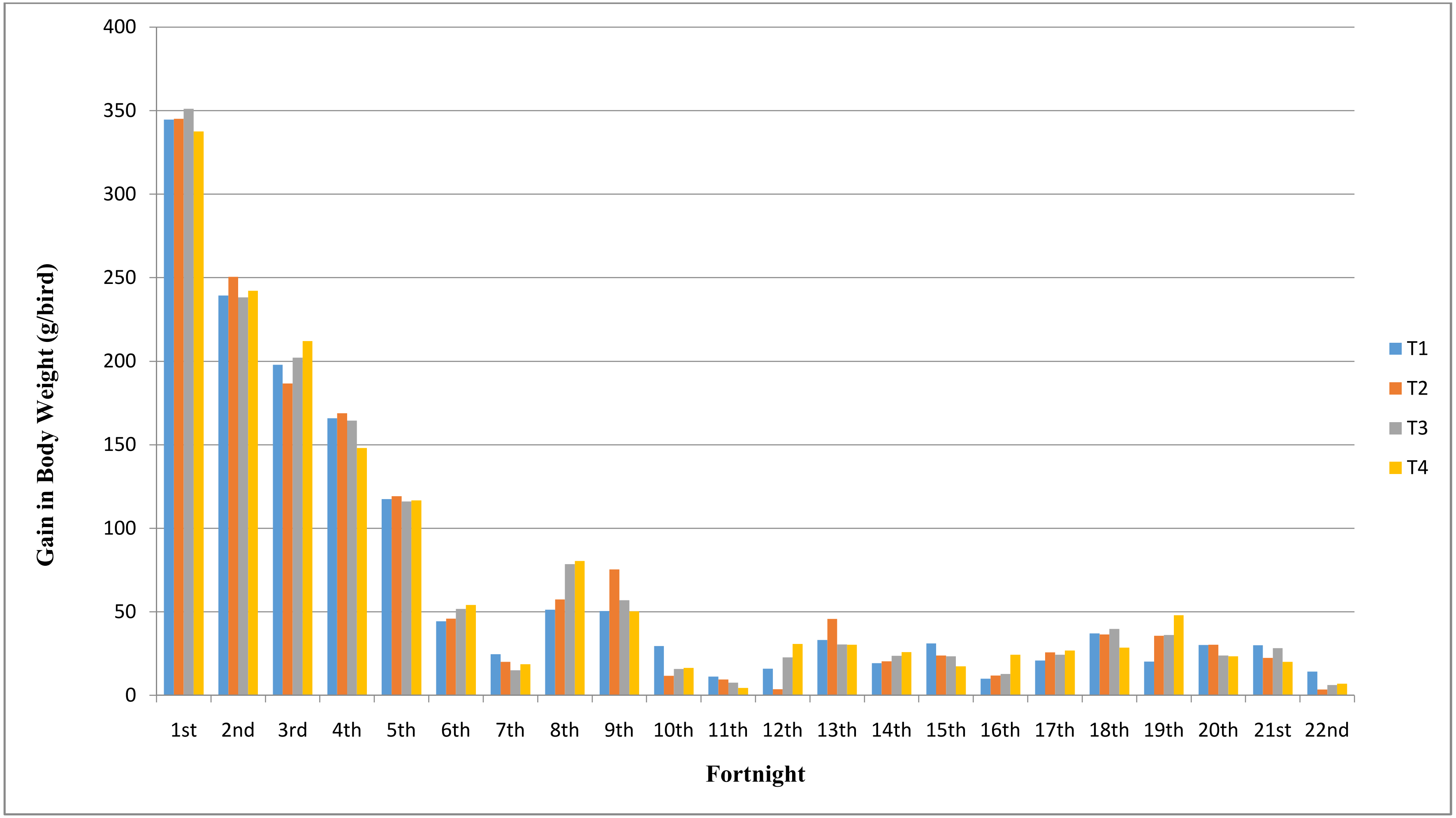

Fig 4.1.2 Gain in body weight (g/bird) of Vanaraja birds in different treatment groups

4.1.3 Feed Intake

The average fortnightly feed intake of different experimental groups during the trial period are presented in Table 4.1.3 and the statistical analysis for total feed intake has been shown in Appendix C (Feed intake). The pattern of feed intake has been graphically illustrated in Fig 4.1.3.

Table 4.1.3 Average feed intake (g/bird) of Vanaraja birdsin different treatment groups

Fortnight	Treatment				C.D Value (0.05)
	T_1	T_2	T_3	T_4	
1st	1653.26^{ab}	1660.49^{a}	1665.99^{a}	1645.04^{b}	13.33
2nd	1670.83	1663.49	1667.16	1663.78	NS
3rd	1666.80	1666.16	1666.33	1664.02	NS
4th	1671.99	1668.03	1670.20	1667.20	NS
5th	1676.99	1665.33	1660.66	1667.20	NS
6th	1677.17	1673.20	1664.66	1670.20	NS
7th	1681.57	1674.60	1667.40	1673.00	NS
8th	1709.40^{a}	1698.60^{b}	1689.00^{c}	1681.60^{d}	5.78
9th	1734.00^{a}	1719.20^{ab}	1708.60^{b}	1703.80^{b}	15.94
10th	1736.60	1733.00	1734.20	1734.00	NS
11th	1736.60	1733.00	1734.20	1734.00	NS
12th	1740.60	1738.80	1739.00	1737.40	NS
13th	1748.60	1747.20	1747.60	1747.80	NS
14th	1762.80	1762.40	1762.00	1761.60	NS
15th	1762.80	1762.40	1762.00	1761.60	NS
16th	1773.60	1771.40	1772.40	1772.60	NS
17th	1780.40	1780.20	1778.60	1780.00	NS
18th	1780.40	1780.20	1778.60	1780.00	NS
19th	1781.40	1780.20	1780.40	1780.00	NS
20th	1787.20	1787.20	1787.00	1786.80	NS
21st	1806.00	1806.00	1804.60	1805.20	NS
22nd	1808.00 ±2.00	1808.00 ±0.94	1805.8 ±1.10	1805.2 ±0.48	NS
Total	38145.82	38079.12	38046.42	38022.04	NS
Mean ±SE	1733.95^{a} ±10.62	1730.86^{b} ±10.97	1729.38^{bc} ±11.0	1728.27^{c} ±11.95	2.372

a, b, c, d

Means bearing different superscripts in a row differ significantly ($P<0.05$)

The total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 38145.82, 38079.12, 38016.42 and 38022.04 g per bird, respectively. The corresponding overall mean feed intake was 1733.95±10.62, 1730.86 ± 10.97, 1729.38 ±11.00 and 1728.27 ± 11.95 g per bird, respectively. Analysis of variance showed that the turmeric supplemented groups had significantly ($P<0.05$) lower feed intake than the control group. Consistent to the present findings, Riasi*et al.* (2012) and Rahardja*et al.* (2015) had also reported lower feed intake when laying hens were fed with turmeric at the rate of 1.5, 2 g and 4 g / kg of feed, respectively. Decreased in feed intake could be due to the change in aroma, palatability and the pungent smell of the turmeric. Contrary to the present findings, Putra *et al.* (2015);Chauhan *et al.* (2018) and Zadeh *et al.* (2022) had reported non- significant effect on feed intake due to turmeric supplementation.

4.1.4 Feed Conversion Ratio

The average fortnightly feed conversion ratio of the different experimental groups up to 52 weeks of age are depicted in Table 4.1.4 and their mean statistical analysis are shown in Appendix D (Feed Conversion Ratio). The graph representing the average fortnightly feed conversion ratio in various groups up to six 52 weeks of age are plotted in Fig 4.1.4.

Table 4.1.4 Average feed conversion ratio of Vanaraja birds in different treatment groups.

Fortnight	Treatment				C.D Value (0.05)
	T1	T2	T3	T4	
1st	4.79^{a}	4.81^{a}	4.74^{a}	4.60^{b}	0.08
2nd	6.97^{ab}	6.63^{b}	6.99^{a}	6.87^{a}	0.22
3rd	8.42^{b}	8.92^{a}	8.24^{c}	7.84^{d}	0.17
4th	10.07^{b}	9.88^{b}	10.15^{b}	11.25^{a}	0.41
5th	14.28	13.97	14.12	14.29	NS
6th	37.88^{a}	36.42^{b}	32.198^{c}	30.85^{c}	1.51
7th	68.35^{c}	83.73^{bc}	111.23^{a}	90.27^{ab}	19.53
8th	33.38^{a}	29.62^{b}	21.52^{c}	20.89^{c}	1.88
9th	34.35^{a}	22.82^{c}	30.01^{b}	33.84^{a}	1.93
10th	58.93^{c}	147.70^{a}	110.21^{b}	105.30^{b}	21.03
11th	154.97^{b}	183.07^{b}	230.24^{b}	388.26^{a}	89.70
12th	109.29^{b}	474.30^{a}	76.72^{b}	56.40^{b}	67.87
13th	52.88^{b}	38.20^{c}	57.48^{a}	57.87^{a}	2.656
14th	91.49^{a}	86.39^{a}	74.45^{b}	67.92^{b}	11.06
15th	56.62^{c}	73.84^{b}	75.53^{b}	101.63^{a}	6.89
16th	177.36^{a}	149.28^{a}	138.43^{a}	72.85^{b}	35.78
17th	85.59^{a}	69.17^{b}	73.35^{b}	66.58^{b}	8.10
18th	48.03^{bc}	48.90^{b}	44.86^{c}	62.52^{a}	8.10
19th	88.18^{a}	50.00^{b}	49.37^{b}	37.18^{c}	3.68
20th	59.36^{b}	59.17^{b}	74.87^{a}	76.79^{a}	5.11
21st	60.42^{b}	80.38^{a}	63.84^{b}	90.26^{a}	7.44
22nd	126.84^{b} ±8.156	521.53^{a} ±92.16	291.25^{b} ±43.01	260.41^{b} ±75.90	11.06
Total	1388.45	2198.73	1599.798	1664.67	NS
Mean±SE	63.113^{d} ±10.10	99.942^{a} ±29.38	72.895^{c} ±15.28	75.668^{b} ±18.91	2.50

a, b, c, d

Means bearing different superscripts in a row differ significantly (P<0.05)

The mean feed conversion ratio of Vanaraja birds in different treatment groups at the end of 22nd fortnight was recorded as 63.11 ± 10.10, 99.942 ± 29.39, 72.895 ± 15.28 and 75.66 ± 18.91 for T_1, T_2, T_3 and T_4 respectively. Statistical analysis had revealed that supplementation of turmeric powderhad significant difference ($P<0.05$) in feed conversion ratio among the different treatment groups. Feed conversion ratio was found to be better in T_2 at 9th and 13th fortnight while at 1st, 3rd, 4th, 6th, 8th 14th, 16th, 17th and 19th fortnight it was observed to be significantly better in T_4as compared to the control group. However, the overall mean FCR was found to be better in control group T_1(63.11 ± 10.10) as compared to turmeric supplemented groups. This could not be ascribed to the addition of turmeric in the diet and as such it might be due to other stress factors. Similar to the present findings, Kanagaraju *et al.* (2017) have also reported significant effect of turmeric supplementation on FCR in layer birds. On the other hand, Lagana *et al.* (2011) and Ooi *et al.* (2018) did not observe any significant difference in FCR in layer birds fed with turmeric based diet. Variation in the findings may be attributed to difference in strain of birds, age of the birds, level of turmeric use and type of feed.

