INFLUENCE OF DIETARY SUPPLEMENTATION OF CINNAMALDEHYDE AND CINNAMIC ACID ON PERFORMANCE OF VANARAJA CHICKEN

Thesis

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Livestock Production and Management

by

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DECLARATION

I, Thejanuo Rio, 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 had not been submitted by me for any research degree in any other university/institute.

This is being 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 **"Influence of dietary supplementation of cinnamaldehyde and cinnamic acid on performance of Vanaraja chicken"** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Livestock Production and Management is the record of research work carried out by Ms. Thejanuo Rio Registration No. Ph.D/LPM/00295 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 **" Influence of dietary supplementation of Cinnamaldehyde and cinnamic acid on performance of Vanaraja chicken"** submitted by Ms. THEJANUO RIO Admission No. Ph-278/19 Registration No. Ph.D/LPM/00295 to the NAGALAND UNIVERSITY in partial fulfillment 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 …….....

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LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORM
ANOVA	Analysis of variance
ad libitum	Freely; as much as
BIS	Bureau of Indian Standards
BW	Body weight
BWG	Body weight gain
CEO	Cinnamon Essential Oil
df	Degree of freedom
FCE	Feed Conversion Efficiency
FCR	Feed conversion rate/ratio
Fig	Figure
g	gram
g/dl	gram per deciliter
Hb	Haemoglobin
HDEP	Hen-Day Egg Production
HHEP	Hen–Housed Egg Production
LDL	Low Density Protein
HDL	High density protein
ICAR	Indian Council of Agricultural Research
i.e.	that is
INR	Indian Rupee

IMAR	International Market Analysis Research and Consulting
Kg	kilogram
mg/dl	milligram per deciliter
NCCLS	National Committee for Clinical Laboratory Standard
NEH	North Eastern Hill
ml	milliliter
mm	Millimeter
MSS	Mean Sum of Squares
PFAs	Phytogenic Feed Additives
PCV	Packed Cell Volume
%	Percentage
PI	Performance Index
SEM	Standard Error of Mean
SOV	Sources of Variance
SS	Sum of Squares

ABSTRACT

This research was aimed to assess the "**Influence of dietary supplementation of cinnamaldehyde and cinnamic acid on performance of Vanaraja chicken"**. A total of 120 day-old Vanaraja chicks (sexed female chick) were distributed into 6 treatments with 5 replications (4 birds per replicate) established in a randomized block design. The treatment consisted of: T_1 (control); T_2 (2.5g cinnamaldehyde)/kg of feed; T_3 (2.5g cinnamic acid)/kg of feed; T_4 (5g cinnamaldehyde)/kg of feed; T_5 (5g cinnamic acid)/kg of feed; and T_6 (2.5g cinnamaldehyde + 2.5 g cinnamic acid)/kg of feed. Up to the age of eight weeks, the birds were reared in deep litter system; following that, they were housed in cages using typical management techniques. The birds were fed with starter feeds from 0- 8 weeks, grower ration from 8- 20, and layer ration after 20 weeks till the experimental period. Initial body weight was recorded at day old and thereafter it was recorded fortnightly. FI (feed intake) and egg production were recorded daily. Blood was collected at 4^{th} and 8^{th} month for evaluation of blood constituents. At the end of the experiment, BW and mean BWG was highest in T_2 (3153.4 g and 183.0 g) group of the birds as compared to other treatments. The lowest mean FI was observed in T_5 (1486.0 g) group, and the best mean feed conversion efficiency were also found in the T_2 (14.65) group of the bird. Mortality and liveability did not differ among the groups; however, performance index was highest in T_2 (9.1) groups of the birds. Among the groups, early sexual maturity was observed in T_2 (125.4 days) group, and the highest egg production as well as better egg quality traits were observed in the T_2 group. In haematological parameters, the highest value of haemoglobin was recorded in T_5 (15.4%) group, and in PCV lowest value was recorded in T_2 (32.3%) group. Whereas, in

biochemical constituents of blood, T_4 groups observed lowest value in total cholesterol (100.7 mg/dl), LDL cholesterol (91.2 mg/dl) and triglyceride (84.3 mg/dl); meanwhile HDL was NS among the group. However, lowest glucose level was observed in T_5 (217.5 mg/dl) groups of the birds. The highest net profit per bird was recorded in T_2 (Rs 210) groups of the birds. The findings of this research thus indicated that the supplementation of cinnamaldehyde @2.5g/kg feed had significantly positive impact on overall performance in terms of egg production, egg quality traits and economy of rearing. Further, the haematological and biochemical constituents were also better in T_2 as compared to the control group. Finally, it can be concluded that supplementation of cinnamaldehyde @ 2.5g/kg of feed in the diet of Vanaraja chicken is beneficial and can be advocated for its supplementation in the diet of Vanaraja birds.

Key words: Vanaraja bird, Cinnamaldehyde, Cinnamic acid, growth performance, egg production, egg quality, blood parameters, net profit

CHAPTER I

INTRODUCTION

INTRODUCTON

Poultry is one of the most consumed meats in the world and has no religious taboo. This has made poultry farming one of the fastest growing businesses in the world. In Poultry farming, different type of domesticated birds are raised, viz. chickens, ducks, turkeys, Japanese quails and geese to produce meat and eggs for food (Amit, 2020). Ali *et al*. (2021) stated that poultry was the most consumed meat globally and in 2020, the production increased to 137 million tons. India is now one of the world's top producers of broiler meat and eggs. According to 20th Livestock Census, the poultry population has increased by 16.81 per cent i.e., 851.81million during 2019, which included a 45.78 per cent increase in backyard poultry (317.07 million) and an increase of 4.5 per cent in commercial poultry (534.74 million). The Indian poultry market was worth a combined INR 2,049 billion in 2019 due to popularity of both broilers and eggs (IMARC, 2020). India has the second largest population of the world with hunger problem and severely malnourished children in most parts of the country. As a result, the nation needs to increase its production of protein-rich food as a task in which poultry industry may prove particularly useful.

In Poultry production maximum recurring expenditure is made on feed and to minimize the total production cost different production and management methods had been practiced, i.e., methods of rearing, the inclusion of natural feed additives as well as better utilization of feed and feed wastage. The improved management practices resulted in a lower down in diseases and mortality incidences and produced a more profitable source of income. The use of poultry

feed is a great concern due to its residues in the product and also related to anti-microbial resistance. So, naturals supplement had been added in poultry diet to enhance the performance of the birds. PFAs (Phytogenic feed additives) have replaced many antibiotic growth promoters as natural alternatives since the natural antioxidants they contain have a good impact on the meat's quality, shelf life, and overall growth performance in poultry (Ali *et al*., 2021). Also, for the prevention of oxidation in processed meat products, different natural feed additives had been used such as essential oils, plant extracts, protein hydrolysates, vitamin E (tocopherols), vitamin C (ascorbic acid) and peptides (Ji *et al.*, 2021). This circumstance had led researchers to examine more on substitution of antibiotics and focus on developing sustainable dietary intervention to enhance the overall performance of the poultry. In fact, medicine herbs represented a very good alternative to antibiotics. For instance, according to Docic and Bilkei (2003), the plant extract used to replace an antibiotic had a good impact on FI, weight growth, utilization, and microbial fermentation in the intestine. The advantages of herbal extracts may include increased digestive secretions, improved food digestion and absorption, altered intestinal microbiota, immune system activation, and antibacterial properties, among other things (Coasta *et al*., 2007 and 2011). Also, Kumari *et al*. (2014) stated that the inclusion of various herbs such as neem leaf, sugar beet, coriander seed, and linseed meals showed a favorable impact on growth performance and carcass traits in broilers.

The Vanaraja is an improved dual-purpose multicolored backyard poultry developed by Project Directorate on Poultry, Hyderabad, for rural and tribal areas. The birds can be reared in different agroclimatic zones, have high general immune competence, perform well on low nutrients and produce more meat and good number of eggs about 120-140 eggs per annum in comparison to Desi chicken. The eggs of Vanaraja are brown in colour, higher in weight and bigger in size as

compared to Desi eggs and fetch a higher price in the market. The birds need six weeks of nursery management and later on, can be reared in cages as well as free range. Though it's an improved variety, more researchers are conducting different experiments to increase the productivity in terms of meat and eggs. Different management practices as well as varied natural feed additives have been used in the Vanaraja diet to enhance the overall performance of the bird. Patel *et al*. (2018) carried out research on the growth performance of the Vanaraja bird in different system of management and observed higher body weight gain in the deep litter system and significantly better FCR in semi intensive system of management. According to Swain *et al*. (2011), feeding Vanaraja laying hens a diet that included probiotics and yeast improved egg quality and overall profitability. According to Perween *et al*. (2016) Vanaraja's BWG and FCR were significantly affected when they were fed a feed high in protein and calories. Swain *et al*. (2017) discovered that supplementing Vanaraja laying hens' diet with 0.5 kg of *Moringa oleifera* leaf meal per 100 kg dramatically increased egg production, better FCR and lower feed cost. Singh *et al*. (2019) observed that the benefit-cost ratio was higher in Vanaraja as compared to local chickens. According to Joshi *et al*. (2020), the egg production, BW, and benefit-cost ratio of Vanaraja were significantly affected when 500 g of azolla was added to their diet per bird, each day.