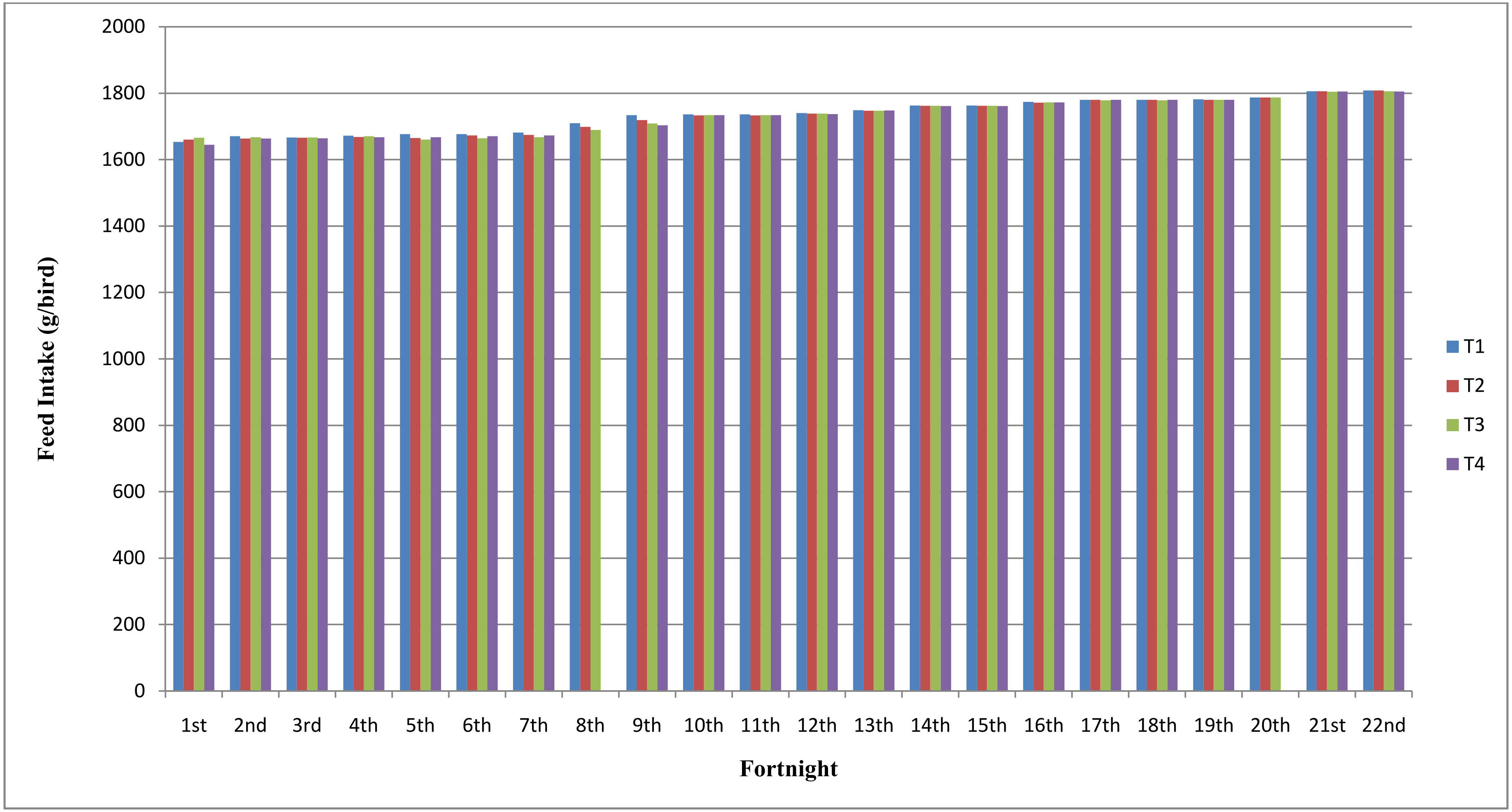

Fig 4.1.3 Feed intake (g/bird) of Vanaraja birds in different treatment groups

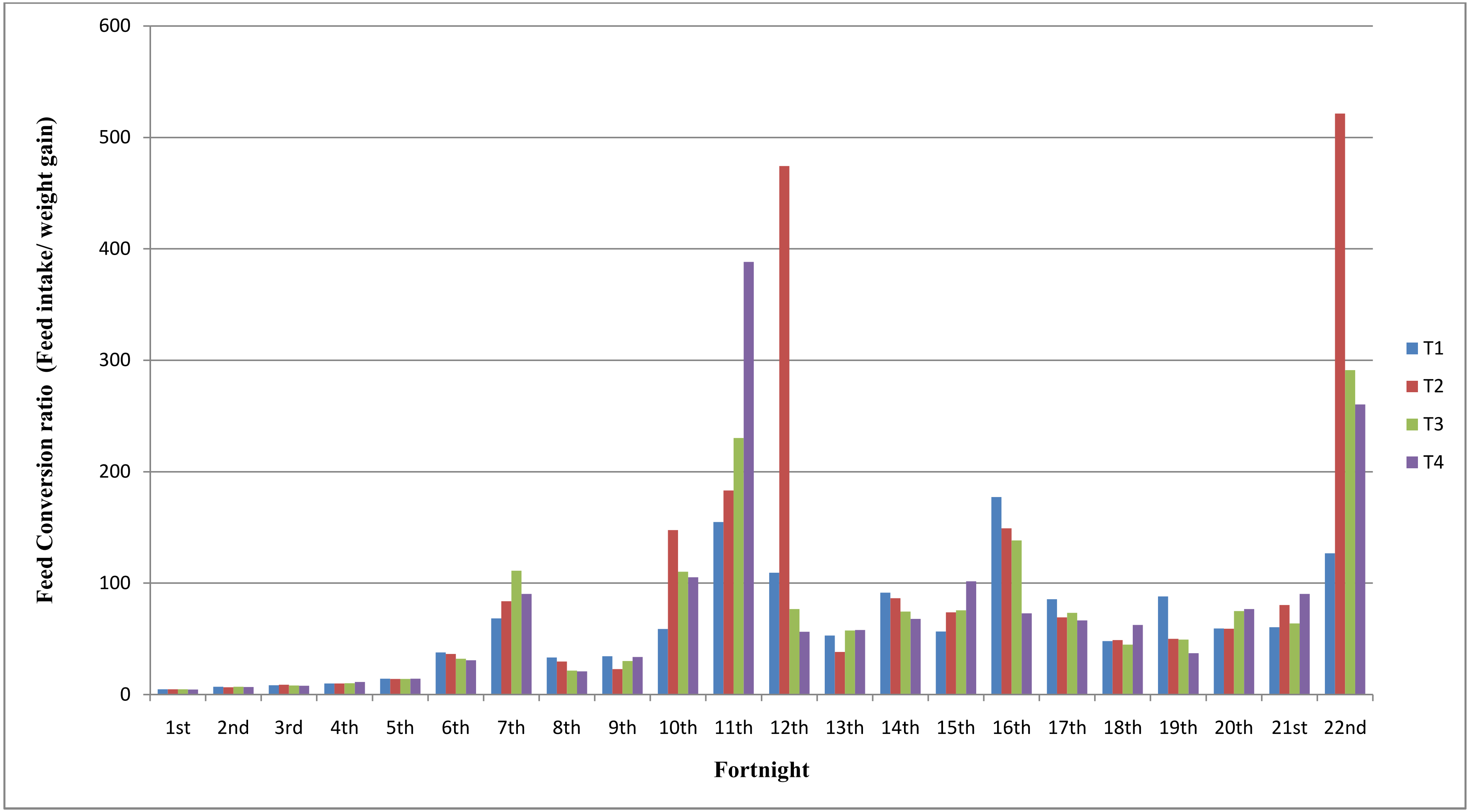

Fig 4.1.4 Feed conversion ratio of Vanaraja birds in different treatment groups

4.1.5 Mortality/ Liveability

The average mortality and liveability per cent till the end of the trial period are shown in Table 4.1.5 and has been graphically plotted in Fig 4.1.5.

Table 4.1.5 Mortality and liveability of Vanaraja birds in different treatment groups

Treatment Groups	Mortality (per cent)	Liveability (per cent)
T_1	11.11	88.89
T_2	11.11	88.89
T_3	3.7	96.30
T_4	7.14	92.86

As per the Table 4.1.5 the mortality percentage of Vanaraja birds throughout the experiment for the different treatment groups T_1, T_2, T_3 and T_4 was 11.11, 11.11, 3.7 and 7.14, respectively. Hence, liveability percentage was recorded as 88.89, 88.89,96.3, and 92.86, respectively.

Higher liveability of birds was observed in groups supplemented with turmeric powder at 0.75 and 1.5 per cent which confirmed the findings of Devegowda (1996) who reported that the curcumin present in turmeric enhanced bird's performance by improving liveability and lowering mortality in poultry birds.Mortality per cent was well within the values reported by Singh *et al*. (2018) for Vanaraja birds.

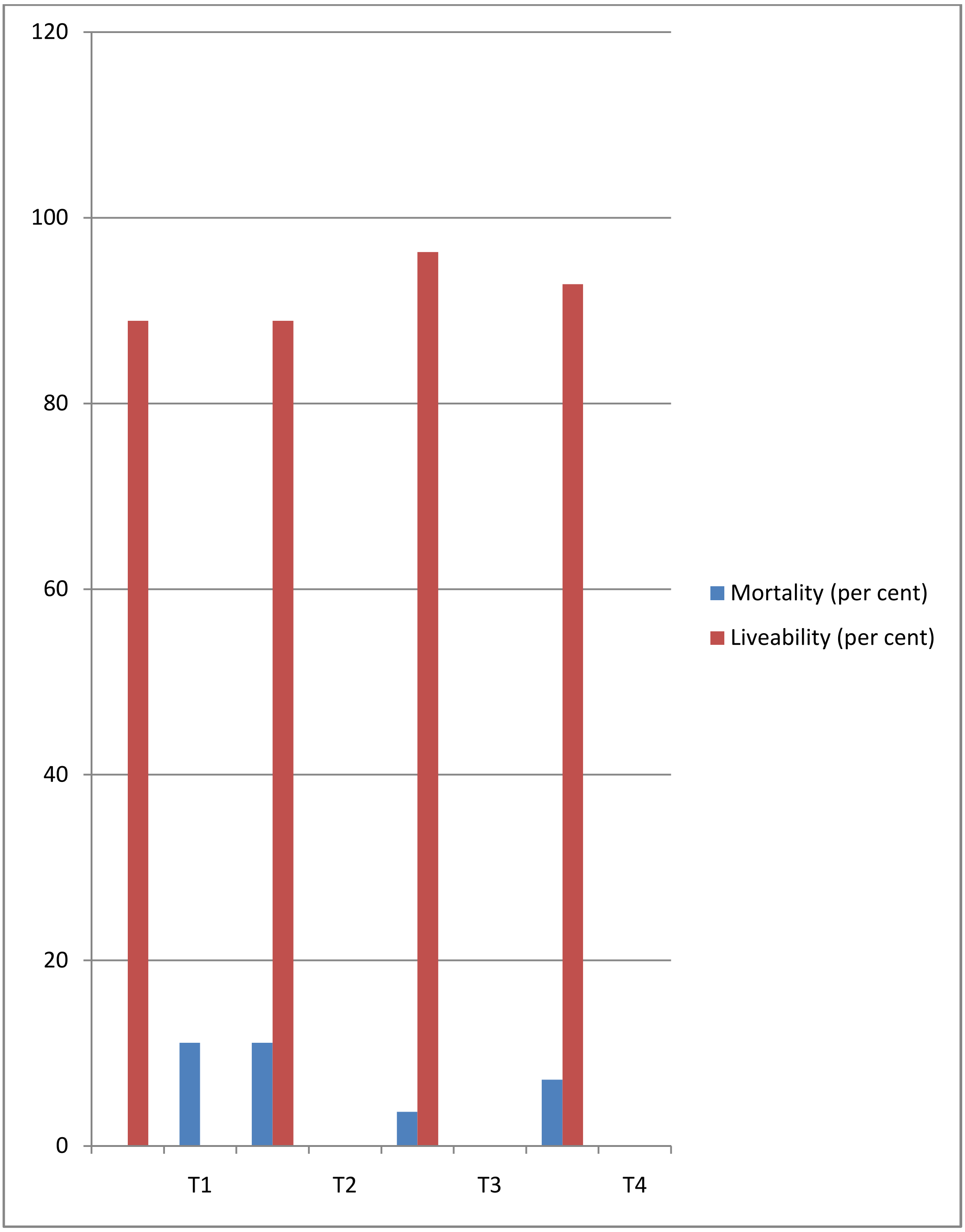

Fig 4.1.5 Mortality and liveability (per cent) of Vanaraja birds in different treatment groups

4.2 Reproductive traits

4.2.1 Age at sexual maturity, body weight and egg weight at onset of egg production

Age at sexual maturity, body weight and egg weight at onset of egg production was calculated from the day of start of the experiment. The data recorded are presented in the Table 4.2.1 and their mean statistical analysis is shown in the Appendix E (Reproductive traits).

Table 4.2.1 Effect of turmeric powder on age at sexual maturity, body weight and egg weight at onset of egg production of Vanaraja birds

Treatment Groups	Age at sexual Maturity(days)	Body weight at onset of egg production(g/bird)	Egg weight at onset of egg production(g/egg)
T_1	176.62 ± 7.04	2553.20^{c} ± 1.52	52.16 ± 0.06
T_2	179.46 ± 2.11	2561.60^{b} ± 1.46	52.20 ± 0.04
T_3	176.70 ± 0.66	2580.00^{a} ± 0.31	52.29 ± 0.04
T_4	176.50 ± 1.20	2582.00^{a} ± 3.39	52.21 ± 0.04
C. D(0.05) value	-	6.019	-

a, b, c

Means bearing different superscripts in the column differ significantly ($P<0.05$)

As per Table 4.2.1, the age at sexual maturity for the different treatment groups i.e. T_1, T_2, T_3 and T_4 was recorded as176.62 ± 7.04, 179.46 ± 2.11,176.7 ± 0.66 and 176.5 ± 1.20 days, respectively. The body weight at onset of egg production for the respective group was recorded as 2553.20± 1.52, 2561.60 ± 1.46, 2580.00 ± 0.31and 2582.00 ± 3.39 g/ bird. Likewise, the egg weight at onset of egg production for the different treatment groups i.e. T_1, T_2, T_3 and T_4 was found to be52.16±0.06, 52.20±0.04, 52.29±0.04 and 52.21±0.04 g/egg.

Analysis of variance had revealed that there was no significant effect on age at sexual maturity and egg weight at onset of egg production due to turmeric supplementationin the diet of laying hens and the values were found to be uniform. Contrary to the present findings, researchers such as Awadein*et al*. (2010) and Saraswati and Tana (2016) have reportedthat supplementation of herbal feed additives such as fenugreek and turmeric in laying hens diet could delay sexual maturity or accelerate sexual maturity.

Age at sexual maturity (days) of Vanaraja bird observed in the present study was found to be well within the range which was reported to be 172 to 185, 164.79, 197.70, 181.53±1.29 and 172.36±2.23 by Bhattacharya *et al.* (2005); Niranjan *et al*. (2008); Haunshi *et al*. (2009); Singh *et al*. (2018) and Chakrabarti *et al.* (2020), respectively. Similiarly, egg weight at 280 days was reported to be 55.87g (Niranjan *et al*., 2008) and 55.85±5.53 g (Chakrabarti *et al*., 2020).

Body weight at the onset of egg production was found to be significantly ($P<0.05$) higher in T_4 followed by T_3, T_2 and theleast in T_1 however the difference between T_3 and T_4 was found to be non-significant. The increase in body weight could be due to the positive effect of turmeric as reported by Basak (2015)and Khodadadi *et al*. (2021).

4.2.2Egg production

The total egg production per bird, Hen house egg production, Hen day egg production (%) for the different treatment groups T_1, T_2, T_3 and T_4 are given below in the Table 4.2.2 and their mean statistical analysis are shown in Appendix E (Reproductive traits).

Table 4.2.2 Effect of turmeric powder on the egg production parameters of Vanaraja birds

Treatment Groups	Total egg production (Nos)	Clutch size (Nos)	Hen house egg production (Nos)	Hen day egg production (%)
T_1	$149.86^c \pm 0.26$	5.32±0.29	19.55 ± 0.44	66.27 ± 0.93
T_2	$157.06^b \pm 1.03$	5.59±0.25	19.63 ± 1.06	69.31 ± 0.89
T_3	$169.73^a \pm 1.34$	5.83±0.44	21.21 ± 0.57	69.91 ± 0.44
T_4	$156.43^b \pm 1.54$	5.53 ±0.13	19.55 ± 0.68	68.34 ± 0.77
CD(0.05)	4.24	-	-	-

a, b, c

Means bearing different superscripts in the column differ significantly (P<0.05)

Egg production per bird from the date of laying till the end of experiment *i.e.*365 days for the different treatment groups $T_{1,}$ $T_{2,}$ T_3, T_4 was 149.86 ± 0.25, 157.06 ± 1.03, 169.73± 1.34 and 156.43 ± 1.54 numbers, respectively. Statistical analysis had revealed significantly (P<0.05) higher egg production in T_3 followed by T_2, T_4 and the least in T_1though the difference among the treatment groups T_2, and T_4 was found to be non- significant. The results of the present study corroborated with the findings of Radwan *et al.* (2008); Park *et al.* (2012); Saraswati*et al.* (2013a) and Azouz*et al.* (2019) who had also reported significant effect of turmeric powder on egg production in laying birds. However, researchers including Malekizadeh*et al.*(2012) and Lagana*et al.* (2011) had reported non-significant effect of turmeric powder on egg production. Differences in the level and duration of supplementation, age and strain of bird, system of rearing, stability of the active compound, product source could be the reason for the variation in the effects of turmeric supplementation.

The clutch size for the different treatment groups T_1, T_2, T_3 and T_4 was found to be 5.32±0.29, 5.59±0.25, 5.83±0.44 and 5.53 ± 0.13 numbers, respectively while the hen house egg production for the different treatment groups T_1, T_2, T_3 and T_4 was 19.55 ± 0.44, 19.63 ± 1.06, 21.21 ± 0.57 and 19.55± 0.68numbers, respectively. The corresponding values for hen day egg production (per cent) was 66.27± 0.93, 69.31 ± 0.89, 69.91 ± 0.44 and 68.34 ± 0.77. As per the statistical analysis, hen day, hen house and clutch size were unaffected by turmeric supplementation and as a result it did not show any significant difference. On the contrary, Kanagaraju*et al.* (2017) and Widjastuti*et al.* (2017) had reported increased hen day and hen housed egg production due to the inclusion of turmeric powder in the diet. Variation in the might be attributed to factors such as species/strain differences, duration of trial, system of rearing, agro- climatic differences, differences in the level of turmeric powder and season.

4.2.3Egg Quality Traits

The values for the egg quality traits observed in different treatment groups at 180 days, 242 days and 365 days are presented in Table 4.2.3 and the statistical analysis has been shown in Appendix F (Egg quality traits).

As per the Table 4.2.3, the albumen index of Vanaraja eggs at 180 days for the different treatment groups *i.e.* T_1, T_2, T_3 and T_4 was 0.312 ± 0.00, 0.310 ± 0.00, 0.322 ± 0.00and 0.318 ± 0.00, respectively. The corresponding values of albumen index at 242 days was 0.326 ± 0.01, 0.350 ± 0.00, 0.368 ± 0.00and 0.352 ± 0.01and at 365 days the values were recorded as 0.492± 0.01, 0.496± 0.01, 0.518± 0.00 and 0.512 ± 0.01.

Analysis of variance indicated that there was no significant ($P>0.05$) difference in albumen index among the different treatment groups at 180 and 365 days. However, at 242 days the albumen index was significantly higher in turmeric supplemented groups in the trend T_3, T_4, T_2 with the least in T_1. The difference among T_3, T_4 and T_2 was found to be non - significant.Similar to the present findings, Mousa*et al*. (2020) had also reported that there was significant ($P<0.05$) increase in albumen index when fed with turmeric supplemented diet. On the contrary, Curvelo*et al.* (2009) revealed that there was no difference in the internal quality of eggs when fed with turmeric on laying hens.

As per the Table 4.2.3, the yolk index of Vanaraja eggs at 180 days for the different treatment groups *i.e*. T_1, T_2, T_3 and T_4 was 0.390 ± 0.01, 0.400± 0.01, 0.420 ± 0.00 and 0.410 ± 0.01, respectively. The corresponding values of yolk index at 242 days was 0.406 ± 0.00, 0.412 ± 0.00, 0.418 ± 0.01 and 0.420 ± 0.00; and at 365 days the values was recorded as 0.408 ± 0.01, 0.414± 0.01, 0.420± 0.01 and 0.430 ± 0.01.

Statistical analysis had revealed that there was no significant ($P<0.05$) difference in yolk index at 180 and 242 days. However, at 365 days and the yolk index of T_4 was found to be significantly ($P<0.05$) higher than T_1. Similarly, according to Radwan *et al*. (2008) and Park *et al*. (2012), there was significant ($P<0.05$) increase in yolk index when birds were fed with turmeric based diet. On the contrary, Saraswati*et al*. (2013b) revealed that there was no difference in yolk index when laying hens were fed with turmeric added diet.

In Table 4.2.3, the Haugh Unit values of Vanaraja eggs at 180 days for the different treatment groups *i.e*. T_1, T_2, T_3 and T_4 was 76.58 ± 1.709, 78.50 ± 0.16, 79.00 ± 0.08 and 78.50 ± 0.11, respectively. The corresponding values of haugh unit values at 242 days was 78.30 ± 0.82, 78.50 ± 0.05, 79.00 ± 0.08 and 78.50 ± 0.08; and at 365 days the values for the respective group was recorded as 0.78.86 ± 0.11, 78.90± 0.06, 79.76 ± 0.25 and 79.62 ± 0.45.

Irrespective of the treatments and age, statistical analysis had shown that there was no significant (P>0.05) difference in haugh unit of Vanaraja eggs which confirmed the findings of Curvelo *et al.* (2009) and Saraswatiand Tana(2016) who had found no significant differences in haugh unit values due to turmeric supplementation. On the contrary, Kujero *et al.* (2012)had reported higher haugh unit at 1.5 % of turmeric supplementation and stated that the inclusion of turmeric in layer feed may have enhanced the egg quality as a result of higher haugh unit values.

As per the Table 4.2.3, the yolk cholesterol values of Vanaraja eggs at 180 days for the different treatment groups T_1, T_2, T_3 and T_4 was 19.92 ± 0.25,19.20 ±0.07, 19.10 ± 0.03 and 18.56 ± 0.37, respectively. The corresponding values at 242 days was 19.30 ± 0.0, 19.10 ± 0.06, 18.92 ± 0.08 and 18.82 ± 0.37; and at 365 days the values for the respective group was recorded as 19.08 ± 0.07, 19.00± 0.08, 18.78 ± 0.66 and 18.74 ± 0.24.

Statistical analysis had revealed significantly (P<0.05) lower yolk cholesterol. At 180, 242 and 365 days, group T_4 had the lowest yolk cholesterol followed by T_3,T_2 and the highest was in control T_1.These results were in agreement with the findings of Rahardja *et al.* (2015) and Ayed *et al.* (2018) who had reported that yolk cholesterol significantly (P<0.05) decreased due to supplementation of turmeric alone or in combination with other herbal additives. The present finding is indicative of the enhancement in egg quality due to supplementation of turmeric. However, Narahari *et al.* (2003) and Curvelo *et al.* (2009) did not observe any influence on egg quality traits when turmeric was supplemented in poultry diet.

Table 4.2.3 Effect of turmeric on egg quality traits of Vanaraja bird at different age

Treatment groups	Albumen index			Yolk index			Haugh unit			Yolk cholesterol (mg/g yolk)		
	180 days	242 days	365 days	180 days	242 days	365 days	180 days	242 days	365 days	180 days	242 days	365 Days
T_1	0.312 ±0.00	0.326^{b} ±0.01	0.492 ±0.01	0.390 ±0.01	0.406 ±0.00	0.408^{b} ±0.01	76.58 ±1.71	78.30 ±0.82	78.86 ±0.11	19.92^{a} ±0.25	19.30^{a} ±0.08	19.08^{a} ±0.07
T_2	0.310 ±0.00	0.350^{a} ±0.01	0.496 ±0.01	0.400 ±0.01	0.412 ±0.00	0.414^{b} ±0.01	78.50 ±0.16	78.50 ±0.05	78.90 ±0.06	19.20^{b} ±0.07	19.10^{ab} ±0.06	19.00^{ab} ±0.08
T_3	0.322 ±0.00	0.368^{a} ±0.01	0.518 ±0.00	0.420 ±0.00	0.418 ±0.01	0.420^{ab} ±0.00	79.00 ±0.08	79.00 ±0.08	79.76 ±0.21	19.10^{b} ±0.03	18.92^{bc} ±0.08	18.78^{b} ±0.06
T_4	0.318 ±0.00	0.352^{a} ±0.01	0.512 ±0.01	0.41 ±0.01	0.420 ±0.01	0.430^{a} ±0.00	78.90 ±0.11	78.50 ±0.09	79.62 ±0.45	18.56^{b} ±0.31	18.82^{c} ±0.37	18.74^{b} ±0.24
C.D (0.05) value	-	0.019	-	-	-	0.014	-	-	-	0.680	0.205	0.263

a,b, c

Means bearing different superscripts in the columndiffer significantly ($P<0.05$)

4.3 Haematological and biochemical blood constituents

4.3.1 Haematological studies

The haematological parameters in different treatment groups are presented in Table 4.3.1 and their statistical analysis is shown in Appendix G (Haematological parameters).

The mean values forTotal White blood cells ($10^3/mm^3$) at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 18.02 ± 10.09, 18.78 ± 0.43, 19.02 ± 0.33, 19.06 ± 0.31; 18.16 ± 0.14, 19.08 ± 0.30, 18.96 ± 0.40, 19.26 ± 0.30 and 18.16 ± 0.12, 19.14 ± 0.43, 19.14 ± 0.25and 19.40 ± 0.29, respectively. Analysis of variance showed that there was significant (P<0.05) difference in total WBC due to turmeric supplementation at 365 days. The turmeric treated group had higher total WBC as compared to the control. Higher values for WBC are indicative of positive effect of the active ingredient of turmeric. The present results are in line with the findings of Guil-Guerrero *et al.* (2017)and Oluwafemi*et al.* (2021) who had observed improvement in several haematological indicators when turmeric was supplemented in layer diet.

The mean values for Total Red blood cells ($10^6/mm^3$)at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 2.92 ± 0.12, 2.92 ± 0.14, 3.10 ± 0.05, 3.06 ± 0.17; 2.92 ± 0.07, 2.96 ± 0.14, 3.08 ± 0.20, 3.00 ± 0.13 and 2.90 ± 0.12, 2.94 ± 0.43, 3.00 ± 0.29and 3.12 ± 0.25, respectively. Analysis of variance showed that there was no significant (P<0.05) difference in total RBC due to turmeric supplementation. These findings were in agreement with the earlier findings of Shende*et al.* (2021) who observed non-significant influence of turmeric onhaemato-biochemical parameters. On the contrary, Oluwafemi*et al.* (2021) had reported that turmeric added diet positively influenced the haematogical and biochemical parameters of birds.

Table 4.3.1 Haematological parameters of Vanaraja as influenced by turmeric powder supplementation

Treatment groups	Total White blood cells ($10^3/mm^3$)			Total Red blood cells ($10^6/mm^3$)		
	180 days	**242 days**	**365 days**	**180 days**	**242 days**	**365 days**
T_1	18.02±0.09	18.16±0.14	18.16^b ±0.12	2.92±0.12	2.92±0.07	2.90±0.12
T_2	18.78±0.43	19.08±0.30	19.14^a ±0.43	2.92±0.14	2.96±0.14	2.94±0.43
T_3	19.02±0.33	18.96±0.40	19.14^a ±0.25	3.10±0.05	3.08±0.20	3.00±0.29
T_4	19.06±0.31	19.26±0.30	19.40^a ±0.29	3.06±0.17	3.00±0.13	3.12±0.25
C.D (0.05) value	-	-	0.883	-	-	-

a,b

Means bearing different superscripts within the column differ significantly (P<0.05)

Table 4.3.2 Effect of turmeric powder on Biochemical constituents of Vanaraja birds at different age

Treatment groups	LDL mg/dl			HDL mg/dl			Triglycerides mg/dl			Cholesterol mg/dl		
	180 Days	242 days	365 days	180 days	242 days	365 days	180 days	242 days	365 days	180 days	242 days	365 Days
T_1	80.20^{a} ±1.88	78.40^{a} ±1.02	76.20^{a} ±1.74	47.00 ±1.61	47.20 ±2.10	48.20 ±1.65	67.80^{a} ±2.65	68.00^{a} ±2.16	68.40^{a} ±2.58	142.00^{a} ±2.30	143.00^{a} ±1.22	142.00^{a} ±0.89
T_2	75.40^{ab} ±1.63	73.40^{a} ±1.88	75.20^{a} ±0.80	49.00 ±2.91	50.20 ±3.07	50.60 ±2.95	60.80^{b} ±2.90	62.00^{b} ±2.40	60.40^{a} ±2.33	136.80^{ab} ±3.30	138.40^{a} ±1.43	140.00^{a} ±1.58
T_3	73.20^{ab} ±4.09	73.00^{ab} ±3.14	73.80^{a} ±1.85	52.20 ±2.08	53.60 ±1.96	53.60 ±1.91	59.20^{b} ±2.12	58.00^{b} ±1.64	57.80^{b} ±1.49	134.40^{b} ±2.80	138.20^{a} ±2.22	138.00^{ab} ±1.22
T_4	68.20^{b} ±1.15	67.40^{b} ±1.07	69.60^{b} ±0.87	51.80 ±2.13	53.40 ±1.96	53.00 ±1.84	57.20^{b} ±1.88	57.60^{b} ±1.56	58.00^{b} ±1.78	130.00^{b} ±0.83	133.00^{b} ±1.54	134.80^{b} ±1.59
C.D (0.05) value	7.386	5.936	4.200	-	-	-	6.737	5.932	5.871	7.541	4.941	4.063

a,b,c, d

Means bearing different superscripts within the column differ significantly (P<0.05)

4.3.2 Biochemical studies

The biochemical constituents of blood in different treatment groups are presented in the Table 4.3.2 and the statistical analysis had been shown in Appendix H (Biochemical parameters).

The mean values for LDL (mg/dl) at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 80.20 ± 1.88, 75.40 ±1.63, 73.20± 4.09, 68.20 ± 1.15; 78.4 ± 1.02, 73.4 ± 1.88, 73.00± 3.14, 67.40 ± 1.07 and 76.20 ± 1.74, 75.20 ± 0.80, 73.80 ± 1.85 and 69.60 ± 1.07, respectively. Analysis of variance showed that there was significant ($P<0.05$) difference in LDL due to turmeric supplementation irrespective of different ages and the values for LDL decreased significantly in T_4 as compared to the control group T_1. Decrease in LDL could be attributed to the curcumin content which helps to use the serum cholesterol from the body to synthesize bile acids for lipid metabolism as reported by Emadi *et al*. (2007). Similar to the present findings, Riasi *et al.* (2012) and Chauhan*et al.* (2014) had also reported that turmeric in layer diet significantly reduced the LDL level.

The mean values for HDL (mg/dl) at different ages (180, 242 and 365 days) for different treatment groups T_1, T_2, T_3 and T_4 was 47± 1.61, 49.00 ± 2.91, 52.20 ± 2.08, 51.80 ± 2.13; 47.20 ± 2.10, 50.20 ± 3.07, 53.6 ± 1.96, 53.4 ± 1.96 and 48.20 ± 1.65, 50.6 ± 2.95, 53.60 ± 1.91and 53.00 ± 1.84, respectively. Though numerically HDL values were observed to be in increasing trend in turmeric supplemented groups, statistically it was found to be non- significant. Radwan *et al*. (2008) had also observed non-significant difference in HDL in layer birds subjected to diet supplemented with different levels of turmeric.