Cinnamon (*Cinnamomum verum and Cinnamomum cassis*), belonging to the Lauraceae family is one of the most delicious and healthiest spices in the world. Cinnamon primarily contained chemical constituents such as volatile oils (eugenol, cinnamaldehyde, weitherhin, and cinnamic acid), proanthocyanidins mucilage, and diterpenes (Jayaprakasha *et al*., 2002). Most of cinnamon's health advantages are attributed to its high concentration of cinnamaldehyde. It had been found that cinnamaldehyde and eugenol had strong antibacterial, antifungal and

antioxidant characteristics (Abd-El-Hack *et al*., 2020). Ciftci *et al*. (2010) stated that cinnamon had antioxidant activity and improved the meat quality of broilers. Moreover, 200 ppm essential oil extracts from oregano, cinnamon and pepper improved digestibility in broilers (Hernandez *et al*., 2004). Liyanage *et al*. (2021) and Ribeiro-Santos *et al*. (2017) reported that cinnamon had great potential as natural anti-microbial, anti-inflammatory, and antioxidant components such as flavonoids, volatile oils, coumarins, curcuminoids, alkaloids, tannins, phenolics as well as other compounds in major amounts. Flavonoids observed in cinnamon, acted as antimicrobial agents in the poultry gut (Diarra and Malouin, 2014 and Iqbal *et al*., 2020). Additionally, Bonilla and Sobra, (2017) discovered that cinnamon's ethanolic extract has potent anti-microbial activity against strains of Salmonella aureus. Similarly, Mehdipour *et al*. (2013), Simsek *et al*. (2015) and Torki *et al*. (2015) observed that cinnamon oil had beneficial effects on FI and FCR in poultry. Devi *et al*. (2018) observed that broilers fed with cinnamon in the diet had better digestibility of nutrients. The aldehyde that gives cinnamon its flavor and smell is called cinnamaldehyde. About 90 per cent of the essential oil from cinnamon bark is cinnamaldehyde. It is utilized as a fungicide and an insecticide in agriculture due to its low toxicity and well-known characteristics. It is used in medicinal field because, by abridging vascular contractility, it stops the progression of hypertension in type 1 and 2 diabetes. The majority of cinnamaldehyde, which has undergone oxidation, is eliminated in urine as cinnamic acid. The 3-phenylprop-2-enoic acid that cinnamic acids produce is an organic aromatic compound with a benzene and carboxylic acid group. It is found in *Cinnamomum cassia*. It has a role as plant metabolite and is also a potential anticancer agent. Cinnamaldehyde is thought to improve the digestive system of broiler chickens by promoting digestion. According to Chowdhury *et al*. (2018), cinnamaldehyde stimulated salivary gland production, which enhanced the

digestion of broiler chicken by increasing the activity of pancreatic and intestinal enzymes. Sarica *et al*. (2009) stated that the inclusion of cinnamon essential oil at 1g per kg in Japanese quail diet had decreased lipid profile. Also, Gomathi *et al*. (2018) stated that meat cholesterol decreased as CEO was added in broiler diet. Furthermore, Yang *et al*. (2019) stated that broiler chicken fed a diet containing 100mg per kg CEO improved immunity and significantly increased cecal *Lactobacillus* and *Bifidobacterium* and decreased cecal *E.coli* making cinnamon essential oil a potential alternative to antibiotics for improving the boiler cecal microbiota. Similarly, cinnamon additives are used to extend the shelf life of meat as well as inhibit the pathogenic bacteria in the gut which enhanced the meat quality of poultry (Yaqoob *et al*. 2022). Therefore, as possible antibiotic alternatives, plant extracts and organic acids have been examined in the feed of poultry. However, research outcomes on the effectiveness of cinnamaldehyde and cinnamic acid in Vanaraja birds are scanty.

In view of the foregoing facts, the current research, entitled **"Influence of dietary supplementation of cinnamaldehyde and cinnamic acid on performance of Vanaraja chicken"** was undertaken with the objectives mentioned below:

1. To determine optimum level of inclusion of cinnamaldehyde and cinnamic acid in diet of Vanaraja chicken on various performance criteria
2. To study the effect of incorporation of cinnamaldehyde and cinnamic acid in diet of Vanaraja chicken on hematological and biological blood constituents.
3. To evaluate the economics of rearing Vanaraja birds fed with cinnamaldehyde and cinnamic acid.

CHAPTER – II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Application of antibiotic growth promoters in poultry diet had been banned globally which has led researchers to find safer and natural alternatives. Hence, natural products such as flaxseed, cinnamon, garlic, turmeric, ginger, etc. are supplemented in poultry diet as an alternative to growth promoters. Many researches have been carried out using cinnamon as a dietary supplement in poultry diet and had shown positive benefit on performance of the birds. Comprehensive overviews of the past relevant literature in supplementation of cinnamon in poultry diet by different researcher are presented bellowed under different sub-heads.

2.1 Effect of cinnamaldehyde and cinnamic acid in poultry diet on various productive and reproductive traits

2.1.1 Body weight and growth rate

Jamroz and Kamel (2002) revealed that broiler fed with combination of essential oils namely capsaicin, carvacrol and cinnamaldehyde showed higher weight gain as compared to control group.

Lee *et al*. (2003) observed that inclusion of cinnamaldehyde in feed did not affect growth performance in female broiler chickens.

Lee *et al*. (2004) found that inclusion of cinnamon to the diet of broiler has significantly enhanced their growth performance.

Muhl and Liebert (2007) stated that supplementation of commercial phytogenic feed additives containing carvacrol, capsicum oleoresin,

cinnamaldehyde, chelerythrin and alkaloids sanguinarin had no significant effect on the performance of broiler chicks.

Al-Kassie (2009) reported that broiler fed with cinnamon essential oil at 200 mg per kg feed had significantly higher body weight gain than the control group.

Ciftci *et al.* (2009) observed that inclusion of Cinnamon essential oil at 500 mg per kg of feed improved body weight gain of the birds as compared to the control group.

Toghyani *et al.* (2011) added cinnamon powder to broiler diet at 2 g per kg and summarized that cinnamon supplementation had signifantly higher broiler body weight as compared to control group.

Molla *et al.* (2012) supplemented polyherbal extract (nishyinda leaf powder, black pepper and cinnamon) 1ml per liter in drinking water and reported significant increase in final live weight and weight gain of broilers compared with control group.

Tonbak and ciftci (2012) observed that inclusion of cinnamon oil (*Cinnamomum zeylanicum L*.) to quail diets at 250 and 500 mg per kg feed had no significant effect on the body weight of the quail.

Mehdipour *et al*. (2013) displayed that addition of cinnamon oil at 200 mg per kg feed significantly improved body weight gain of quail as compared to control.

Sampath and Atapattu (2013) reported that incorporation of cinnamon powder at different level (0.1, 0.2, 0.3, 0.4 and 0.5 per cent) in broiler diet had significant impact on body weight and body weight gain of the bird, where

application of 0.3 percent cinnamon powder showed the best result as compared with all the treatment and the control group.

Hossian *et al*. (2014) found that supplementation of cinnamon, black cumin and chilli powder at 1 per cent in the diet had significantly better growth performance over the control group.

Safa-Eltazi (2014) reported that inclusion of different level cinnamon powder (3, 5 and 7 per cent) to broiler diet significantly ($P< 0.05$) enhanced the body weight and body weight gain of the bird compared to the control group.

Shirzadegan (2014) revealed that supplementation of different concentration of cinnamon powder in the diet of broiler chicken, especially at the level of 0.05per cent resulted in higher body weight and body weight gain than the other group.

Symeon *et al*. (2014) reported that cinnamon oil supplementation in diet of broilers did not affect body weight of the birds.

Hussein *et al*. (2015) found that inclusion of cinnamon powder on broiler diet increased the body weight gain of the bird when compared with the control group.

Gerzilov *et al*. (2015) observed that at the end of the experiment (52 weeks of age) the chickens supplemented with herbal mixture in their diet had no significant difference at the live weight of the bird.

Torki *et al.* (2015) reported that single and combined effect of zinc and cinnamon essential oil in diet of laying hen under cold stress condition had no effect on body weight of the bird.

Abudabos *et al*. (2018) observed that inclusion of phytobiotic containing carvacrol, cinnamaldehyde and capsaicin in broiler diet had no significant changes on body weight gain among the treatment and control group.

Ali *et al*. (2018) reported that inclusion of cinnamon powder in broiler diet had lower body weight and body weight gain when compared to the control group.

Devi *et al*. (2018) displayed that inclusion of cinnamon essential oil with ajwain essential oil in broiler diet significantly improved body weight of birds.

Gupta *et al*. (2018) found that supplementation of cinnamon powder in broiler diet had higher body weight and body weight gain compared to the control group.

Mehdipour and Afsharmanesh (2018) reported that inclusion of cinnamon powder in quail diet had no significant effect on body weight gain of the bird.

Ahmed *et al*. (2019) observed that inclusion of cinnamon oil in Japanese quail diet had no significant effect on body weight and body weight gain of the bird.

Chowlu *et al*. (2019) reported that dietary supplementation of cinnamon powder in broiler chicken irrespective of level had no significant ($P>0.05$) effect on the body weight and weight gain.

Gaikwad *et al*. (2019) observed that supplementation of cinnamon powder at 10g, 20g and 30g per kg of feed had significantly increased the body weight but there was no significant effect on weight gain of broiler as compared to control group.

Suwarta and Suryani (2019) reported that inclusion of turmeric and cinnamon powder mixture in quail diet had no significant difference in body weight compared to the control group.

Behera *et al*. (2020) reported higher body weight and body weight gain for broiler fed diet containing 1 per cent cinnamon powder compared to the control group.

Krauze *et al*. (2020) reported that inclusion of probiotic containing cinnamon oil at 0.25 ml per liter of drinking water had no significant impact on body weight and body weight gain of broiler bird compared with the control group.

Moustafa *et al*. (2020) found that inclusion of cinnamon oil at 100mg/kg diet had significantly enhanced body weight and body weight gain of broiler bird compared with the control group.

Soliman and Kamel (2020) reported that inclusion of 1 per cent cinnamon per kg feed in layer ration had no significant difference on body weight gain of layer hen on comparison with control group.