The mean values for Triglycerides (mg/dl) at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 67.80 ± 2.80, 60.80 ±2.90, 59.20 ± 1.06, 57.20 ± 1.88; 68.00 ± 2.16, 62.00 ± 2.40, 58.00 ± 1.64, 57.60 ±

1.56 and 68.40 ± 2.58, 60.40 ± 1.80, 57.80 ± 1.49 and 58.00 ± 1.78, respectively. Analysis of variance showed that there was significant ($P<0.05$) difference in serum triglycerides and the values were found to be significantly lower in turmeric supplemented groups with the lowest level in T_4as compared to T_1. Several researchers including Kermanshahi and Riasi (2006); Riasi *et al.* (2012) and Chauhan*et al.* (2014) had also reported that turmeric in layer diet lowered triglycerides significantly. Decrease in serum triglycerides may be attributed to the inhibitory action of turmeric for secretion of liver triglyceride (Chattopadhyal*et al.*, 2004) and increased activity of lipoprotein lipase as reported by Graham (2009).

The mean values for cholesterol (mg/dl) at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 142.00 ± 2.30, 136.80 ± 3.30, 134.40 ± 2.80, 130.00 ± 0.83; 143.00 ± 1.22, 138.40 ± 1.43, 138.20 ± 2.22, 133.00 ± 1.54 and 142.00 ± 0.89, 140 ± 1.58, 138.00 ± 1.22 and 134.80 ± 1.59, respectively. Statistical analysis had revealed that turmeric supplementation had significant ($P<0.05$) effect on the serum cholesterol at all the given ages *i.e.*180, 242 and 365 days. Lower level of cholesterol was observed in all the groups fed with turmeric powder as compared to the control. These observations were in agreement with the findings of Kermanshahi and Riasi (2006); Radwan *et al.* (2008) and Riasi *et al.* (2012) who had also reported that turmeric in layer diet markedly decreased the cholesterol. The conversion of cholesterol to bile acid by the action of curcumin, a path to eliminate cholesterol from the body as reported by Srinivasan and Sambaiah(1991) could be the reason for lower cholesterol level in the turmeric supplemented group.

Contrary to the above findings, Gumus*et al.* (2018) had reported non-significant effect of turmeric on the above parameters. Variations in the findings could be attributed to factors such as species/strain differences, duration of trial, system of rearing, agro- climatic differences, differences in the level of turmeric powder and season.

4.4 Economics

The effect of dietary supplementation of turmeric powder on the economics of Vanaraja production in different treatment groups are presented in the Table 4.4.

Table 4.4 Economics of Vanaraja bird production in different treatment groups (Rs/ bird)

Sl. No.	ITEMS	Treatment Groups			
		T_1	T_2	T_3	T_4
1	Cost of Vanaraja chick	40.00	40.00	40.00	40.00
2	Cost of feed	1258.00	1256.60	1255.51	1254.72
3	Cost of turmeric powder	-	28.55	42.75	85.50
4	Cost of medicine	10.33	10.33	10.33	10.33
5	Cost of labour	85.40	85.40	85.40	85.40
6	Miscellaneous	28.38	28.38	28.38	23.38
7	Cost of production	1422.92	1449.26	1462.37	1504.33
8	Average Weight of Vanaraja (Kg)	2.903	2.916	2.934	2.948
9	Average weight gain (Kg)	1.538	1.550	1.568	1.584
10	Cost of production per Kg weight	490.15	497.00	498.42	510.28
11	Sale of Vanaraja @Rs.250 per Kg live weight	725.75	729.00	733.50	737.00
12	Sale of eggs @Rs. 8 per egg	1198.88	1256.48	1357.84	1251.44
13	Sale of gunny bags @Rs.20/bag	15.25	15.23	15.21	15.20
14	Total receipt (Rs)/bird	1939.88	2000.71	2.106.55	2003.64
15	Profit per bird	516.96	551.45	644.18	499.31
16	Net profit per Kg gain	336.12	355.77	410.82	315.22

As per the Table 4.4, average cost of production per bird for T_1, T_2, T_3 and T_4 was 1422.92, 1449.26, 1462.37, 1504.33 rupees, respectively. Corresponding values for average cost of production per kg live weight of bird was 490.15, 497.00, 498.42 and 510.28 rupees, respectively.

Profit per bird for T_1, T_2, T_3 and T_4 was 516.96,551.45, 644.18 and 499.31 rupees, respectively. Corresponding values for net profit per kg gain in weight was 336.12, 355.77,410.82 and 315.22 rupees, respectively.

In terms of economy, higher net profit per bird and net profit per kg weight gain was observed in group T_3 followed by T_2, T_1 and the least in T_4while the total cost of production was found to be higher in all the turmeric supplemented groups as compared to than the control. The present finding was in agreement with Kafi *et al.* (2017) who had reported that net return was more economical when 0.75 per cent of turmeric was supplemented in feed as compared to control groups. Higher cost of production was mainlydue to the cost of turmeric. Overall, turmeric supplementation had positive effect on the egg production traits, haematological and biochemical constituents as well as the net return in turmeric supplemented group which is indicative that turmeric supplementation can improve the performance of birds, enhance the quality of meat and egg and income as also reported by Chauhan *et al.* (2018) and Sweta*et al.* (2018). Turmeric which thrives well in the region can be grown locally which will help to offset the cost of turmeric and thereby reduce the production cost and increase the net profit.

CHAPTER – 5

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Use of herbal feed additives is considered as an alternative to chemical agents particularly antibiotic growth promoters which have raised concern because of its adverse residual effect. Supplementation of herbal feed additives in poultry nutrition is in vogue not only to improve productive and reproductive performance of birds but also to obtain quality products which is safe for human consumption and wellbeing. Turmeric is well known for its therapeutic properties and has been in use since ages for treating different ailments besides its culinary usage. Turmeric has main active compound curcuminoids mainly curcumin which act as antibacterial, antifungal, antiparasitic, antiviral, and antioxidant.Turmeric is also widely used in this region as a spice and in traditional medicines for human as well as for animal. Considering the benefits of turmeric, the present investigation was conceived to study the effects of turmeric on productive traits, reproductive traits and blood profile of Vanaraja birds under the agro-climatic condition of Nagaland.

In order to carry out the present study, 120 numbers of two months old Vanaraja pullets were reared under cage system of rearing. The experimental birds were subjected to diet supplemented with turmeric powder. The experiment was carried out as per Completely Randomized Design. Birds were randomly divided into four treatment groups (T_1, T_2, T_3 and T_4) of 30 birds each with 5 replications having 6 birds in each replicate. Group T_1 served as control and the other groups *i.e.* T_2, T_3 and T_4 were fed with basal diet supplemented with turmeric powder at the level of 0.5, 0.75 and 1.5 per cent, respectively.

5.1 Productive traits

5.1.1 Body weight

Average body weight in different groups recorded at the end of 22nd fortnight for different treatment groups was 2903.45 ± 0.50, 2916.13 ± 0.34, 2934.66 ± 0.52 and 2948.13±0.06g per bird for T_1, T_2, T_3 and T_4 groups, respectively. Statistically, there was significant ($P<0.05$) difference in body weight amongst the treatment groups under the prevailing agro-climatic condition.

5.1.2 Body Weight gain

Overallbody weight gain for different treatment groups i.e. T_1, T_2, T_3 and T_4 was 1538.13, 1549.53, 1568.54 and 1583.66 g/fortnight/bird respectively. As per statistical analysis, supplementation of turmeric powder had significant effect on the overall weight gain. It was found to increase ($P<0.05$) with the increase in the level of turmeric powder.

5.1.3 Feed Consumption

Overall mean feed intake was 1733.95±10.62, 1730.86 ± 10.97, 1729.38 ±11.00 and 1728.27 ± 11.95 g per bird, respectively.Statistical analysis had revealed that feed intake was significantly ($P<0.05$) lower in T_4 followed byT_3, T_2 and the highest in T_1.

5.1.4 Feed conversion Ratio (FCR)

The mean feed conversion ratio of Vanaraja birds in different treatment groups at the end of 22nd fortnight was recorded as 63.11 ± 10.10, 99.94 ± 29.39, 72.89 ± 15.28 and 75.66 ± 18.91 for T_1, T_2, T_3 and T_4, respectively. Statistical analysis had revealed that supplementation of turmeric powder showed significant difference ($P<0.05$) in feed conversion ratio among the different treatment groups. The overall mean FCR was found to be better in control group T_1 (63.11 ± 10.10) as compared to turmeric supplemented groups.

5.1.5 Mortality/Liveability

The mortality percentage for the different treatment groups T_1, T_2, T_3 and T_4 was 11.11, 11.11, 3.7 and 7.14, respectively. Liveability per cent was recorded to be highest in T_3 followed by T_4 and least in T_1 and T_2.

5.2 Reproductive traits

5.2.1 Age at sexual maturity

Age at sexual maturity for the different treatment groups T_1, T_2, T_3 and T_4 was 176.62 ± 7.04, 179.46 ± 2.11, 176.7 ± 0.66 and 176.50 ± 1.20 days, respectively which was found to be non-significant.

5.2.2 Body weight at the onset of egg production

Body weight at onset of egg production for the different treatment groups T_1, T_2, T_3 and T_4 was recorded as 2553.20± 1.52, 2561.60 ± 1.46, 2580.00 ± 0.31 and 2582.00 ± 3.39g per bird, respectively. Body weight at the onset of egg production was found to be significantly ($P<0.05$) higher in T_4 followed by T_3, T_2 and least in T_1.

5.2.3 Egg weight at the onset of egg production

Egg weight at onset of egg production for the different treatment groups T_1, T_2, T_3 and T_4 was 52.16±0.06, 52.20±0.04, 52.29±0.04 and 52.21±0.04 g/egg, respectively. Statistically, there was no significant difference among the treatment groups.

5.2.4 Total Egg production

Total egg production per bird for the different treatment groups T_1, T_2, T_3 and $T_4$from the onset till the end of the trial period was 149.86 ± 0.25, 157.06 ± 1.03, 169.73± 1.34 and 156.43 ± 1.54 numbers/ birds, respectively. Total egg production was significantly ($P<0.05$) higher in the turmeric supplemented groups as compared tothe control group.

5.2.5 Clutch size

The clutch size for the different treatment groups T_1, T_2, T_3 and T_4 was5.32±0.29, 5.59±0.25, 5.83±0.44 and 5.53 ± 0.13 numbers, respectively. Statistically, there was no significant difference in clutch size among the different treatment groups.

5.2.6 Hen house egg production

The hen house egg production for the different treatment groups T_1, T_2, T_3 and T_4 was19.55 ± 0.44, 19.63 ± 1.06, 21.21 ± 0.57 and 19.55 ± 0.68 numbers, respectively. However, statistically, there was no significant ($P>0.05$) difference in hen house egg production amongst the treatment groups.

5.2.7 Hen day egg production

The values for hen day egg production (per cent) was66.27± 0.93, 69.31 ± 0.89, 69.91 ± 0.44 and 68.34 ± 0.77, respectively. Statistical analysis had revealed that there was no significant ($P>0.05$) difference in hen day egg production amongst the treatment groups.

5.3 Egg Quality Traits

5.3.1 Albumen index

Albumen index of Vanaraja eggs at different ages (180, 242 and 365 days) for treatment groups T_1, T_2, T_3 and T_4 was 0.312 ± 0.00, 0.310 ± 0.00, 0.322 ± 0.00, 0.318 ± 0.00; 0.326 ± 0.01, 0.350 ± 0.00, 0.368 ± 0.00, 0.352 ± 0.01 and

0.492± 0.01, 0.496± 0.01, 0.518± 0.00 and 0.512 ± 0.01. Statistically, there was no significant (P>0.05) difference on albumen index among the different treatment groups at 180 and 365 days. However, at 242 days, albumen index was found to be significantly higher in turmeric supplemented groups as compared to the control T_1.

5.3.2 Yolk index

Yolk index of Vanaraja eggs at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was0.390 ± 0.01, 0.400 ± 0.01, 0.420 ± 0.00, 0.410 ± 0.00; 0.406 ± 0.00, 0.412 ± 0.00, 0.418 ± 0.00, 0.420 ± 0.00 and 0.408 ± 0.01, 0.414± 0.01, 0.420± 0.00,0.430 ± 0.00, respectively. Statistically, significant difference was observed only at 365 days where the yolk index of T_4 was found to be significantly higher than $T_{1.}$

5.3.3 Haugh unit

Haugh Unit values of Vanaraja eggs at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 76.58 ± 1.71, 78.50 ± 0.16, 79.00 ± 0.08 and 78.90 ± 0.11 ; 78.30 ± 0.82, 78.50 ± 0.05, 79.00 ± 0.08 78.50 ± 0.08 and 0.78.86 ± 0.11, 78.09± 0.06, 79.76 ± 0.25, 79.62 ± 0.45, respectively. Irrespective of the treatments, in all the ages, no significant (P>0.05) difference was observed in haugh unit values.

5.3.4 Yolk cholesterol

Yolk cholesterol values of Vanaraja eggs at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 719.92 ± 0.25, 19.20 ± 0.07, 19.10 ± 0.03, 18.56 ± 0.36; 19.30 ± 0.08, 19.10 ± 0.06, 18.92 ± 0.08, 18.82 ± 0.37 and 19.08 ± 0.06, 19.00± 0.08, 18.78 ± 0.66, 18.74 ± 0.24, respectively. Supplementation of turmeric powder had significant effect on yolk cholesterol at all ages and it was found to be in decreasing trend with the increase in the level of turmeric powder.

5.4 Haematological and Biochemical parameters

5.4.1 Total White Blood Cells Count

Values for Total White blood cells ($10^3/mm^3$) at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 18.02 ± 10.09, 18.78 ± 0.43, 19.02 ± 0.33, 19.06 ± 0.31; 18.16 ± 0.14, 19.08 ± 0.30, 18.96 ± 0.40, 19.26 ± 0.30 and 18.16 ± 0.12, 19.14 ± 0.43, 19.14 ± 0.25and 19.40 ± 0.29, respectively. Statistical analysis had indicated differences ($P<0.05$) in total white blood cells at 365 days where turmeric treated group had higher total WBC as compared to the control.

5.4.2 Total Red Blood Cells Count

Values for Total Red blood cells ($10^6/mm^3$) at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 2.92 ± 0.12, 2.92 ± 0.14, 3.10 ± 0.05, 3.06 ± 0.17; 2.92 ± 0.07, 2.96 ± 0.14, 3.08 ± 0.20, 3.00 ± 0.13 and 2.90 ± 0.12, 2.94 ± 0.43, 3.00 ± 0.29 and 3.12 ± 0.25, respectively. There was no significant effect on RBC due to inclusion of turmeric in the diet.

5.4.3 Low Density Lipoprotein

Low density lipoprotein at different ages (180, 242 and 365 days) for different groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 80.20 ± 1.88, 75.40 ±1.63, 73.20± 4.09, 68.20 ± 1.15; 78.4 ± 1.02, 73.4 ± 1.88, 73.0 ± 3.14, 67.40 ± 1.07 and 0.76.20 ± 1.74, 75.20 ± 0.80, 73.80 ± 1.85 and 67.40 ± 1.07, respectively. There was significant ($P<0.05$) difference in LDL due to turmeric supplementation irrespective of different ages. The highest amount of LDL was observed in control group and the least amount was in $T_{4.}$

5.4.4 High Density Lipoprotein

The average values for HDL at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 47± 1.61, 1.88, 49.00 ± 2.91, 52.20 ± 2.08, 51.80 ± 2.13; 47.20 ± 2.10, 50.20 ± 3.07, 53.60 ± 1.96, 53.40 ± 1.96 and 48.20 ± 1.65, 50.60 ± 2.95, 53.60 ± 1.91and 53.00 ± 1.84, respectively. Statistically, there was no significant ($P>0.05$) difference in HDL due to turmeric supplementation.

5.4.5 Triglyceride

The mean values for Triglycerides at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 67.80 ± 2.80, 60.80 ±2.90, 59.20 ± 1.06, 57.20 ± 1.88; 68.00 ± 2.16, 62.00 ± 2.40, 58.00 ± 1.64, 57.60 ± 1.56 and 68.40 ± 2.58, 60.40 ± 1.80, 57.80 ± 1.49 and 58.00 ± 1.78, respectively. Triglycerides was found to be higher ($P<0.05$) in control group $T_1$and the least amount was in T_4. However, there was no variation between the turmeric treated groups statistically.

5.4.6 Cholesterol

The mean values for cholesterol at different ages (180, 242 and 365 days) for different groups T_1, T_2, T_3 and T_4 was 142.00 ± 2.30, 136.80 ± 3.30, 134.40 ± 2.80, 130.00 ± 0.83; 143.00 ± 1.22, 138.40 ± 1.43, 138.20 ± 2.22, 133.00 ± 1.54 and 142.00 ± 0.89, 140 ± 1.58, 138.00 ± 1.22 and 134.80 ± 1.59, respectively. Cholesterol was significantly ($P<0.05$) lower in T_4group as compared to control group T_1.

5.5Economics

Total cost of production per bird and per kg live weight was highest in group T_4 followed by T_3, T_2 and least in T_1. Highest net profit per bird and net profit per kg weight gain was recorded in T_3 followed by T_2, T_1 and the least in $T_{4.}$

5.7. Conclusions:

1. Body weight was significantly higher in T_4 followed by T_3, then T_2 and least in $T_{1.}$

2. There was significant ($P>0.05$) difference in overall body weight gain amongst the treatment groups due to turmeric supplementation.

3. Feed intake was significantly ($P<0.05$) lower in T_4 followed by$T_{3,}$ T_2 and the highest in $T_{1.}$

4. Best mean FCR was observed in control group $T_{1.}$

5. T_3 group had the least mortality rate and the highest liveability per cent

6. There was no significant effect on age at sexual maturity due to supplementation of turmeric powder in the diet of laying hens.

7. Body weight at the onset of egg production was found to be significantly higher ($P<0.05$) in T_4 and the least in T_1.

8. There was no significant difference in egg weight at onset of egg production due to turmeric supplementation.

9. Egg production was significantly higher in turmeric supplemented group T_3 followed by T_2, T_4 and the least in $T_{1.}$

10. There was no significant difference in clutch size among the different treatment groups.

11. Analysis of variance did not show any significant (P>0.05) difference in hen house and hen day egg production amongst the treatment groups.

12. At 242 days the albumen index was significantly higher in turmeric supplemented groups T_3 followed by T_4, T_2 with the least in T_1.

13. At 365 days, the yolk index of T_4 was found to be significantly higher than T_1.

14. There was no significance (P>0.05) difference in haugh unit of Vanaraja eggs among the treatment groups.

15. Group T_4 had lowest yolk cholesterol followed by T_3, T_2 and the highest was in control T_1

16. Higher (P<0.05) total WBC was observed in turmeric supplementation at 365 days as compared to control.

17. There was no significant (P<0.05) difference in total RBC due to turmeric supplementation.

18. Significantly (P<0.05) lower LDL was observed in T_4 as compared to T_1.

19. There was no significant (P<0.05) difference in HDL due to turmeric supplementation irrespective of the groups.

20. Higher level of triglyceride was observed in control T_1 while the least was observed in T_4.

21. Significantly (P<0.05) lower serum cholesterol was observed in T_4 as compared to T_1.

22. Highest net profit per bird and net profit per kg weight gain was recorded in T_3 and least in T_4.

As per the above findings, all the turmeric powder supplemented groupsshowed better performance in terms of body weight, weight gain, egg production and egg quality traits, haematological and biochemical traits and net returns as compared to the control group. Further, amongst the treatment groups, T_3 performed better in almost all the parameters. Therefore,in conclusion, use of turmeric powder at the rate of 0.75 per cent can be advocated in poultry diet as feed additive for better production performanceand for producing quality poultry products for maximum return.

5.8 Future plan

1. Studies can be carried out using larger bird population and for longer duration in order to supplement the present findings.
2. Comparative studies on the efficacy of turmeric powder and other herbal products on the health aspects of layer birds and other local germplasm may be carried out.
3. Further studies using turmeric powder as an alternative to antibiotic growth promoter on other species of livestock can be beneficial.
4. Extensive studies on organoleptic test and nutritional composition of the meat and egg from birds fed with turmeric can be carried out to ascertain its beneficial effects for popularization.

REFERENCES

REFERENCES

Aggarwal, B.B., Sundaram, C. Malani, N. and H. Ichikawa, H. 2007.Curcumin*:* The Indian solid gold*. Advances in Experimental Medicine and Biology*.**595**: 1-75.

Akbarian, A., Golian, A., Kermanshahi, H., Gilani, A. and Moradi, S. 2012. Influence of turmeric rhizome and black pepper on blood constituents and performance of broiler chickens. *African Journal of Biotechnology*.**11**: 8606-8611.

Ali, B. H., Marrif, H., Noureldayemc, S. A., Bakheitd, A. O. and Blunden, G. 2006. Biological properties of curcumin: A review. *Natural Product Communications*.**1**:509-521.

Al-Jaleel, R. A. Abd. 2012. Use of turmeric (*Curcuma longa*) on the performance and some physiological traits on broiler diets. *The Iraqi Journal of Veterinary Medicines.***36**(1): 51- 57

Al-Kassie, G. A. M., Mohseen, A. M. and Abd-ALJaleel, R. A. 2011.Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet.*Research Opinion in Animal & Veterinary Science*.**1**: 31-34.

Al-Sultan, S .I. 2003.The effect of *Curcuma longa* (turmeric) on overall performance of broiler chickens.*International Journal Poultry Science*.**2**(5): 351-353.

Al-Sultan, S. I. and Gameel, A. A. 2004. Histopathological changes in the livers of broiler chicken supplemented with turmeric (*Curcuma longa). International Journal of Poultry Science*.**3**: 333-336.

Arslan, M., Haq, A., Ashraf, M., Iqbal, J. and Mund, M. D. 2017. Effect of turmeric (*Curcuma longa*) supplementation on growth performance, immune response, carcass characteristics and cholesterol profile in broilers.*Veterinaria*.**66**: 16- 20.

Attiaa, Y.A., Al-Harthia, M.A. and Hassanb, S.S. 2017. Turmeric (*Curcuma longa* Linn.) as a phytogenic growth promoter alternative for antibiotic and comparable to mannan oligosaccharides for broiler chicks.*Revista Mexicana de Ciencias Pecuarias*.**8** (1): 11-21.

Awadein, N. B., Eid, Y. Z. and Abd El-Ghany, F. A. 2010.Effect of dietary supplementation with phytoestrogens sources before sexual maturity on productive performance of Mandarah hens.*Egyptian Poultry Science Journal*.**30**: 829- 846.

Ayed, H. M., Aissa, A. and Noumi, M. 2018. Comparative study between the effects of feed inclusion with garlic (*Allium Sativum*), cloves and turmeric (*Curcuma Longa*) rhizome powder on laying hen's performance and egg quality. *Iranian Journal of Applied Animal Science.***8** (4): 693- 701.

Azouz, H. M. M., Gadelrab, S. S., Beshara. M. M., Zeinab, M., Desouki, S. and Shazly, A. 2019. Effects of dietary turmeric and hot pepper powder supplementation on productive performance of local laying hens. *Egyptian Poultry Science Journal.***39:** 935- 951.

Basak, S. 2015. Turmeric oil – functional feed additive for poultry nutrition. https://www.linkedin.com/pulse/turmeric-oil-functional-feed-additive-poultry-nutrition-basak. Accessed on 28 August 2017.

Beevers, C. S. and Huang, S. 2011. Pharmacological and clinical properties of curcumin.A Review.*Botanics: Targets and Therapy*.**1**: 5-18

Bhattacharya, M., Buragohain, R., Ahmed, F.A., Pathak, P.K. and Ghosh, M. K. 2005.Laying performance of Vanaraja birds in high altitude areas of Arunachal Pradesh under backyard system of rearing. In:Proceedings of XXIII IPSACON on Indian Poultry Production in changed global scenario: Challenges and opportunities. Hyderabad. Pp 198.

Bozkurt, M., Hippenstiel, F., Abdel-Wareth, A. A., Kehraus, S., Kucukyilmaz, K. and Sudekum, K. H. 2014. Effects of selected herbs and essential oils on performance, egg quality and some metabolic activities in laying hens–A review.*European Poultry Science*.**78**:1612-9199.

Chakrabarti, A., Jha,B.K.,Sarkar, P.K. and Yadav,V.K.2020. Performance of Vanaraja and Kaveri poultry birds in tribal villages of Jharkhand. *Journal of Entomology and Zoology Studies.***85**:1960-1966.

Chattopadhyay, I., Biswas, K., Bandyopadhyay, U. and Banerjee, R.K. 2004. Turmeric and curcumin: Biological actions and medicinal applications. *Current Science.***87**: 44–53.

Chauhan, S. S., Caeser, D. D., Shakkarpude, J. Shrivastava, K., Khan, M. A. and Mishra, A. 2018. Effect of turmeric supplementation on production performance of adult laying birds. *International Journal of Current Microbiology and Applied Sciences.***7** (8): 840-844.

Chauhan, S. S., Jain, N., Quadri, M. A., Gelaut, B. S., Chaurasia, R. And Shakkarpude, J. 2014. Effect of turmeric (*Curcuma longa*) on blood glucose in Jabalpur color layer birds.*Environment Ecology*.**32** (2): 408-409.

Choudhury, D. 2019. Study on the nutrient composition of local variety of turmeric (*Curcuma long*). *The Pharma Innovation Journal*.**8** (2): 205- 207.

Curvelo, E. R., Geraldo, A., Silva, L. M., Santos, T. A. and Vieira-Filho. 2009. Levels of inclusion of curcumin extract and turmeric in diets for semidried hens and their effects on performance and egg yolk coloration. **In**: Proceedings of the II Federal Institute of Minas Gerais Science Technology Week.

Dalal, R. and Koti, D. 2018.Turmeric powder as feed additives in laying hen - A review. *Journal of Pharmocognosy and Phytochemistry*.**7** (3): 2686- 2689.

Demir, E., Sarica, S., Ozcan, M. A. and Suicmez, M. 2003. The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diets.*Poultry Science*.**4**: 44-45.

Denli, M., Okan, F. and Celik, K. 2003.Effect of dietary organic acid and antibiotic supplementation to diets on broiler performance and carcass yield.*Pakistan Journal of Nutrition*.**2**: 89-91.

Devegowda, D. G. 1996. Herbal medicines, an untapped treasure in poultry production **In**: Proceedings of 20th World Poultry Congress at New Delhi, India.

Docic, M. and Bilkei, G. 2003. Differences in antibiotic in *Escherichia coli* isolated from East-European swine herds with or without prophylactic use of antibiotics. *Journal of Veterinary Medicine, Infectious Disease and Veterinary Public Health*.**50**: 27-30.

Dono, N. D. 2014. Turmeric (*Curcuma longa linn*.) supplementation as an alternative to antibiotics in poultry diets.*Indonesian Bulletin of Animal and Veterinary Sciences*.**23**(1):41-9.

Durrani, F.R., Ismail, M., Sultan, A., Suhail, S. M., Chand, N. and Durrani, Z. 2006. Effect of different levels of feed added turmeric (*Curcuma Longa*) on the performance of broiler chicks. *Journal of Agricultural and Biological Science*.**1** (2): 9–11.

Edens, F.W. 2003. An alternative for antibiotic used in poultry: probiotics. *Nutritional Abstracts & Reviews*.**74** (2): 628.

Eevuri, T. R. and Putturu, R. 2013. Use of certain herbal preparations in broiler feeds-A review. *Veterinary World*.**6** (3): 172-179.

Emadi, M., Kermanshahi, H. and Maroufyan, E. 2007. Effect of varying levels of turmeric rhizome powder on some blood parameters of broiler chickens fed corn-soybean meal based diets. *International Journal of Poultry Science*.**6** (5): 345-348.

Faitarone, A. B. G., Garcia, E. A., Roça, R. D. O., Ricardo, H. D. A., Andrade, E. N., Pelícia, K. and Vercese, F. 2013. Cholesterol levels and nutritional composition of commercial layers eggs fed diets with different vegetable oils. *Brazilian Journal of Animal Science.***15** (1), 31-37.

Fallah, R. and Mirzaei, E. 2016.Effect of dietary inclusion of turmeric and thyme powders on performance, blood parameters and immune system of broiler chickens.*Journal of Livestock Science.***7**: 180-186.

Godara, A. S. and Singh, A. 2019.Effect of feed restriction and turmeric powder supplementation on broiler performance.*Haryana Veterinary*. **58** (2): 254-256.