Wasman and Mustafa (2020) observed that supplementation of 1ml cinnamon oil per kg quail diet had significantly higher body weight compared to the control group.

Krauze *et al*. (2021) reported that inclusion of phytobiotic containing cinnamon oil had significantly increased the body weight of broiler chicken as compared to control group.

Odutayo *et al*. (2021) reported that inclusion of cinnamon powder at 4 per cent per kg feed on broiler diet had higher body weight (2042.68±80.08 g/bird)

and body weight gain (1996.2±79.93 g/bird) of broiler bird compared with the control group(1939±91.64 g/bird and 1892.17±91.05 g/bird).

Adedeji *et al*. (2022) reported that incorporation of cinnamon powder at 4 g per 4 litres of water had significantly higher body weight and body weight gain of cockerel bird on comparison with the control group.

Alqhtani *et al*. (2022) observed inclusion of cinnamon on broiler diet had no significant impact on BW and BWG of the bird on comparison to the control group.

Saied *et al*. (2022) found that inclusion of cinnamon oil in broiler fed diet had significantly improved the body weight and body weight gain in comparison with control group.

Qaid *et al*. (2022) observed no significant difference in body weight but body weight gain was significantly higher on control group compared with cinnamon supplemented group.

Islam and Nishibori (2023) found that inclusion of cinnamon on broiler diet had no significant difference on body weight of the bird among the cinnamon supplemented and control group.

Hussein *et al*. (2023) reported that inclusion of cinnamon oil in broiler diet significantly increased body weight and body weight gain of the birds when compared to the control group.

Nath *et al*. (2023) observed that supplementation of cinnamon oil 100mg per kg feed had significantly increased the body weight gain of broiler bird compared with the control group.

2.1.2 Feed intake and feed conversion efficiency

Jamroz and Kamel (2002) reported that broiler fed with combination of essential oils namely capsaicin, carvacrol and cinnamaldehyde showed better feed conversion ration as compared to control group.

Lee *et al*. (2003) founded that inclusion of cinnamaldehyde in female broiler diet had no significant effect on feed intake and feed conversion rate, but water intake was decreased significantly.

Hernandez *et al*. (2004) reported that broiler feed containing essential oil extract from cinnamon, pepper and oregano had no significant influence on the feed intake and feed conversion rate of the birds.

Al-Kassie (2009) founded that supplementation of 200 ppm essential oil from a combination of thyme and cinnamon had significant impacts on feed intake and feed conversion rate as compared to the control group.

Ciftci *et al*. (2009) pointed out that broiler diet supplemented with 500 ppm cinnamon oil showed better result in feed conversion efficiency in comparison with avilamycin (antibiotic) groups and the control group.

Kang *et al*. (2010) reported that supplementation of fermented apple pomace and cinnamon in laying hen diet had no significant impact on feed intake and feed conversion ratio compared to the control group.

Koochaksaraie *et al*. (2011) reported that inclusion of cinnamon powder in broiler diet had no significant difference in feed intake and feed conversion ratio from 7-49 days of age when compared to control group.

Molla *et al*. (2012) reported that supplementation of polyherbal extract (nishyinda leaf powder, black pepper and cinnamon) 1 ml per liter of drinking water increased feed intake but no significant difference was observed in feed conversion ratio among the control and treatment group.

Tonbak and Ciftci (2012) indicated that inclusion of cinnamon oil (Cinnamomum zeylanicum L.) to the diets of quail at concentration of 250 and 500 mg per kg had no significant effect on feed conversion rate of quail.

Mehdipour *et al*. (2013) showed that inclusion of cinnamon oil at 200 mg per kg in quail diet significantly influence feed conversion ratio compared to control group, however feed intake was not affected.

Sampath and Atapattu (2013) reported that incorporation of cinnamon powder at different level (0.1, 0.2, 0.3, 0.4 and 0.5 per cent) on broiler diet had significantly reduced feed intake and improve feed conversion ratio of the bird, compared with the control group.

Hossian *et al.* (2014) observed that supplementation of cinnamon at 1per cent on broiler ration had no significant impact on feed intake but better feed conversion ratio of the bird was found in cinnamon treatment group compared with the control group.

Safa-Eltazi (2014) reported that inclusion of different level cinnamon powder (3, 5 and 7 per cent) to broiler fed diet had higher feed intake and better feed conversion ratio compared to the control group.

Symeon *et al.* (2014) reported that cinnamon oil supplementation in diet of broilers did not affect feed intake and feed conversion ratio of the birds.

Gerzilov *et al*. (2015) observed that at the end of the investigation period the chickens supplemented with herbal mixture in their diet had better feed conversion ratio than the control group.

Hussein *et al*. (2015) found that inclusion of cinnamon powder on broiler diet increased the feed intake and improved feed conversion ratio of the bird when compared with the control group.

Simsek *et al*. (2015) observed that inclusion of cinnamon oil 200ppm, rosemary oil 200ppm or combination of cinnamon and rosemary oil of 100ppm each had no effect on feed intake but feed conversion rate improved significantly by the use of 200ppm cinnamon oil.

Torki *et al*. (2015) found that inclusion cinnamon oil at 40 mg/kg feed of laying ration under cold stress condition had no effect on feed intake but improved feed conversion rate of the bird compared to control group.

Pathak *et al*. (2016) founded that broiler feeding on diets treated with enramycin (125 mg per kg), or a combination of calcium formate and cinnamaldehyde (500 mg per kg) had significantly improved feed conversion rate compared with the control group.

Abudabos *et al*. (2018) observed that inclusion of phytobiotic containing carvacrol, cinnamaldehyde and capsaicin in broiler diet had no significant changes on feed intake and feed conversion ratio among the treatment and control group. Also, no significant changed was found on production efficiency factor among the groups.

Ali *et al*. (2018) reported that inclusion of cinnamon powder in broiler diet had lower feed intake and no significant difference in feed conversion ratio when compared to the control group.

Gupta *et al*. (2018) found that supplementation of cinnamon powder in broiler fed diet had higher feed intake but better feed conversion ration when compared to the control group. Also, cinnamon powder supplemented group had better performance index when compared to the control group.

Mehdipour and Afsharmanesh (2018) reported that inclusion of cinnamon powder in quail diet had no significant effect on feed intake but supplementing 200 mg cinnamon powder had significant impact on feed conversion ratio compared to the control group.

Ahmed *et al*. (2019) observed that inclusion of cinnamon oil in Japanese quail diet had no significant difference on feed intake and feed conversion ratio compared with those fed basal diet.

Chowlu *et al*. (2019) reported that dietary supplementation of cinnamon powder in broiler chicken irrespective of level had no significant ($P>0.05$) effect on the feed intake and feed conversion efficiency over control group.

Gaikwad *et al*. (2019) observed that supplementation of cinnamon powder in broiler diet lower the feed intake and improved feed conversion rate as compared to control group.

Santos *et al*. (2019) reported that incorporation of cinnamon powder in the diet of Japanese laying quail had no significant effect ($P>0.05$) on the feed intake of the bird compared with the control group.

Suwarta and Suryani (2019) reported that inclusion of turmeric and cinnamon powder mixture in quail diet reduced the feed intake and significantly improved feed conversion ration compared to the control group.

Abo Ghanima *et al*. (2020) reported that feed intake and feed conversion rate were significantly ($P<0.05$ or 0.01) better in rosemary and cinnamon groups compared to control group.

Behera *et al*. (2020) reported higher feed intake and better feed conversion ratio for broiler fed diet containing 1 per cent cinnamon powder compared to the control group.

Krauze *et al*. (2020) reported that inclusion of probiotic containing cinnamon oil at 0.25 ml per liter of drinking water had no significant impact on feed intake and feed conversion ratio of broiler bird compared with the control group.

Moustafa *et al*. (2020) found that inclusion of cinnamon oil at 100mg/kg diet had significantly increased feed intake and improved feed conversion ratio of broiler bird compared with the control group.

Wasman and Mustafa (2020) observed that supplementation of 1ml cinnamon oil per kg quail diet had significantly higher feed intake and better feed conversion ratio compared to the control group.

Dosoky *et al*. (2021) observed that incorporation of cinnamon in Japanese quail diet had no significant difference in feed intake but feed conversion ratio was significantly better in cinnamon treatment group in comparison with control group.

Krauze *et al*. (2021) reported that inclusion of phytobiotic containing cinnamon oil had significantly improved feed conversion ratio of broiler chicken as compared to control group.

Odutayo *et al*. (2021) reported that inclusion of different level of cinnamon powder on broiler diet had reduced the total feed intake and improved the feed conversion ratio of the bird compared with the control group.

Adedeji *et al*. (2022)[a] reported that incorporation of different level of cinnamon powder (2.5, 3.0, 3.5 and 4.0 g per 4 liters of water) had significantly higher feed intake compared with the control group. Also, control group had better feed conversion ratio compared with the cinnamon supplemented group.

Alqhtani *et al*. (2022) observed inclusion of cinnamon on broiler diet had no significant impact on FI and FCR of the bird on comparison to the control group.

Saied *et al*. (2022) found that inclusion of cinnamon oil in broiler fed diet had decreased the feed intake and significantly improved feed conversion ratio in comparison with control group.

Qaid *et al*. (2022) observed no significant difference in feed intake in broiler bird but feed conversion ratio was significantly higher in control group compared with the cinnamon supplemented group. Also, production efficiency group was significantly higher in control group when compared with cinnamon supplemented group.

Islam and Nishibori (2023) found that inclusion of cinnamon on broiler diet had no significant difference on feed intake and FCR of the bird among the cinnamon supplemented and control group.

Hussein *et al*. (2023) reported that dietary supplementation of cinnamon oil on broiler ration had significantly reduced the feed intake and had positive effect on feed conversion ratio compared with the control group. Overall, diet containing cinnamon oil had better performance index when compared to the control group.