Gomez, K.A. and Gomez, A.A. 1984.Statistical procedure for agricultural research. 2nd Edition, Willey, Hoboken. pp28-192.

Gowda, N. K., Ledoux, D. R., Rottinghaus, G. E., Bermudez, A. J. and Chen, Y. C. 2008. Efficacy of turmeric (*Curcuma longa*), containing a known level of curcumin, and a hydrated sodium calcium aluminosilicate to ameliorate the adverse effects of aflatoxin in broiler chicks. *Poultry Sciences*.**87**(6):1125-1130.

Gowda, N. K., Ledoux, D. R., Rottinghaus, G. E., Bermudez, A. J. and Chen, Y. C. 2009. Antioxidant efficacy of curcuminoids from turmeric (*Curcuma longa* L.*)* powder in broiler chickens fed diets containing aflatoxin B .*British Journal of Nutrition.***102**(11):1629-1634.

Graham, A. 2009. Curcumin adds spice to the debate: lipid metabolism in liver disease. *Journal of Pharmacology*.**157**(8): 1352–1353.

Guil-Guerrero**,** J. L., Ramos**,** L., Zuniga- Paredes**,** J. C., Carlosama-Yepez, M., Moreno**,** C. and Ruales**,** P. 2017. Effects of turmeric rhizome powder and curcumin on poultry production.A review.*Journal of Animal and Feed Sciences.***26**: 293–302.Gumus, H., Oguz, M. N., Bugdayci, K. E. and Oguz, F. K. 2018. Effects of sumac and turmeric as feed additives on performance, egg quality traits, and blood parameters of laying hens. *Brazilian Journal of Animal Science.***47**: 0114.

Gunes, H., Gulen, D., Mutlu, R., Gumus, A., Tas, T. And Topkaya, A. E. 2016. Antibacterial effects of curcumin: An in vitro minimum inhibitory concentration study. *Toxicology Industrial Health*. **32**:246–250.

Haugh, R. R. 1937. The Haugh unit for measuring egg quality. US egg poultry magazine. **43**: pp 552-555

Haunshi, S., Doley, S.and Shakuntala, I. 2009. Production performance of indigenous chicken of Northeastern region and improved varieties developed for backyard farming. *Indian Journal of Animal Science.***79**:901-905.

Ikpeama, A., Onwuka, G.I. and Nwankwo, C. 2014. Nutritional composition of tumeric (*Curcuma longa*) and its antimicrobial properties. *International Journal of Science and Engineering Research*.**5**: 1085-1089.

Incharoen, T. and Yamauchi, K. 2009. Production performance, egg quality and intestinal histology in laying hens fed dietary dried fermented ginger. *International Journal of Poultry Science*.**8**:1078-1085.

International Market Analysis Research and Consulting Group. 2020. Indian poultry market: Industry trends, share, size, growth, opportunity and forecast 2020-2025.https://www.imarcgroup.com/indian-poultry-market Accessed on 17 march 2021.

Islam, R., Nath, P., Bharali, A. and Borah, R. 2015. Analysis of benefit-cost (B: C) ratio of Vanaraja and local chicken of Assam under backyard system of rearing. *Journal of Research in Agriculture and Animal Science*.**3** (7): 07-10.

Kafi, A., Uddin, M. N., Uddin, M. J., Khan, M. M. H. and Haque, M. E. 2017.Effect of dietary supplementation of turmeric (*Curcuma longa*), ginger (*Zingiberofficinale*) and their combination as feed additives on feed intake, growth performance and economics of broiler.*International Journal of Poultry Science*.**16**: 257-265.

Kanagaraju, P., Omprakash, A. V., Rathnapraba, S. and Rajmanohar, G. 2017. Effect of turmeric (*Curcuma Longa*) on the egg production and bio- chemical parameters in layers.*Indian Veterinary Journal*.**94** (04): 24 – 26.

Kapoor, L. D.1990. Handbook of ayurvedic medicinal plants. CRC Press Boca Raton, Florida, USA, p. 85.

Kermanshahi, H. and Riasi, A. 2006.Effect of turmeric rhizome powder (*Curcuma longa*) and soluble non- starch polysaccharides degrading enzyme on some blood parameters of laying hens. *International Journal of Poultry Science*.**5**: 494-498.

Ketharaj, M. and Jeyakumar, S. 2009.The silver lining in the stagnant agriculture sector and poultry farming.http:www.ffymag.com. Accessed on 15 April 2018.

Khan, R.U., Naz, S., Javdani, M., Nikousefat, Z., Selvaggi, M., Tufarelli, V. and Laudadio, V. 2012. The use of turmeric (*Curcuma longa*) in poultry feed. *World Poultry Science Journal*.**68**: 97-103.

Khodadadi, M., Sheikhi., N., Nazarpak, H.H. and Brujeni, N. 2021. Effects of dietary turmeric (*Curcuma longa*) on innate and acquired immune responses in broiler chicken.*Veterinary and Animal Science*. 14: 100213.

Kilany, O. E. and Mahmoud, M. M. A. 2014. Turmeric and exogenous enzyme supplementation improve growth performance and immune status of Japanese quail. *World Veterinary Journal*.**4**:20–29.

Kim, M. and Kim, Y. 2010. Hypocholesterolemic effects of curcumin via up-regulation of cholesterol 7a-hydroxylase in rats fed a high fat diet. *Nutritional Research and Practices*.**4**(3): 191-195.

Kohli, K., Ali, J., Antasari, M. J. and Rahemen, Z. A. 2005.Natural anti-inflamoatory agent.*Education forum.***37**(3): 141-147.

Kujero, G. O., Njoku, C. P. and Emmanuel, O. 2012. Reproductive and physiological responses and egg quality traits of Isa brown chickens fed diets supplemented with ginger or turmeric powder. https://doi.org/10.21203/rs.3.rs-985543/v1. Accessed on 4 April 2022.

Lagana, C., Pizzolante, C. C., Saldanha, E. S. and Moraes, J. E. 2011. Turmeric root and annato seed in second-cycle layer diets: performance and egg quality. *Brazilian Journal of Animal Science*.**13** (3):171-176.

Malekizadeh, M., Moeini, M. M. and Ghazi, S. H. 2012.The effects of different levels of ginger (*Zingiberofficinale*Rosc) and turmeric (*Curcuma longa* Linn) rhizomes powder on some blood metabolites and production performance characteristics of laying hens. *Journal of Agricultural Science Technology.* **14**:127-134.

Marathe, S. A., Balakrishnan, A., Negi, V. D, Sakorey, D., Chandra, N. and Chakravortty, D. 2016. Curcumin reduces the motility of Salmonella enteric *Serovar Typhimurium* by binding to the flagella, thereby leading to flagellar fragility and shedding. *Journal of Bacteriology*.**198**:1798–1811.

Mehta, R. and Nambiar, R. G. 2013.Poultry industry in India.http:www.fao.org. Accessed on 19 April 2018.

Moeini, M. M., Malekizadeh, M. and Ghazi, S. 2011. The effects of different levels of ginger (*Zingiberofficinale*) and turmeric (*Curcuma longa*) rhizomes powder on productive performance characteristics of laying hens. *Journal of Agricultural Science Technology*.**14** (1):127-134.

Mondal, M. A., Yeasmin, T., Karim, R., Siddiqui, M. N., Raihanun- Nabi, S. M., Sayed, M. A. and Siddiky, M. N. A. 2015. Effect of dietary supplementation of turmeric (*Curcuma longa*) powder on the growth performance and carcass traits of broiler chicks.*South Asian Association for Regional CooperationJournal of Agriculture*.**13**: 188-199.

Moorthy, M., Saravanan, S., Mehala, C., Ravi, S., Ravikumar, M. and Viswanathan, K. 2009.Performance of single comb white leghorn layers fed with Aloe vera, *Curcuma longa* (turmeric) and probiotic. *International Journal of Poultry Science*.**8** (8):775-778.

Mousa, B. H., Nafaa, H. H. and Al- Rawi, Y. T. 2018.Effect of garlic and turmeric on egg quality, internal quality, internal weights, bacterial population and intestinal histomorphology of laying hens. https://www.researchgate.net/publication/329754216. Accessed on 4 September 2022.

Naderi, M., Akbari, M.R., Asadi-Khoshoei, E., Khaksar, K. and Khajali, F. 2014. Effects of dietary inclusion of turmeric (*curcuma longa*) and cinnamon (*cinnamomum verum*) powders on performance, organs relative weight and some immune system parameters in broiler chickens.*Poultry Science*. **2**: 153-163

Nanung, D. D. 2013.Turmeric (*curcuma longa* linn.) supplementation as an alternative to antibiotics in poultry diets.*Indonesian Journal of Bulletin Animal & Veterinary Science.***23**: 41-49.

Narahari, D., Sujatha, T. and Kirubakaran, A. 2003.Effect of diet on egg and serum lipid profile.**In**: Proceedings of 21st Conference of Indian Poultry Science Association, Bareilly, U.P. India, 98–99.

Nikola, P., Dragana, L., Nedeljka, S., Olivera, D. and Nedeljka, N. 2018. Effects of turmeric powder (*Curcuma Longa*) in laying hens nutrition: table eggs production, quality and lipid profile. *Concept Daily & Veterinary Science*.**2**(1):162-164

Niranjan, M., Sharma, R.P., Rajkumar, U., Reddy, B. L. N., Chatterjee, R. N. and Battacharya, T. K. 2008.Comparative evaluation of production performance in improved chicken varieties for backyard farming.*International Journal of Poultry Science.7*(11):1128-1131.

Nouzarian, R., Tabeidian, S. A., Toghyani, M., Ghalamkari, G. and Toghyani, M. 2011.Effect of turmeric powder on performance, carcass traits, humoral immune responses and serum metabolites in broiler chickens.*Journal of Animal and Feed Science*.**20**: 389- 400.

Olarotimi, O. J. 2018. Turmeric (*Curcuma longa*): An underutilized phytogenic additives in poultry nutrition. *Turkish Journal of Agriculture.***6**(1): 102-106.

Oluwafemi, R. A. 2021. Effects of turmeric oil as a dietary supplements on the hematology and serum biochemical indices of broiler chickens. *Bioinformatics and Proteomics*. **5**(1): 000138.

Ooi, P. S., Rohaida, A. R., Nur, A. D., Devin, D., Borhan, A. H., Kartini, S., Jupikely, J. S., Abdul, R. M. and Alimon, A. R. 2018. Effect of local medicinal herbs as feed additives on production performance and faecal parameters in laying hens.*Malaysian Journal of Poultry Science*. **21**(2): 59-67.

Pal, S., Choudhuri, T., Chattopadhyay, S., Bhattacharya, A., Datta, G.K., Das, T. and Sa, G. 2001. Mechanisms of curcumin-induced apoptosis of Ehrlich's ascites carcinoma cells.*Biochemistry, Biophysics and Research Communication*.**288** (3): 658–665.

Park, S. S., Kim, J. M., Kim, E. J., Kim, H. S., An, B. K. and Kang, C. W. 2012. Effects of dietary turmeric powder on laying performance and egg qualities in laying hens. *Korean Journal of Poultry Science.***39**(1): 27-32.

Putra, S. H., Saraswati, T. R. and Isdadiyanto, S. 2015. Profile triglycerides Japanese Quail (*Coturnix coturnix Japonica*) after giving turmeric (*Curcuma longa*) powder. *International Journal of Science and Engeering*.**8**(1):65-68.

Qinna, N. A., Kamona, B. S., Alhussainy, T. M., Taha, H., Badwan, A. A., and Matalka, K. Z. 2012. Effects of prickly pear dried leaves, artichoke leaves, turmeric and garlic extracts, and their combinations on preventing dyslipidemia in rats. *International Scholarly Research Network Pharmacology.*1-7.

Radwan, N., Hassan, R. A., Qota, E. M. and Fayek, H. M. 2008.Effect of natural antioxidant on oxidative stability of eggs and productive and reproductive performance of laying hens.*International Journal of Poultry Science.***7**(2): 134-50.

Rahardja, D. P., Rahman, H. M. and Lestari, V. S. 2015**.**Egg production performance of old laying hen fed dietary turmeric powder. *International Journal of Animal and Veterinary Science.***9** (7):748-758.

Rahmatnejad, E., Roshanfekr, H., Ashayerizadeh, O., Mamooee, M. And Ashayerizadeh, A. 2009. Evaluation of the effect of several non-antibiotic additives on growth performance of broiler chickens.*Journal of Animal and Veterinary Advances.***8**: 1670-1673.

Ramana, D.B.V., Nirmala, G., Maruthi, V. and Rao, G. R. 2010. Performance of Vanaraja as backyard poultry.*Indian Veterinary Journal***. 87**: 517- 518.

Riasi, A., Kermanshahi, H. and Mahdavi, A. H. 2012. Production performance, egg quality and some serum metabolites of older commercial laying hens fed different levels of turmeric rhizome (*Curcuma longa*) powder. *Journal of Medicinal Plants Research*.**6**(11):2141-2145.

Romanoff, A. L. and Romanoff, A. L. 1949.The avian egg. John Wiley and Sons, Inc., New York.

Saikia, A. K., Gogoi, G. and Neog, M. 2017. Productive and reproductive performance of Vanaraja birds reared by tribal community of Dhemaji district of Assam.*Jay KrishiVigyan*. **6**(1): 162-165.

Saraswati, T. R. and Tana, S. 2016. Effect of turmeric powder supplementation to the age of sexual maturity, physical and chemical quality of the first Japanese quail's (*Coturnix japonica*) egg.*Biosaintifika Journal of Biology and Biology Education*.**8** (1):18-24.

Saraswati, T. R., Manalu, W., Ekastuti, D. R. and Kusumorini, N. 2013a. Increased egg production of Japanese quail (*Cortunix japonica*) by improving liver function through turmeric powder supplementation.*International Journal of Poultry Science.***12** (10):601.

Saraswati, T. R., Manalu, W., Ekastuti, D. R. and Kusumorini, N. 2013b. The role of turmeric powder in lipid metabolism and its effect on quality of the first quail's egg.*Journal of the Indonesian Tropical Animal Agriculture*.**38** (2):123-130.

Sastry, G. A. 1985. Veterinary clinical pathology.3rd Ed. CBS publishers and Distributers, Delhi, India.pp 5-17.

Sawale, G. K., Gosh, R. C., Ravikanth, K., Maini, S. and Rekhe, D. S. 2009. Experimental mycotoxicosis in layer induced by ochratoxin A and its amelioration with herbo mineral toxin binder Toxiroak.*International Journal of Poultry Science*.**8**(8):798-803.

Sengupta, M., Sharma, G. D.and Charaborty, B. 2011.Hepato protective and immunomodulatory properties of aqueous extract of *Curcuma longa* in carbon tetra chloride intoxicated Swiss albino mice. *Asian Pacific.Journal of Tropical Biomedicine*.**1**(3): 193-199.

Seo, K., Choi, M. S., Jung, U. J., Kim, H. J., Yeo, J., Jeon, S. M. and Lee, M. K. 2008. Effect of curcumin supplementation on blood glucose, plasma insulin, and glucose homeostasis related enzyme activities in diabetic db/db mice. *Molecular Nutritional Food Research*.**52**(9):995-1004.

Shende. 2021. Effect of turmeric (*Curcuma longa*) powder and synbiotic as alternative to antibiotic growth promoter on haemato-biochemical parameters and comparative economics of broiler chicks. *International Journal of Bio-resource and Stress Management.***12** (2): 125-130.

Sheriff, M. H. 2016. Effect of adding different dietary levels of turmeric (*Curcuma longa Linn*) powder on the productive performance and egg quality of laying hens.*International Journal of Poultry science*.**15** (4): 156- 160.

Shrishail, H. K., Harish, H. Ravichandra, G., Tulsianand, S.D. and Shruthi. 2013. Turmeric: nature's precious medicine. *Asian Journal of Pharmaceutical and Clinical Research.***6**(3): 10-16.

Shweta, S. C., Caeser, D. D., Shakkarpude, J., Kush, S., Mendi, A. K. and Mishra, A. 2018. Effect of turmeric supplementation on production performance of adult laying birds.*International Journal of Current Microbiology and Applied Science*.**7** (8): 840-844.

Silva, W. J. D., Gouveia, A. B. V. S., Sousa, F. E. D., Santos, F. R. D., Minafra-Rezende, C. S., Silva, J. M. S. and Minafra, C. S. 2018. Turmeric and sorghum for egg-laying quails.*Italian Journal of Animal Science*.**17** (20): 368-376.

Singh, P., Kachroo, D., Thakur, N.P., Khajuria, V., Kumar, P., Kumar, M. and Kour, G. 2018.Comparative performance of Vanaraja, Gramapriya and indigenous desi bird under backyard system of rearing in Jammu Province, India.*International Journal of Current Microbiology and Applied Sciences*.**7**(2): 101-105.

Srimal, R. C. 1997. Turmeric: A brief review of medicinal properties. *Fitoterapia*.**68**: 483-493.

Srinivasan, K. and Sambaiah, K. 1991.The effect of spices on cholesterol 7 alpha-hydroxylase activity and on serum and hepatic cholesterol levels in the rat. *International Journal for Vitamin and Nutrition Research*.**61**(4):364-369.

Sugiharto, S. 2016. Role of nutraceuticals in gut health and growth performance of poultry.*Journal of the Saudi Society of Agricultural Sciences*.**15**(2): 99.

Sulastri, M. P. and Basri, H. 2019. The effect of turmeric and ginger powder on Japanese quail (*Coturnix coturnix japonica*) serum lipid profile.*Biosaintifika: Journal of Biol-ogy and Biology Education*. **11**(2): 243-248.

Thaloor, D. 1999. Systemic administration of the NF-B inhibitor curcumin stimulates muscle regeneration after traumatic injury. *American Journal of Physiology*.**277**: 320-329.

Thrall, M. A., Baker, D. C. and Campbell, T. W. 2004.Veterinary hematology and clinical chemistry. 2nd ed. Baltimore, MD: Lippincott: Williams & Wilkins. pp 259–276.

Wang, D., Huifang, H., Zhou, L., Wei, L., Hanlin, Z., Guanyu, H., Jia, L. and Lin, H. 2016. Effects of dietary supplementation with turmeric, rhizome extract on growth performance, carcass characteristics, antioxidant capability and meat quality of Wenchang broiler chickens.*Italian Journal Animal Science*.**14**:344-349.

Washburn, K. W. and Nix, D. F. 1973. A rapid techniques for extraction of yolk cholesterol. *Poultry Science*.**53**: 1118-1122.

Wenk, C. 2003. Herbs and botanicals as feed additives in monogastric animals. *Asian-Australian Journal of Animal Sciences*.**16**(2): 282–290.

Widjastuti, T., Setiawan, I. and Abun. 2017.The Use of turmeric (*Curcuma domestica val*) meal in the rations as feed additive on hen-day production and egg quality of Sentul chicken.*Animal Science.*131-136.

Wilson, K. J. and Beyer, R. S. 2002.Poultry nutrition information for small flock.http://www.oznet.ksu.edu. Accessed on 15th April 2018.

World Health Organisation. 1987. Principles for the safety assessment of food additives and contaminants in food, Environmental Health Criteria, WorldHealth Organization, Geneva. 174: pp 70.

Yang, Y., Iji, P.A. and Choct, M. 2009. Dietary modulation of gut microflora in broiler chickens: a review of the role of six kinds of alternatives to in-feed antibiotic. *World's Poultry Science Journal*. **65**: 97-114.

Youssef, M. K. E., El-Newihi, A. M., Omar, S. M. and Ahmed, Z. S. 2014.Assessment of proximate chemical composition, nutritional status, fatty acid composition and antioxidants of Curcumin (Zingiberaceae) and Mustard Seeds Powders (Brassicaceae).*Food and Public Health*. **4**: 286-292

Zadeh, M. A, Mirghelenj, S. A., Hasanlou, P. and Shakouri, A. H. 2022. Effects of turmeric (*Curcuma longa*) powder supplementation in laying hens' diet on production performance, blood biochemical parameters and egg quality traits.https://www.researchgate.net/publication/361563371. Accessed on 5 September 2022.

Zhao, X., Yang, Z. B., Yang, W. R., Wang, Y., Jiang, S. Z. and Zhang, G. G. 2011. Effects of ginger root (*Zingiber officinale*) on laying performance and antioxidant status of laying hens and on dietary oxidation stability.*Poultry Science*.**90**(8)**:**1720-1727.

Zhongze, H., Like, W. and Aiyou, W. 2008. Effect of curcumin on fat metabolism in Wanjiang Yellow chickens.*Cereals and Feed Industry*.**4**: 12.

Zhu, Y., Zhang, X, D. P., Wang, Z., Luo, P., Huang, Y., Liu, Z., Zhang, H. and Chen, W. 2022. Dietary herbaceous mixture supplementation reduced hepatic lipid deposition and improved hepatic health status in post-peak laying hens. *Poultry Science*.**101**(6):101870.

Zlatkis, A., Zak, B. and Boyle, A. J. 1953. A new method for the direct determination of serum cholesterol. *Journal of Laboratory Clinical Medicine*. **41**: 486-487.

APPENDICES

APPENDIX-A

BODY WEIGHT

0^{th} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	13.977	4.655	2.704	3.24
Error	16	27.565	1.728	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.091
Treatments found to be non- significant

1^{st} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	443.178	147.729	9.252	3.24
Error	16	255.462	15.965	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.239
Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 7.388 CD(0.05) = 5.356

2^{nd} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	678.777	226.259	9.609	3.24
Error	16	376.977	23.561	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.249
Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 8.962 CD(0.05) = 6.502

3^{rd} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2624.438	874.816	66.02	3.24
Error	16	211.980	13.247	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.167
Treatments found Significant at 1% and 5% level of significance
CD (0.01) = 6.723 CD (0.05) = 4.883

4th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	359.832	119.944	27.396	3.24
Error	16	70.049	4.375	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.092

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.862 CD(0.05) = 2.803

5th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	284.025	94.671	33.332	3.24
Error	16	45.440	2.843	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.061

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.114 CD(0.05) = 2.256

6th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1163.018	387.672	327.013	3.24
Error	16	18.966	1.184	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.048

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.014 CD(0.05) = 1.458

7th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	537.814	179.278	36.742	3.24
Error	16	78.070	4.874	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.081

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 4.088 CD(0.05) = 2.967

8th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	6025.989	2008.663	516.886	3.24
Error	16	62.178	3.881	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.076

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.648 CD(0.05) = 2.641

9th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5875.342	1958.447	712.518	3.24
Error	16	43.975	2.746	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.060

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.068 CD(0.05) = 2.229

10th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2645.621	881.877	624.325	3.24
Error	16	22.603	1.415	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.048

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.196 CD(0.05) = 1.59

11th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1709.013	569.671	400.982	3.24
Error	16	22.736	1.426	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.048

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.209 CD(0.05) = 1.591

12th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5187.095	1729.031	1352.982	3.24
Error	16	20.440	1.279	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.042

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.084 CD(0.05) = 1.517

13th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3296.936	1098.978	867.570	3.24
Error	16	20.267	1.267	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.045

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.072 CD(0.05) = 1.500

14th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4736.033	1578.671	836.987	3.24
Error	16	30.172	1.881	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.052

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.531 CD(0.05) = 1.844

15th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2321.805	773.935	804.374	3.24
Error	16	15.395	0.961	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.035

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 1.811 CD(0.05) = 1.311

16th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5328.896	1776.298	903.386	3.24
Error	16	31.461	1.962	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.056

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.594 CD(0.05) = 1.881

17th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	6576.901	2192.303	1620.548	3.24
Error	16	21.640	1.358	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.046

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.147 CD(0.05) = 1.554

18th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4872.644	1624.214	936.104	3.24
Error	16	27.761	1.730	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.045

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.434 CD(0.05) = 1.761

19th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	12561.856	4187.288	1141.172	3.24
Error	16	58.702	3.662	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.068

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.537 CD(0.05) = 2.563

20th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	9929.243	3309.747	947.709	3.24
Error	16	55.879	3.493	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.066

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.454 CD(0.05) = 2.506

21st fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	7512.552	2504.187	1165.071	3.24
Error	16	34.391	2.143	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.052

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.704 CD(0.05) = 1.967

22nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5835.003	1945.004	1479.257	3.24
Error	16	21.035	1.318	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.031
Treatments found Significant at 1% and 5% level of significance
CD (0.01) = 2.113 CD (0.05) = 1.534

APPENDIX – B

BODY WEIGHT GAIN

1ST fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	547.151	182.380	10.649	3.24
Error	16	274.184	17.138	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.180

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 7.646 CD(0.05) = 5.554

2nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	468.171	156.057	2.519	3.24
Error	16	991.669	61.978	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.243

Treatments found to be Non-Significant

3rd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1658.914	552.978	70.854	3.24
Error	16	124.865	7.807	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.391

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 5.167 CD(0.05) = 3.745

4th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1307.057	435.689	17.124	3.24
Error	16	406.983	25.432	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.115

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 9.312 CD(0.05) = 6.762

5th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	27.316	9.102	1.671	3.24
Error	16	86.769	5.420	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.984

Treatments found to be Non-Significant

6th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	327.258	109.082	42.575	3.24
Error	16	40.990	2.562	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.262

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.951 CD(0.05) = 2.142

7th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	237.637	79.212	9.123	3.24
Error	16	138.951	8.683	-	-
Total	19	-	-	-	-

Coefficient of Variation = 15.087

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 5.441 CD(0.05) = 3.952

8th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3280.369	1093.456	156.613	3.24
Error	16	111.701	6.986	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.954

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 4.883 CD(0.05) = 3.547

9th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2084.121	694.703	95.095	3.24
Error	16	116.899	7.306	-	-
Total	19	-	-	-	-

Coefficient of Variation = 4.638

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 4.993 CD(0.05) = 3.620

10th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	888.784	296.264	73.046	3.24
Error	16	64.895	4.057	-	-
Total	19	-	-	-	-

Coefficient of Variation = 10.970

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.724 CD(0.05) = 2.702

11th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	125.139	41.719	33.584	3.24
Error	16	19.873	1.241	-	-
Total	19	-	-	-	-

Coefficient of Variation = 13.645

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.059 CD(0.05) = 1.493

12th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1975.467	658.489	181.387	3.24
Error	16	58.089	3.632	-	-
Total	19	-	-	-	-

Coefficient of Variation = 10.437

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.518 CD(0.05) = 2.556

13th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	815.265	271.755	161.974	3.24
Error	16	26.842	1.677	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.717

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.399 CD(0.05) = 1.737

14th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	139.388	46.462	11.682	3.24
Error	16	63.603	3.972	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.931

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.683 CD(0.05) = 2.672

15th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	478.849	159.613	90.123	3.24
Error	16	28.335	1.770	-	-
Total	19	-	-	-	-

Coefficient of Variation = 5.568

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.455 CD(0.05) = 1.783

16th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	632.360	210.786	44.259	3.24
Error	16	76.213	4.763	-	-
Total	19	-	-	-	-

Coefficient of Variation = 14.797

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 4.039 CD(0.05) = 2.92

17th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	100.948	33.646	8.537	3.24
Error	16	63.080	3.940	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.149

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.663 CD(0.05) = 2.664

18th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	350.524	116.841	31.318	3.24
Error	16	59.699	3.731	-	-
Total	19	-	-	-	-

Coefficient of Variation = 5.453

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.564 CD(0.05) = 2.589

19th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1930.199	643.399	188.912	3.24
Error	16	54.491	3.406	-	-
Total	19	-	-	-	-

Coefficient of Variation = 5.280

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.402 CD(0.05) = 2.473

20th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	217.998	72.669	13.784	3.24
Error	16	84.352	5.272	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.543
Treatments found Significant at 1% and 5% level of significance
CD (0.01) = 4.248 CD (0.05) = 3.076

21st fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	329.514	109.838	17.653	3.24
Error	16	99.542	6.222	-	-
Total	19	-	-	-	-

Coefficient of Variation = 9.913

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 4.608 CD(0.05) = 3.342

22nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	318.557	106.189	23.556	3.24
Error	16	72.138	4.503	-	-
Total	19	-	-	-	-

Coefficient of Variation = 27.524

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.925 CD(0.05) = 2.849

Overall body weight gain					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	6103.97	2034.65	456.76	3.24
Error	16	71.270	4.455	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.132

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.890 CD(0.05) = 2.828

APPENDIX – C

FEED INTAKE

0^{TH} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	402.672	134.224	0.051	3.24
Error	84	224651.803	2674.422	-	-
Total	87	-	-	-	-

Coefficient of Variation = 2.982

Treatments found to be Non-Significant

1^{st} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1238.101	412.700	4.174	3.24
Error	16Z	1581.801	98.860	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.603

Treatments found Significant at 5% level of Significance CD(0.05)= 13.336

2^{nd} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	177.335	59.118	1.457	3.24
Error	16	650.154	40.634	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.385