Nath *et al*. (2023) observed that supplementation of cinnamon oil on broiler ration had significantly reduced the feed intake and significantly better feed conversion ratio of the bird compared with the control group. Hence, cinnamon supplemented group enhanced the performance efficiency index of the bird.

2.1.3 Mortality

Ebrahim *et al*. (2013) found that inclusion of cinnamon, red pepper, ginger and cumin on broiler diet did not affect the mortality percentage among the treatment and control group.

Safa-Eltazi (2014) reported that inclusion of different level cinnamon powder (3, 5 and 7 per cent) to broiler fed diet had no significant ($P>0.05$) effect on the mortality rate of the bird.

Symeon *et al*. (2014) observed that incorporation of cinnamon oil in diet of broilers had no influence in mortality rate.

Gerzilov *et al*. (2015) reported that death rate in control chickens until 7 weeks of age was significantly higher than the experimental chicken (18.33% vs 1%).

Mehdipour and Afsharmanesh (2018) reported that inclusion of cinnamon powder in quail diet had no influence in mortality rate among the group.

Chowlu *et al*. (2019) observed that dietary supplementation of cinnamon powder in broiler chicken, had no mortality irrespective of treatment groups.

Krauze *et al*. (2020) reported that inclusion of probiotic containing cinnamon oil at 0.25 ml per liter of drinking water had no significant difference on mortality rate of broiler bird compared with the control group.

Krauze *et al*. (2021) reported that inclusion of phytobiotic containing cinnamon oil had no significant impact on mortality rate of broiler chicken among the treatment group and the control group.

Odutayo *et al*. (2021) reported that inclusion of different level of cinnamon powder on broiler diet had no major effect between the treatment groups and control group on the mortality rate of the bird.

Adedeji *et al*. (2022[a]) observed that cockerel chicken fed with cinnamon powder at different level in the diet had lower mortality rate compared to the control group.

Islam and Nishibori (2023) found that inclusion of cinnamon on broiler diet had no significant difference on mortality per cent of the bird among the cinnamon supplemented and control group.

2.1.4 Reproductive traits

Kang *et al*. (2010) reported that supplementation of fermented apple pomace and cinnamon in laying hen diet had no significant impact on egg production, egg weight, egg mass and haugh unit compared to the control group.

Vali *et al*. (2013) found that the cinnamon and thyme significantly improved egg quality parameters in Japanese quail.

Gerzilov *et al*. (2015) observed that supplementation of herbal combination in the diet had not influenced the egg productivity, but at the end of the investigation period the chickens from the experimental group had higher egg laying capacity. Also the average egg weight increased gradually in both groups from 42-43 g and by the end of the experiment attained 66-67 g. There was also no significant difference in the egg yolk cholesterol level between both groups($P > 0.05$).

Torki *et al*. (2015) reported that single and combined effect of zinc and cinnamon essential oil in diet of laying hen under cold stress condition had positive effect on Hen-day production, egg weight and egg mass. Also, incorporation of cinnamon essential oil at 40mg/kg feed increases the value of egg index but had no significant changed on Haugh unit among treatment group and control group.

Simsek *et al*. (2015) reported that inclusion of cinnamon oil 200ppm, rosemary oil 200ppm or combination of cinnamon and rosemary oil of 100ppm each had no effect on egg weight and body weight at onset of egg production. At the end of the experiment, there was no significant difference on albumen rate, yolk rate and shape index. Also, all the treatment significantly improved fertility, but not hatchability.

Vali and Mottaghi (2016) observed that dietary supplementation of cinnamon (*Cinnamomum verum)* and thyme (*Thymus vulgaris*) powder in Japanese quails significantly ($P<0.05$) increased egg shell weight and egg shell thickness compared to the control group.

Bastos *et al*. (2017) observed that inclusion of cinnamon powder had significant difference on feed conversion per mass of egg but there was no

significant difference on egg weight, percentage of yolk, shell and albumen among cinnamon supplemented group and control group.

Santos *et al*. (2019) reported that incorporation of cinnamon powder in the diet of Japanese laying quail had no significant effect (P>0.05) on parameters like egg mass, egg weight, albumen height, Haugh unit, yolk weight, albumen weight, proportion of yolk and proportion of albumen of the bird compared with the control group.

Suwarta and Suryani (2019) reported that inclusion of turmeric and cinnamon powder mixture in quail diet had significantly increased egg production, egg weight, yolk weight, egg white weight and decreased egg yolk cholesterol compared to the control group.

Abo Ghanima *et al*. (2020) reported that supplementation of rosemary and cinnamon essential oil in laying hen diet showed significantly positive effects on hen performance, egg production and weight, and egg quality traits.

Soliman and Kamel (2020) reported that inclusion of 1 per cent cinnamon per kg feed in layer ration had significantly increase the egg weight compared with the control group, however there was no significant changes on egg production, egg mass, yolk percentage, albumen percentage, shell percentage and yolk cholesterol among the cinnamon supplemented group and control group.

Wasman and Mustafa (2020) observed that supplementation of 1ml cinnamon oil per kg quail diet had significantly higher egg weight compared to the control group.

Dosoky *et al*. (2021) observed higher egg weight at onset pf egg production, laying rate, egg number and egg mass in cinnamon supplemented

group but there was no significant effect in egg weight, albumen weight, albumen percentage, yolk weight, yolk percentage, yolk index and egg shell percentage in Japanese quail on comparison with control group. Yolk cholesterol was significantly lower in cinnamon supplemented group compared to the control group.

Sulaiman and Adedokun (2021) reported that inclusion of cinnamon powder at 0.4g per 4 litres of water significantly increased the values of egg weight, egg mass, albumen weight and yolk weight compared with the control group.

2.2. Blood Haematology and Biochemical Constituents

Lee *et al*. (2003) found that feeding of thymol, cinnamaldehyde or CRINA poultry did not affect micronutrient digestibility or plasma lipid in female broiler chicken.

Kang *et al*. (2010) reported that supplementation of fermented apple pomace and cinnamon in laying hen diet had no significant difference on glucose, total cholesterol and triglyceride compared to the control group.

Koochaksaraie *et al*. (2010) observed that inclusion of different level (250, 500, 1000 and 2000 mg) of cinnamon powder per kg diet in broiler chicks had no significant difference among the treatment and control group.

Koochaksaraie *et al.* (2011) reported that supplement of cinnamon powder on broiler diet had significant increase in glucose level as well as triglyceride level compared with the control group. However, there was no statistical difference on cholesterol level among the treatment group and control group.

Toghyani *et al.* (2011) reported that broiler diet supplemented with cinnamon had no significant effect on triglyceride, total cholesterol, LDL, HDL and haemoglobin but value of triglyceride, total cholesterol, LDL was lower than the control group and HDL as well as haemoglobin value was higher than control group.

Sampath and Atapattu (2013) reported that incorporation of cinnamon powder at different level (0.1, 0.2, 0.3, 0.4 and 0.5 per cent) on broiler diet had increased the cholesterol level compared with the control group.

Hossian *et al*. (2014) observed that supplementation with 1per cent cinnamon on broiler diet had significant ($P<0.05$) decreased cholesterol and glucose level of the bird compared with the control group.

Shirzadegan (2014) reported that inclusion of cinnamon powder in broiler diet significantly decreased the glucose level, but no significant difference was observed in cholesterol, triglyceride and LDL.

Gerzilov *et al*. (2015) observed that the herbal mixture supplement significantly decreased the blood serum cholesterol and triglyceride level at 7 ($P<0.001$) and at 52 weeks ($P<0.05$) of age.

Hussein *et al*. (2015) found that inclusion of cinnamon powder on broiler diet reduced glucose, cholesterol and triglyceride level of the bird when compared with the control group.

Torki *et al*. (2015) reported that incorporation of cinnamon oil at 40mg/kg feed in layer ration lowered the level of cholesterol, glucose and triglyceride when compared with the control group.

Bastos *et al*. (2017) reported that inclusion of cinnamon on quail diet had no significant effect on glucose and cholesterol level, but triglyceride was significantly higher on cinnamon supplemented group on comparison with control group.

Abudabos *et al*. (2018) observed that inclusion of phytobiotic containing carvacrol, cinnamaldehyde and capsaicin in broiler diet had no significant ($P > 0.05$) difference on glucose level and triglyceride level among the treatment and control group.

Ali *et al*. (2018) observed that inclusion of 5 per cent cinnamon powder in broiler fed diet had the lowest glucose level, cholesterol level and LDL level and 3 per cent cinnamon powder had the lowest HDL level compared to the control group.

Abo Ghanima *et al.* (2020) reported that supplementation of cinnamon essential oil in laying hen diet had no significant impact on haemoglobin and pack cell volume but lower cholesterol level compared to the control group.

Krauze *et al*. (2020) reported that inclusion of probiotic containing cinnamon oil at 0.25 ml per liter of drinking water had no significant difference on haemoglobin level but significantly lowered the level of total cholesterol and low density cholesterol on the bird. However, high density cholesterol level increased on cinnamon oil supplemented group when compared with the control group.

Moustafa *et al*. (2020) found that inclusion of cinnamon oil at 100mg/kg diet had significantly lowered the level of cholesterol, triglyceride and low-density lipoprotein cholesterol but significantly increased high-density lipoprotein cholesterol level of broiler bird compared with the control group.

Soliman and Kamel (2020) reported that inclusion of 1 per cent cinnamon per kg feed in layer ration had no significant difference on triglyceride, total cholesterol, HDL and LDL value compared with the control group, however numerically triglyceride (117.7±9.48), total cholesterol (132.5±3.72) and LDL (58.7±4.01) value was lowered than control group but HDL value in cinnamon supplement group (73.8±1.66) was higher than control group (67.3±3.39).

Dosoky *et al*. (2021) observed that incorporation of cinnamon in Japanese quail diet lowered the values of triglyceride, cholesterol, HDL and LDL compared with the control group.

Krauze *et al*. (2021) reported that inclusion of phytobiotic containing cinnamon oil had significantly lowered the level of total cholesterol and LDL but increased HDL level in broiler chicken as compared to control group.

Odutayo *et al*. (2021) reported that inclusion of cinnamon powder in broiler diet had no significant impact on the level of pack cell volume and haemoglobin when compared to the control group. Also, supplementation of different level of cinnamon powder (2, 4, 6 and 8 per cent per kg feed) reduced the level of triglyceride and total cholesterol on comparison with the control group.

Adedeji *et al*. (2022[b]) reported that incorporation of cinnamon powder on cockerel chicken diet had significantly reduced haemoglobin level compared with control group. However, 1.0g and 2.0g cinnamon powder per 4 liter of water reduced the cholesterol level (45.73 mg/dl and 43.18 mg/dl), but 0.5g and 1.5g cinnamon powder per 4 liter of water increased the cholesterol level (60.21 mg/dl and 64.01 mg/dl) on comparison with the control group (47.67 mg/dl).

Alqhtani *et al*. (2022) observed inclusion of cinnamon on broiler diet had no significant impact on glucose and cholesterol value; however cinnamon supplemented group had slightly lower value compared to the control group.

Saied *et al*. (2022) found that inclusion of cinnamon oil in broiler fed diet had no significant changes in Haemoglobin but higher level of cinnamon oil (1000 and 1500 mg per kg feed) significantly increased packed cell volume in comparison with cinnamon oil at 500mg per kg feed and control group. Also, cinnamon oil supplemented treatment group had lower values of total cholesterol, triglyceride, low density lipoprotein but higher values of high density lipoprotein compared to the control group.

Facchi *et al*. (2023) observed that supplementation of carvacrol and cinnamaldehyde on broiler diet had no significant difference on the cholesterol level among the treatment and control group.

Hussein *et al*. (2023) reported that dietary supplementation of cinnamon oil on broiler ration had significantly lowered total cholesterol and LDL level but increased HDL level when compared with the control group.

Islam and Nishibori (2023) found that inclusion of cinnamon on broiler diet had no significant difference on lipids profile of the blood such as total cholesterol, triglyceride, HDL and LDL level of the bird among the cinnamon supplemented and control group.

2.3 Economics of Rearing

Molla *et al*. (2012) reported that supplementation of polyherbal extract (nishyinda leaf powder, black pepper and cinnamon) 1ml per liter in drinking water of broiler fetched more profit as compared to the control group.

Hossian *et al*. (2014) observed that supplementation with 1 per cent cinnamon in broiler diet had significantly more profit per bird and benefit cost ratio compared to control group and can be used as a good alternative of antibiotics in broiler diet.

Safa-Eltazi (2014) revealed that diet supplemented with 5 per cent cinnamon powder in the broiler diet had higher profitability ratio as compared to the control group.

Singh *et al*. (2014) reported that dietary inclusion of cinnamon powder at 0.05 percent level can be used as a natural alternative to antibiotic growth promoters in respect of cost.

Chowlu *et al*. (2019) observed that there was higher net profit per unit of weight in control group as compared to cinnamon supplement groups.

Gaikwad *et al*. (2019) reported that supplementation of cinnamon powder in broiler diet was more profitable than control group.

Nath *et al*. (2022) observed that maximum net profit per kg bird was in cinnamon oil supplemented group compared to control group.

Islam and Nishibori (2023) found that inclusion of cinnamon on broiler diet had no significant difference on net profit of the bird among the cinnamon supplemented and control group.

CHAPTER – III

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was carried out to study the growth performance, feed intake, feed conversion rate, mortality, performance index, reproductive traits, egg quality traits, haematological and biochemical constituents and economics of rearing Vanaraja birds provided with cinnamaldehyde and cinnamic acid supplemented diet following scientific and standard management practices.

3.1 Location of work

The present study was conducted in the Instructional farm (Poultry Unit) of the Department of Livestock Production and Management, SAS-Nagaland University, Medziphema Campus, Nagaland. The farm is located at 93.20^0 E to 95.15^0 longitude and latitude between 25.6^0N at an elevation of 310 meters above mean sea level.

3.2 Preparation of the brooder house:

Before the arrival of chicks, the brooder house was sanitized through proper disposal of the waste materials like faeces, leftover feeds, dirt etc. Feeders and drinkers to be used were washed and cleaned. Adequate ventilation and lighting were ensured through doors, and wire netting wall. Disinfectant such as lime powder was used in the floor; also, kerosene oil was applied at the corners of the brooder house to avoid anti-disinfestations. Potassium permanganate was used in the footbath which is located at the entrance of the brooder house. After disinfection of the brooder house, the floor of the house was covered with rice husk and saw dust as litter material with a depth of 4-5 inch. Newspaper was placed above the litter material to prevent the chicks from picking the litter material as well as prevention from any injuries.

3.3 Experimental birds:

A total of 120 day-old Vanaraja chicks (sexed female chicks) were taken for the experiment which were procured from ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema, Nagaland. On arrival, the chicks were weighed in group consisting of twenty chicks and were randomly allocated to one of the dietary treatment groups. Each treatment group consisted of five replicates with four birds each under randomized block design. The birds were offered standard layer starter, grower and layer finisher diet. The chick were fed as per BIS (2007)

3.4 Cinnamaldehyde and cinnamic acid:

Cinnamaldehyde and cinnamic acid were purchased from Healthgate, New Delhi and was added in the layer diet as feed supplement according to the desired requirement for the experiment.

3.5 Experimental Diet:

The standard layer ration was procured from a reputed commercial feed store i.e. M/S. S.S. Poultry Karbi Anglong, Assam and M/S. Theja Store, Medziphema, Nagaland. The birds of treatment group 1 (Control T_1) were provided chick feed from 0 to 8 weeks, grower feed from 9 to 20 weeks and layer feed from 21 to 34 weeks. The birds of other treatment group were also offered the same standard layer ration as in T_1 but supplemented with cinnamaldehyde @2.5g ($T_{2)}$, cinnamaldehyde @5g (T_4), cinnamic acid @2.5g (T_3), cinnamic acid @5g (T_5) and cinnamaldehyde @2.5g + cinnamic acid @2.5g (T_6) per kg feed. Feeds were weight daily so as to ensure *ad libitum* feeding to the birds. Water is essential commodity in poultry production so fresh and clean was provided *ad libitum* throughout the experimental period. The birds were raised under deep litter up to 8 weeks. Thereafter, they were shifted in laying cages for a period of

34 weeks in treatment and replication wise and maintained under uniform standard management practices.

3.5.1 Brooding and rearing

Brooding management was provided to the chicks generally up to 6 weeks of age as chicks requires extra heat at this stage due to their ill-developed thermoregulatory mechanism. Six hover brooders with electric bulb (60 watts bulb) as source of heat were used for brooding of the chicks and metal sheet were used as brooder guard. Temporary partitions were made, and the experimental birds were reared in six different compartments as per different level of feeding experiment. Prior to the arrival of the chicks, the temperature of the brooder was maintained at 95^{o}F (37.5^{o}C) for 24 hours with the help of four 60 watt bulbs and then the temperature was reduced at the rate of 5^{o}F successive week until the room temperature of 60^{o}F-70^{o}F (21^{o}C) was reach or until the chicks was fully feathered. The wire netted wall of the brooder house was covered with gunny bags in order to check the entry of hot or cold wind inside the brooder house to maintain the required temperature. The drinkers were checked daily for spillage and leaking of water on the litter material. Turning of litter was done at regular intervals to prevent dampness in the house. After the completion of 8 weeks, the birds were transferred to the layer cages.

3.5.2 Feed and watering

On the arrival, the chicks were put on the brooder gently and provided with electrolytes water to give energy and to reduce the transportation stress caused due to long journey or inclement weather conditions. To ensure all the chicks are drinking water, the chicks were held by hand and their beaks were dipped in water. The chicks were weighed in batch of 20 in numbers and were randomly housed in the compartment. After placing the chicks in the brooder, maize grit was offered on the newspaper and from the 2nd day onwards, the usual chick feed

Plate – 1

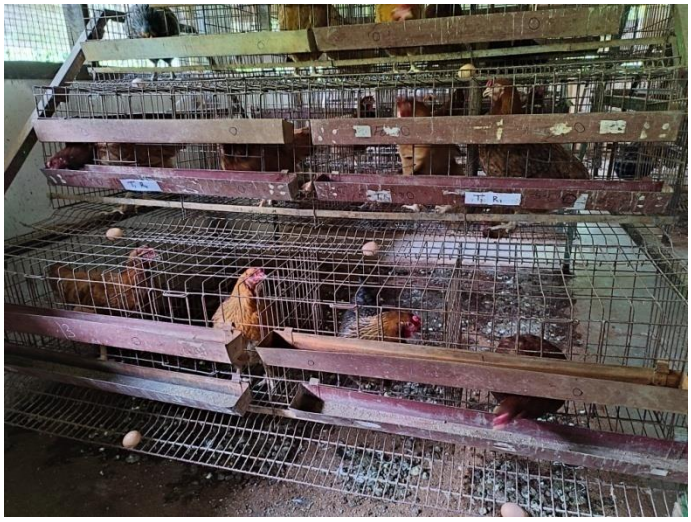
Brooding and rearing of experimental birds

Day-old chicks

Brooding in deep litter system

Weighing of bird

Rearing of bird in cage



Laying of egg in cage

Egg collection

Weighing of egg

were given to the chicks. The birds received feed and water *ad libitum* during the experimental period. Two drinkers were placed at the edge of the brooder with two linear feeders placed opposite to each other in each compartment in the brooder house. Chick feed was fed form 0-8weeks, grower feed from 9-20weeks and layer feed from 21-34 weeks. To prevent feed wastage, the feeders were filled up to ¾th level. Measured quantity of feed was given daily at 6 a.m. and 2 p.m. The leftover feed was measured on the next day to calculate daily feed consumption of the bird.