Treatments found to be Non-Significant

3^{rd} fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	22.907	7.632	0.205	3.24
Error	16	599.976	37.493	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.366

Treatments found to be Non-Significant

4th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	70.436	23.472	0.792	3.24
Error	16	471.195	29.447	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.320

Treatments found to be Non-Significant

5th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3998.963	1332.981	1.710	3.24
Error	16	12449.998	778.129	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.673

Treatments found to be Non-Significant

6th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	416.687	138.892	1.455	3.24
Error	16	1525.706	95.357	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.582

Treatments found to be Non-Significant

7th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	510.869	170.289	1.608	3.24
Error	16	1701.998	106.376	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.610

Treatments found to be Non-Significant

8th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2176.950	725.650	39.014	3.24
Error	16	297.599	18.599	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.254

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 7.964 CD(0.05) = 5.785

9th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2686.000	895.333	6.337	3.24
Error	16	2262.800	141.425	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.698
Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 21.967 CD(0.05) = 15.941

10th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	34.950	11.650	2.741	3.24
Error	16	68.000	4.250	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.118

Treatments found to be Non-Significant

11th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	34.950	11.650	2.741	3.24
Error	16	68.000	4.250	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.118

Treatments found to be Non-Significant

12th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	25.750	8.583	2.682	3.24
Error	16	51.200	3.200	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.108
Treatments found to be Non-Significant

13th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5.200	1.733	0.251	3.24
Error	16	110.000	6.875	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.150
Treatments found to be Non-Significant

14th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4.000	1.333	1.611	3.24
Error	16	13.200	0.820	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.055
Treatments found to be Non-Significant

15th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4.000	1.333	1.611	3.24
Error	16	13.200	0.820	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.055
Treatments found to be Non-Significant

16th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	12.200	4.066	1.333	3.24
Error	16	48.799	3.049	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.095

Treatments found to be Non-Significant

17thfortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.549	0.183	0.733	3.24
Error	16	4.000	0.250	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.020

Treatments found to be Non-Significant

18thfortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.549	0.183	0.733	3.24
Error	16	4.000	0.250	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.020

Treatments found to be Non-Significant

19th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5.799	1.933	0.937	3.24
Error	16	33.200	2.070	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.089

Treatments found to be Non-Significant

20th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4.150	1.383	0.301	3.24
Error	16	71.599	4.479	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.113

Treatments found to be Non-Significant

21st fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	6.950	2.316	0.175	3.24
Error	16	210.000	13.125	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.206

Treatments found to be Non-Significant

22nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	32.150	10.716	1.347	3.24
Error	16	127.599	7.979	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.153

Treatments found to be Non-Significant

Total Mean feed intake					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	91.034	30.341	9.711	3.24
Error	16	49.999	3.129	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.101

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.267 CD(0.05) = 2.372

APPENDIX- D

(FEED CONVERSION RATIO)

1st fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.131	0.040	10.703	3.24
Error	16	0.068	0.003	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.384

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.121 CD(0.05) = 0.089

2nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.338	0.116	3.898	3.24
Error	16	0.451	0.023	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.461

Treatments found Significant at 5% level of Significance CD(0.05)= 0.228

3rd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3.032	1.014	57.833	3.24
Error	16	0.280	0.015	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.582

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.244 CD(0.05) = 0.173

4th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5.736	1.915	19.965	3.24
Error	16	1.539	0.096	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.982

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.574 CD(0.05) = 0.417

5th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.356	0.112	0.804	3.24
Error	16	2.334	0.140	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.697

Treatments found to be Non-Significant

6th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	168.862	56.280	43.841	3.24
Error	16	20.533	1.287	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.294

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.091 CD(0.05) = 1.51

7th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3793.313	1264.434	5.957	3.24
Error	16	3397.489	212.348	-	-
Total	19	-	-	-	-

Coefficient of Variation = 16.499

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 26.923 CD(0.05) = 19.532

8th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	575.489	191.829	97.120	3.24
Error	16	31.609	1.971	-	-
Total	19	-	-	-	-

Coefficient of Variation = 5.320

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 2.593 CD(0.05) = 1.883

9th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	416.419	138.806	66.787	3.24
Error	16	33.257	2.074	-	-
Total	19	-	-	-	-

Coefficient of Variation = 4.750
Treatments found Significant at 1% and 5% level of significance
CD (0.01) = 2.663 CD (0.05) = 1.93

10th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	21129.748	7043.249	28.607	3.24
Error	16	3939.758	246.239	-	-
Total	19	-	-	-	-

Coefficient of Variation = 14.651

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 28.982 CD(0.05) = 21.037

11th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	205336.551	68445.513	15.297	3.24
Error	16	71615.663	4475.978	-	-
Total	19	-	-	-	-

Coefficient of Variation = 26.969

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 123.593 CD(0.05) = 89.705

12th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	642073.986	214024.668	83.515	3.24
Error	16	41002.594	2562.663	-	-
Total	19	-	-	-	-

Coefficient of Variation = 27.485

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 93.525 CD(0.05) = 67.872

13th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1279.737	426.572	108.906	3.24
Error	16	62.672	3.911	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.836

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.653 CD(0.05) = 2.656

14th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1830.045	610.018	8.961	3.24
Error	16	1089.172	68.075	-	-
Total	19	-	-	-	-

Coefficient of Variation = 10.225

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 15.243 CD(0.05) = 11.065

15th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	5293.512	1764.500	66.654	3.24
Error	16	423.558	26.474	-	-
Total	19	-	-	-	-

Coefficient of Variation = 6.661

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 9.501 CD(0.05) = 6.896

16th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	25910.621	8636.873	12.122	3.24
Error	16	11398.794	712.429	-	-
Total	19	-	-	-	-

Coefficient of Variation = 19.926

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 49.305 CD(0.05) = 35.788

17th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1071.696	357.235	9.789	3.24
Error	16	583.958	36.493	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.157

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 11.167 CD(0.05) = 8.102

18th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1071.683	357.227	9.785	3.24
Error	16	583.965	36.499	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.158

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 11.168 CD(0.05) = 8.102

19th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	918.847	306.289	40.509	3.24
Error	16	120.999	7.561	-	-
Total	19	-	-	-	-

Coefficient of Variation = 5.371

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 5.082 CD(0.05) = 3.681

20th fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	7423.179	2474.393	170.145	3.24
Error	16	232.687	14.547	-	-
Total	19	-	-	-	-

Coefficient of Variation = 6.763

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 7.040 CD(0.05) = 5.111

21st fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1336.099	445.366	14.434	3.24
Error	16	493.565	30.840	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.171

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 10.266 CD(0.05) = 7.449

22nd fortnight					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2981.733	993.914	14.600	3.24
Error	16	1088.691	68.042	-	-
Total	19	-	-	-	-

Coefficient of Variation = 11.088

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 15.239 CD(0.05) = 11.060

Total Mean feed conversion ratio					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3673.117	1224.373	349.826	3.24
Error	16	56.000	3.500	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.405

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 3.451 CD(0.05) = 2.504

APPENDIX - E

(REPRODUCTIVE TRAITS)

Age at sexual maturity					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	30.632	10.216	0.147	3.24
Error	16	1120.800	70.050	-	-
Total	19	-	-	-	-

Coefficient of Variation = 4.720
Treatments found to be Non-Significant

Body weight at onset of egg production					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2971.200	990.400	49.214	3.24
Error	16	322.000	20.125	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.176
Treatments found Significant at 1% and 5% level of significance
CD (0.01) = 8.286 CD (0.05) = 6.019

Egg weight at onset of egg production					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.041	0.013	1.159	3.24
Error	16	0.221	0.011	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.226
Treatments found to be Non-Significant

Totalegg production					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	42.959	14.319	7.637	3.24
Error	16	30.000	1.875	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.101
Treatments found Significant at 1% and 5% level of significance

Clutch size					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.019	0.003	0.936	3.24
Error	16	0.072	0.006	-	-
Total	19	-	-	-	-

CD(0.01) = 2.526 CD(0.05) = 1.839

Coefficient of Variation = 1.878

Treatments found to be Non-Significant

Hen house egg production					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	2.075	0.698	0.245	3.24
Error	16	45.200	2.825	-	-
Total	19	-	-	-	-

Coefficient of Variation = 10.812

Treatments found to be Non-Significant

Hen day egg production					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3.533	1.174	0.513	3.24
Error	16	36.800	2.300	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.970

Treatments found to be Non-Significant

APPENDIX – F

(EGG QUALITY TRAITS)

Albumen index (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.004	0.001	2.333	3.24
Error	16	0.000	6.5E0	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.553
Treatments found to be Non-Significant

Albumen index (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.005	0.005	8.333	3.24
Error	16	0.008	0.001	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.842
Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.027 CD(0.05) = 0.019

Albumen index (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.003	0.007	2.995	3.24
Error	16	0.001	0.002	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.191
Treatments found to be Non-Significant

Yolk index (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1.985	0.668	1.023	3.24
Error	16	10.308	0.648	-	-
Total	19	-	-	-	-

Coefficient of Variation = 137.161
Treatments found to be Non-Significant

Yolk index (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.006	0.002	2.500	3.24
Error	16	0.002	0.005	-	-
Total	19	-	-	-	-

Coefficient of Variation= 2.164
Treatments found to be Non-Significant

Yolk index (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.003	0.004	4.400	3.24
Error	16	0.006	0.001	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.393
Treatments found Significant at 5% level of Significance
CD(0.05)= 0.014

Haugh unit (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	19.184	6.398	1.725	3.24
Error	16	59.388	3.717	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.462
Treatments found to be Non-Significant

Haugh unit (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	1.334	0.448	0.505	3.24
Error	16	14.000	0.875	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.194
Treatments found to be Non-Significant

Haugh unit (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3.334	1.111	3.098	3.24
Error	16	5.759	0.355	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.752
Treatments found to be Non-Significant

Yolk cholesterol (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4.685	1.561	6.042	3.24
Error	16	4.140	0.257	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.650

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.937 CD(0.05) = 0.680

Yolk cholesterol (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.665	0.221	9.494	3.24
Error	16	0.376	0.025	-	-
Total	19	-	-	-	-

Coefficient of Variation = 0.803

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 0.282 CD(0.05) = 0.205

Yolk cholesterol (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.419	0.133	3.610	3.24
Error	16	0.600	0.030	-	-
Total	19	-	-	-	-

Coefficient of Variation = 1.034

Treatments found Significant at 5% level of Significance
CD(0.05)= 0.263

APPENDIX – G

(HAEMATOLOGICAL PARAMETERS)

WBC (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3.496	1.163	2.214	3.24
Error	16	8.416	0.526	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.872

Treatments found to be Non-Significant

WBC (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	3.545	1.185	2.569	3.24
Error	16	7.364	0.462	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.591

Treatments found to be Non-Significant

WBC (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	4.485	1.498	3.408	3.24
Error	16	7.024	0.439	-	-
Total	19	-	-	-	-

Coefficient of Variation = 3.484

Treatments found Significant at 5% level of Significance
CD(0.05)= 0.883

RBC (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.132	0.044	0.516	3.24
Error	16	1.368	0.085	-	-
Total	19	-	-	-	-

Coefficient of Variation = 9.747
Treatments found to be Non-Significant

RBC (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.070	0.023	0.424	3.24
Error	16	0.888	0.055	-	-
Total	19	-	-	-	-

Coefficient of Variation = 7.870

Treatments found to be Non-Significant

RBC (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	0.138	0.046	0.919	3.24
Error	16	0.800	0.050	-	-
Total	19	-	-	-	-

Coefficient of Variation = 7.474

Treatments found to be Non-Significant

APPENDIX – H

(BIOCHEMICAL PARAMETERS)

HDL (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	90.400	30.133	1.205	3.24
Error	16	399.600	24.975	-	-
Total	19	-	-	-	-

Coefficient of Variation = 9.999

Treatments found to be Non-Significant

HDL (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	137.800	45.933	1.702	3.24
Error	16	432.000	27.000	-	-
Total	19	-	-	-	-

Coefficient of Variation = 10.165

Treatments found to be Non-Significant

HDL (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	91.350	30.450	1.315	3.24
Error	16	371.200	23.200	-	-
Total	19	-	-	-	-

Coefficient of Variation = 9.380

Treatments found to be Non-Significant

LDL (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	372.150	124.050	4.083	3.24
Error	16	485.600	30.350	-	-
Total	19	-	-	-	-

Coefficient of Variation = 7.416

Treatments found Significant at 5% level of Significance

CD(0.05)= 7.386

LDL (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	303.350	101.116	5.150	3.24
Error	16	313.600	19.600	-	-
Total	19	-	-	-	-

Coefficient of Variation = 6.064

Treatments found Significant at 5% level of Significance
CD (0.05) = 5.

LDL (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	126.600	42.200	4.282	3.24
Error	16	157.600	9.850	-	-
Total	19	-	-	-	-

Coefficient of Variation = 4.254

Treatments found Significant at 5% level of Significance
CD (0.05)= 4.200

Triglycerides (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	318.550	106.183	4.216	3.24
Error	16	403.200	25.200	-	-
Total	19	-	-	-	-

Coefficient of Variation = 8.198

Treatments found Significant at 5% level of Significance
CD(0.05)= 6.737

Triglycerides (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	349.600	116.533	5.951	3.24
Error	16	313.200	19.575	-	-
Total	19	-	-	-	-

Coefficient of Variation = 7.208

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 8.175 CD(0.05) = 5.932

Triglycerides (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	371.350	123.783	6.440	3.24
Error	16	307.200	19.200	-	-
Total	19	-	-	-	-

Coefficient of Variation = 7.166

Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 8.099 CD(0.05) = 5.871

Serum cholesterol (180 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	375.200	125.066	3.956	3.24
Error	16	506.000	31.625	-	-
Total	19	-	-	-	-

Coefficient of Variation = 4.140
Treatments found Significant at 5% level of Significance
CD(0.05)= 7.541

Serum cholesterol (242 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	250.550	83.516	6.126	3.24
Error	16	218.000	13.625	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.678
Treatments found Significant at 1% and 5% level of significance
CD(0.01) = 6.811 CD(0.05) = 4.941

Serum cholesterol (365 days)					
Source of variation	**Degrees of freedom**	**Sum of squares**	**MeanSum of squares**	**F cal**	**F tabulated**
Treatments	3	141.400	47.133	5.131	3.24
Error	16	146.800	9.175	-	-
Total	19	-	-	-	-

Coefficient of Variation = 2.188
Treatments found Significant at 5% level of Significance
CD(0.05)= 4.063