3.5.3 Lighting and Health

Extra heat was provided to the birds for 0-8 weeks but no extra heat was required during growing period i.e. 9 -20 weeks because if extra light was provided it may lead to early maturity of pullets resulting in production of more number of smaller sized eggs, incidence of prolapsed and egg bound condition. Twelve hours natural day light was sufficient for them. During laying period, 16-17 hours light duration was maintained. On the other hand, 7 hours complete darkness in the layer house was provided to allow the bird to take rest. Vaccination schedule is as follows.

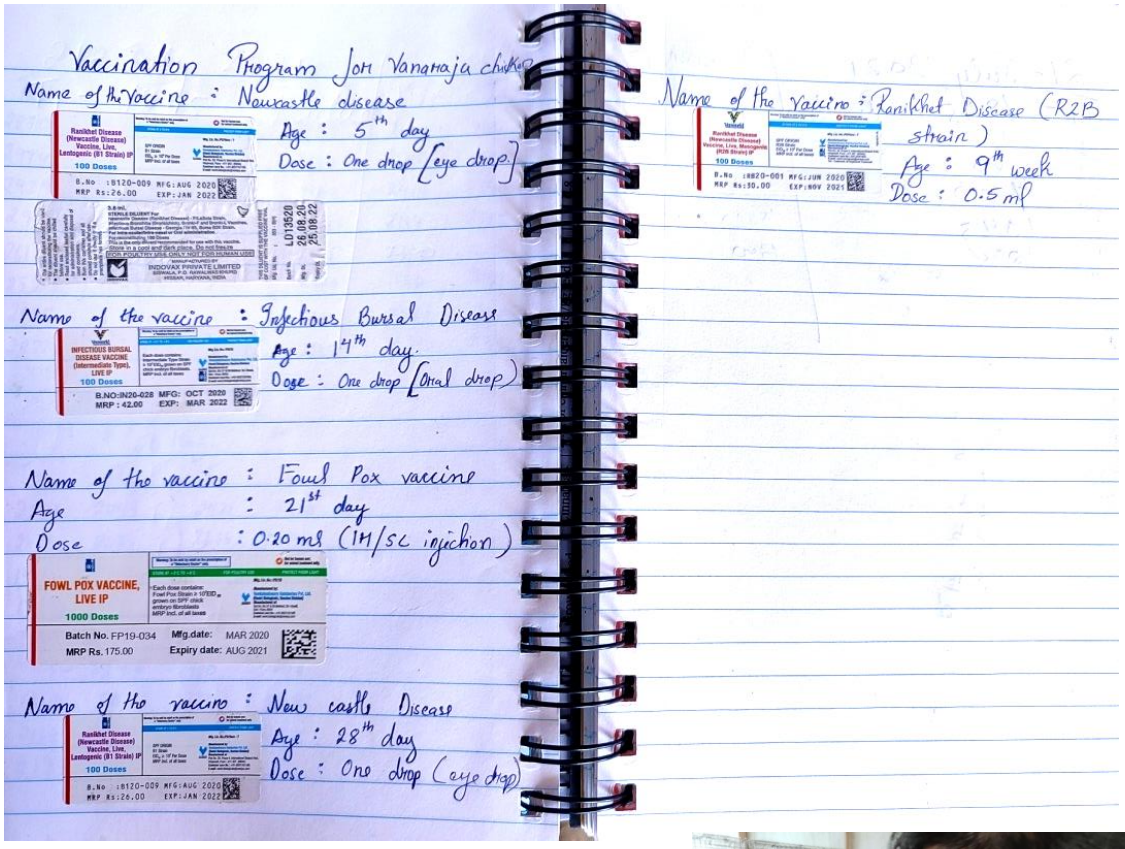
Table 3.1 Vaccination program for Vanaraja chickens

Age	Name of the vaccine	Strain	Dose	Route
5th day	Newcastle disease	Lasota	One drop	Eye drop
14th day	Infectious bursal disease	Georgia	One drop	Oral drop
21st day	Pox	Fowl pox	0.20 ml	IM/SC injection
28th day	Newcastle disease	Lasota	One drop	Eye drop
9th week	Newcastle disease*	R2B	0.50 ml	SC injection
12th week	Pox*	Fowl pox	0.20 ml	SC injection

*Repeat these two vaccines at every 6 months interval
Source: ICAR-Directorate of Poultry Research: ISO 9001-2008.

Plate – 2

Vaccination



Vaccination schedule

Vaccination route: eye drop

Intramuscular Injection

3.6. Experimental Procedure

One hundred twenty (120) chicks (day-old) were randomly divided into six (6) different treatments consisting of twenty (20) chicks in each treatment having five replicates of four (4) chicks each. The chicks were reared for 0-8 weeks in the brooder house under deep litter system and then transferred in cages after 8 weeks of age and were reared till the experimental period i.e. 34 weeks of age. The chicks were fed with chick feed from 0-8weeks, grower feed from 9-20weeks and layer feed from 21-34 weeks. Group 1 (T1) served as control was provided the basal diet. The chicks in the other 5 treatment groups were provided with the same basal diet as in T1 but supplemented with different levels of cinnamaldehyde and cinnamic acid. The details of the distribution of chicks and their treatment are summarized in table 3.2

Table 3.2: Details of distribution of chicks and their treatment

Group	**Basal Diet**	**Feed additives**	**Dose**	**Duration (weeks)**
T_1	Chick feed Grower feed Layer feed	None	None None	0-8 9-20 21-34
T_2	Chick feed Grower feed Layer feed	Cinnamaldehyde	2.5g of cinnamaldehyde /kg feed 2.5g of cinnamaldehyde /kg feed 2.5g of cinnamaldehyde /kg feed	0-8 9-20 21-34
T_3	Chick feed Grower feed	Cinnamic acid	2.5g cinnamic acid / kg of feed 2.5g cinnamic acid / kg of feed 2.5g cinnamic acid / kg of feed	0-8 9-20

	Layer feed			21-34
T_4	Chick feed Grower feed Layer feed	Cinnamaldehyde	5g of cinnamaldehyde /kg feed 5g of cinnamaldehyde /kg feed 5g of cinnamaldehyde /kg feed	0-8 9-20 21-34
T_5	Chick feed Grower feed Layer feed	Cinnamic acid	5g cinnamic acid/ kg of feed. 5g cinnamic acid/ kg of feed. 5 g cinnamic acid/ kg of feed.	0-8 9-20 21-34
T_6	Chick feed Grower feed Layer feed	Cinnamaldehyde + Cinnamic acid	2.5g cinnamaldehyde + 2.5 g cinnamic acid/ kg 2.5g cinnamaldehyde + 2.5 g cinnamic acid/ kg 2.5g cinnamaldehyde + 2.5 g cinnamic acid/ kg	0-8 9-20 21-34

3.6.1. Reproduction traits

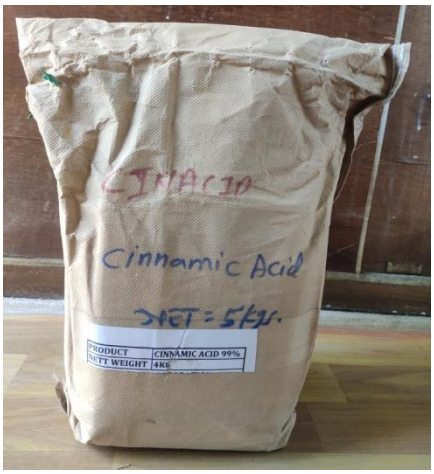
3.6.1.1 Body Weight and Growth Rate:

Weight of the day old chicks was recorded. Thereafter, the average body weight of the Vanaraja chicks were recorded at fortnightly intervals which were taken in the morning hours prior to feeding and watering. A digital weighing balance having a maximum capacity of 20 kg was used for the entire experiment for weighing the birds. During the first four weeks, the average weight of the chicks was recorded in groups of 10. This was done by placing 10 chicks each in a pre – weighed bamboo basket. After 6^{th} week of age, the birds were weighed individually at fortnightly intervals till they attained 34^{th} weeks of age.

Plate – 3

Feed supplement: Cinnamaldehyde and Cinnamic acid

Cinnamaldehyde



Cinnamic acid

Godrej Poultry layer feed

Mixing of feed with cinnamaldehyde

3.6.1.2 Feed Intake and Feed Conversion Efficiency

Ad libitum feed and water were provided to all the groups throughout the experimental period. The amount of feed fed to the birds was recorded daily and the feed residue, if any, was recorded the next morning. Feed intake was calculated by offering weighed quantity of feeds according to the treatments with the help of a precise digital weighing balance and expressed in gram. The leftover feed was subtracted from the total amount of feed supplied the previous day to arrive at the exact quantity of feed consumed by the birds per day. From these data, the average and weekly feed consumption was calculated for each bird in each group and expressed in grams. The Feed Conversion Efficiency (FCE) of different experimental groups was calculated by adopting the following formula (Banday, 2014):

$$\text{Feed Conversion Effeciency (FCE)} = \frac{\text{Quantity of feed consume (g)}}{\text{Total body weight gain (g)}}$$

3.6.1.3 Mortality/Liveability and Performance Index

Mortality was recorded throughout the experimental period and was expressed in percentage using the following formula (Jalaluddin, 2014):

$$\text{Mortality (M)} = \frac{\text{Total no. of birds died}}{\text{Total no of live birds}} \times 100$$

Liveability percentage was calculated by subtracting the mortality percentage from 100.

Performance Index (PI) was calculated by adopting the formula of Bird (1955):

$$\text{Performance Index (PI)} = \frac{\text{Average body weight (g)x \% Liveability}}{\text{Cumulative FCE x no of days}} \div 10$$

3.6.2 Reproductive traits

3.6.2.1 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 i.e. morning, afternoon and evening. The collected eggs were filled in the egg trays and stored at room temperature. Age at first egg was calculated by counting the number of days starting from day old to the day of first egg.

3.6.2.2 Body weight at 1st egg and egg weight at 1st laying

Body weight of the birds that laid its first egg is recorded. Egg weight was measured by using a digital weighing balance.

3.6.2.3 Clutch size, egg mass and total egg production up to 34th week of age

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, egg mass, hen day egg production and hen housed egg production using the following formula (Banday, 2014):

$$\text{HDEP} = \frac{\text{Total no. of eggs produced during the period}}{\text{Total no. of hen days in the same period}} \times 100$$

$$\text{HHEP} = \frac{\text{Total no. of eggs laid during the period}}{\text{Total no. of hen house at the beginning of laying period}} \times 100$$

Average egg mass = per cent HDEP × Average egg weight in grams
(Per hen per day in gram)

3.6.3 Egg quality traits

Egg quality traits were determined by randomly selecting 5 eggs from each treatment. After weighing the selected eggs, each egg was broken with a sharp knife and the shell was broken into two even halves allowing the white to drip out of the shell into a petri dish. After all the white has dripped out, the yolk is

transferred into another petri dish. For the measurement of shell weight, albumen weight and yolk weight, a digital balance was used. The main parameters to determine the quality of the eggs during the experiment were shape index, albumen index, yolk index, shell ratio, yolk weight, albumen weight, haugh unit, and yolk cholesterol. Yolk height and albumen height was measured using an instrument called spherometer and for measuring length and diameter of yolk and albumen, Vernier caliper was used.

3.6.3.1 Shape index

The egg width and length were measured using vernier calipers then shape index was calculated using the formula (Saleh, 2013):

$$\text{Egg shape index} = \frac{\text{Transversal axis}}{\text{Longitudinal axis}} \times 100$$

3.6.3.2 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 Saleh (2013) :

$$\text{Yolk index} = \frac{\text{Yolk height(mm)}}{\text{Yolk diameter(mm)}} \times 100$$

3.6.3.3 Albumen index

Albumen index (AI) is related to albumen height and albumen width and was calculated by following the formula given by Saleh (2013):

$$\text{Albumen index} = \frac{\text{Albumen height (mm)}}{\text{Albumen width(mm)}} \times 100$$

3.6.3.3 Shell ratio

After removing the albumen and yolk, the shell was weighted with the help of a digital balance. The shell weight was divided by egg weight to get the shell ratio. The calculated formulas given by Kumar *et al.* (2022) are as follows:

$$\text{Shell ratio} = \frac{\text{shell weight (g)}}{\text{egg weight (g)}} \times 100$$

3.6.3.4 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 (HU) score was calculated by adopting the following formula (Haugh, 1937):

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

Where, H is the albumen height (mm) and W is the egg weight (g).

The haugh unit values ranges 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 scores the better the quality of egg.

3.6.3.5 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 (1974).

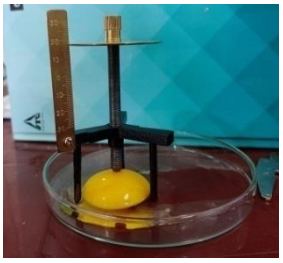
Procedures

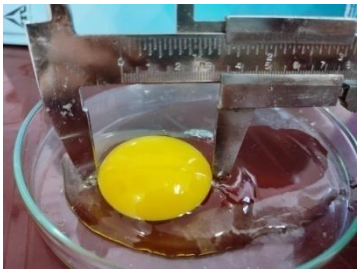
1. One gram sample of yolk was mixed with 15 ml. of 2:1 chloroform-methanol and shaken 12 times by hand.

Plate – 4

Egg quality, haematological and biochemical evaluation

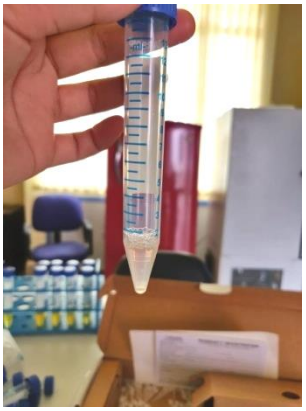
Weighing of egg



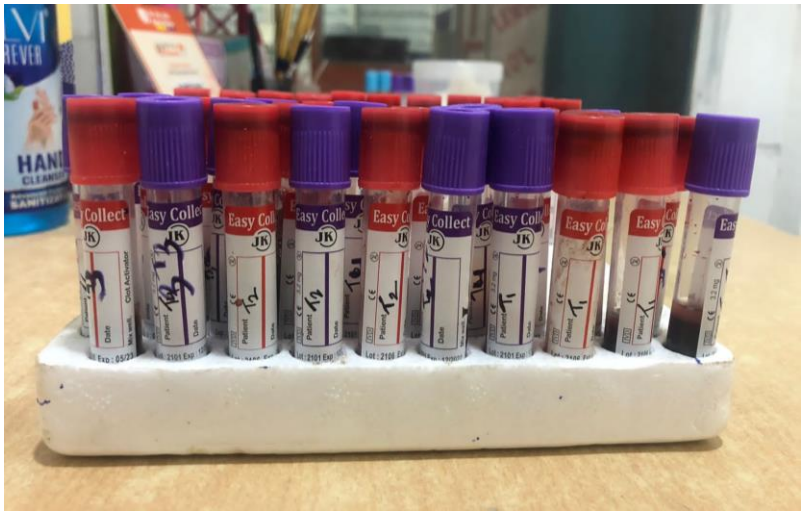


Yolk diameter and width measurement

Yolk before centrifuge



Yolk after centrifuge



Blood sample for evaluation of haematological and biochemical constituen

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.

Table 3.3 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	5 mmol/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 3.4 Protocol for cholesterol analysis

	Blank	Standard	Test
Cholesterol reagent (1)	1.0 ml	1.0 ml	1.0 ml
Cholesterol standard	-	10 µl	-
Specimen	-	-	10 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37ºC. 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).

$$\text{Cholesterol (mg/g yolk)} = \frac{\text{Absorbance of Test x 200 x V}}{\text{Abdsorbance standard x 200 x W}}$$

3.6.4 Blood parameters

On the 17th week and 34th week of age, three birds in each treatment were randomly selected from any three replicate groups for blood collection. The blood was collected from the wing vein of the birds by sterilizing and numbing an area of the wing with disinfectant and cotton wool and then collecting about 2 ml of blood with the use of sterile needles into well labelled sterilized tubes containing Heparin as anticoagulant. Hematological profiles such as Cholesterol, triglyceride, glucose level, low density lipoprotein (LDL), high density lipoprotein (HDL), haemoglobin concentration (Hb) and packed Cell Volume (PCV) were determined using different procedure.

3.6.4.1. Cholesterol

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. The standard kit for two reagents was procured from DIATEK healthcare Pvt. Ltd.

Table 3.5 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	5 mmol/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 3.6 Protocol for cholesterol analysis

	Blank	Standard	Test
Cholesterol reagent	1.0 ml	1.0 ml	1.0 ml
Cholesterol standard	-	10 µl	-
Specimen	-	-	10 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37ºC. The absorbance was read for Standard (S) and Test (T) against Blank (B) with 510 nm. Cholesterol concentration was estimated as per the method described by Richmond (1973).

Calculation:

$$\text{Cholesterol (mg/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of standard}} \times 200$$

3.6.4.2 Triglycerides

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled.

Table 3.7 The composition of the reagent in triglyceride standard kit:

Reagent 1 (R1)	**2 x 50 ml**
Good's Buffer (pH 7.2)	50 mmol/l
4-Chlorophenol	4 mmol/l
ATP	2 mmol/l
Mg^{2+}	15 mmol/l
Glycerokinase (GK)	0.4 kU/l
Peroxidase (POD)	2 kU/l
Lipoprotein lipase (LPL)	4 kU/l
4-Aminoantipyrine	0.5 mmol/l
Glycerin-3-phosphatoxidase (GPO)	1.5 kU/l

Standard: 200 mg/dl

Table 3.8 Protocol for triglyceride analysis:

	Blank	Standard	Test
Triglyceride reagent (1)	1.0 ml	1.0 ml	1.0 ml
Triglyceride standard	-	10 µl	-
Specimen	-	-	10 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37ºC. The absorbance was read for Standard (S) and Test (T) against Blank (B) with 510 nm. The value obtained were calculated as per the following formula and expressed in mg/dl

Calculation:

$$\text{Triglyceride (mg/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of standard}} \times 200$$

3.6.4.3. High-density lipoproteins (HDL)

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. The standard kit for two reagents was procured from DIATEK healthcare Pvt. Ltd.

Table 3.9 Composition of the reagents in the HDL standard kit:

Reagent 1 (R1)	**60mL**
TODB	1 mmol/l
Ascorbate oxidase	3.0 U/ml
PVS	2 mg/l

PEGME	0.2%
$MgCl_2$	2 mmol/l
Buffer (pH 6.5)	10 mmol/l
Reagent 2 (R2)	**20 mL**
Cholesterol esterase	4 U/ml
Cholesterol oxidase	10 U/ml
Peroxidase	30 U/ml
4-aminoantipyrine	2.5 mmol/l
Detergent	0.5%
Buffer (pH 6.5)	10 mmol/l

Calibrator: reconstituted with 1.0 ml Distilled water.

Calibrator concentration: HDL: 1.62 mmol/l or 62.79 mg/dl

LDL: 3.16 mmol/l or 122.48 mg/dl

Table 3.10: Protocol for HDL analysis:

	Blank	Standard	Test
Triglyceride reagent (1)	450 µl	450 µl	450 µl
Triglyceride standard	-	6 µl	-
Specimen	-	-	6 µl
Mixed and incubated for 15 minutes at 37ºC			
Reagent (2)	150 µl	150 µl	150 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37ºC. The absorbance was read for Standard (S) and Test (T) against Blank (B) at 600 nm.

HDL concentration was estimated as per the method described by Izawa *et al.* (1997).

Calculation:

$$\text{HDL-C Conc.(mmol/l)} = \frac{A_{\text{Test}} - A_{\text{Blank}}}{A_{\text{Calibrator}} - A_{\text{Blank}}} \times \text{calibrator conc.}$$

3.6.4.4. Low density lipoproteins (LDL)

The serum was separated out into a clean plastic screw-cap vial from the collected whole blood sample and neatly labeled. The standard kit for two reagents was procured from DIATEK healthcare Pvt. Ltd.

Table 3.11 Composition of the reagents in the LDL standard kit:

Reagent 1 (R1)	**30 mL**
Cholesterol esterase	5 kU
Cholesterol oxidase	5 kU
Peroxidase	20 kU
4-aminoantipyrine	0.5 g/l
$MgCl_2$	2 mmol/l
Detergent	0.5 g/l
Preservative	0.5 g/l
Goods buffer	10 mmol/l
Reagent 2 (R2)	**10 ml**
TODB	2 mmol/l
Detergent	1%
Preservative	0.5 g/l
Goods buffer	10 mmol/l

Calibrator: reconstituted with 1.0 ml Distilled water.

Calibrator concentration: HDL:1.54 mmol/l or 59.69 mg/dl

LDL: 3.10 mmol/l or 120.16 mg/dl

Table 3.12 Protocol for LDL analysis:

	Blank	Standard	Test
Reagent (1)	450 µl	450 µl	450 µl

LDL Calibrator	-	6 µl	-
Specimen	-	-	6 µl
Mixed and incubated for 15 minutes at 37°C			
Reagent (2)	150 µl	150 µl	150 µl

End Point Method:

The solution was mixed and incubated for 5 minutes at 37°C. The absorbance was read for Standard (S) and Test (T) against Blank (B) at 600 nm. LDL concentration was estimated as per the method described by Wieland and Seidal (1983).

Calculation:

$$\text{LDL-C Conc.(mmol/l)} = \frac{A_{\text{Test}} - A_{\text{Blank}}}{A_{\text{Calibrator}} - A_{\text{Blank}}} \times \text{calibrator conc.}$$

3.6.4.5 Glucose

Glucose is the major carbohydrate present in blood. Its oxidation in the cells is the source of energy for the body. Increased levels of glucose are found in diabetes mellitus, hyperparathyroidism, pancreatitis and renal failure. Decreased levels are found in insulinoma, hypothyroidism, hypopituitarism and extensive liver disease. Glucose concentration was expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers with one test tube marked as S (standard).
2. 1ml of reagent (A) was taken in all the sample test tubes.
3. In the test tube marked for standard 10 µl of the glucose standard was added.
4. In the sample test tubes, 10ul of serum was added, mixed and incubated at room temperature (25-30°C) for 10 minutes.

5. The absorbance of this solution was measured at 500nm in a spectrophotometer after adjusting the optical density at 0 by mixing distilled water and reagent (A) as blank. The reading was accordingly recorded.
6. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{Glucose} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 100$$

3.6.4.6. Haemoglobin (Hb)

The analysis was done using hemoglobinometer as per method described by Sahli (1909). The protocol followed is described as under:

- The oxalated blood was mixed in the specimen tube by rotation.
- For making the solution to estimate hemoglobin, 1 ml of HCl was added in 9 ml of distilled water to make a final volume of 10 ml.
- 10 per cent of HCl solution with 20 µl of blood sample was added in the specimen tube and mixed thoroughly which gave out dark color.
- The tube was kept in a dark place for 30 minutes.
- At the end of this period, the tube was kept in the comparator and distilled water was added drop by drop and stirred with a glass. The procedure was repeated until the colour in the tube matched the colour of the standard in the comparator.
- When the colour matched, the tube was removed from the comparator and the reading of the level of the fluid was done in g per cent from bottom to top.
- The blood and the Diluting fluid in the pipette were mixed together by rotating (horizontally) the pipette between the palms.

- Cleaning out the cover glass that was placed over the grooved area of Hemocytometer.
- Putting the RBC pipette, the solution present in it was mixed again and 1-2 drops from the pipette was discarded before charging the chamber.

3.6.4.7. PCV (Packed cell volume %)

The method recommended by NCCLS of determining hematocrit or packed cell volume (PCV) is centrifugation. Hematocrit (PCV) is the measure of the ratio of the volume occupied by the red blood cells to the volume of whole blood. The blood sample is drawn into a capillary and centrifuged, and then the ratio can be measured and expressed as a decimal or percentage fraction.

Procedure:

- Capillary tubes are filled by capillary forces. A minimum of two capillaries is required to ensure balance in the centrifuge.
- After five minutes of centrifugation the hematocrit can be measured while the tubes are still kept in a horizontal position. A distinct column of packed erythrocytes are followed by first a small turbid layer- the Buffy coat layer and then a clear column of plasma.
- Hematocrit is estimated by calculating the ratio of the column of packed erythrocytes to the total length of the sample in the capillary tube, measured with a graphic reading device.
- The measurement should be performed within 10 minutes to avoid merging of the layers.

3.7 Economics of Feeding cinnamaldehyde and cinnamic acid

The economics of feeding diet supplemented with cinnamaldehyde and cinnamic acid was calculated on the basis of overall cost of inputs, i.e. the cost of chicks, feeds, labour, medicines and other miscellaneous cost. The live weight of

the bird at the end of experiment was considered to calculate the gross return per bird and net profit per bird.

3.8 Statistical Analysis:

The experimental data collected were estimated and statistical analyzed of different group on various parameters were performed using ANOVA in a randomized block design as described by Snedecor and Cochran (1998). The results are given as means, standard error and $P<0.05$ was considered to be statistically difference.

CHAPTER – IV

RESULTS AND DISCUSSIONS

RESULTS AND DISCUSSION

The current study was conducted with 120 day-old Vanaraja chicks (sexed-female chick) which were reared till they attained 34th weeks of age. The birds were put through 6 dietary treatments namely, T_1, T_2, T_3, T_4, T_5 and T_6 containing 0, 2.5 g cinnamaldehyde, 2.5 g cinnamic acid, 5 g cinnamaldehyde, 5 g cinnamic acid and 2.5 g cinnamaldehyde + 2.5 g cinnamic acid.

Data for different parameters were recorded such as BWG (body weight gain), BW (body weight), FI, FCE (feed Conversion Efficiency), mortality, liveability, performance index, egg quality traits, haematological and biochemical parameters, and economy of rearing. All recorded data were analyzed statistically and presented in tables and illustrated by graphs in order to give a quick visual access to the salient findings. The next sections of this chapter cover the results of the current research.

4.1 Productive traits

4.1.1 Body weight

The observation on variation in body weight of different treatment groups from day- old to 34th weeks of age is shown in table 4.1. The mean body weight of different experimental groups at fortnightly interval up to the end of 34th weeks has been graphically plotted in Fig. 4.1. The statistical analysis of the average body weight at different fortnight is given in Appendix 1(Body Weight).

Table 4.1 Average body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

Fortnight	Treatment						SEM	CD (0.05)
	T_1	T_2	T_3	T_4	T_5	T_6		
0	38.8	42.8	38.2	40.8	41.0	41.6	2.1	NS
1st	179.0^{bc}	182.9^{c}	166.4^{a}	164.4^{a}	177.4^{b}	174.9^{b}	1.5	4.8
2nd	445.7^{c}	482.5^{d}	446.6^{c}	431.8^{b}	455.2^{c}	391.0^{a}	4.1	12.5
3rd	806.8^{a}	828.5^{c}	799.1^{a}	816.1^{b}	861.1^{d}	892.8^{e}	2.5	7.8
4th	1236.0^{bc}	1294.0^{c}	1131.2^{a}	1146.2^{a}	1227.8^{b}	1230.6^{bc}	20.9	64.6
5th	1509.0^{b}	1564.4^{c}	1469.6^{b}	1398.0^{a}	1488.0^{b}	1502.2^{b}	15.9	48.9
6th	1853.0^{c}	1865.0^{c}	1788.0^{b}	1708.4^{a}	1771.2^{b}	1792.4^{b}	13.3	41.0
7th	2002.0^{b}	2151.8^{c}	1963.6^{b}	1982.4^{b}	1868.2^{a}	1953.0^{b}	24.7	76.0
8th	2176.2^{bc}	2245.2^{c}	2175.8^{bc}	2187.8^{bc}	1969.6^{a}	2148.0^{b}	27.6	85.1
9th	2323.2^{b}	2305.2^{b}	2301.4^{b}	2260.2^{b}	2071.0^{a}	2256.0^{b}	30.6	94.4
10th	2486.0^{c}	2493.0^{c}	2410.6^{bc}	2379.8^{b}	2210.2^{a}	2346.2^{b}	31.9	98.2
11th	2541.2^{b}	2560.2^{b}	2500.8^{b}	2489^{b}	2255.6^{a}	2488^{b}	31.6	97.4
12th	2608.4^{bc}	2654.2^{c}	2627.8^{bc}	2568.4^{bc}	2337.2^{a}	2541.4^{b}	32.6	100.4
13th	2665.4^{bc}	2739.0^{c}	2642.8^{bc}	2616.8^{b}	2410.0^{a}	2620.4^{b}	31.7	97.7
14th	2705.6^{b}	2810.0^{c}	2702.2^{b}	2667.4^{b}	2498.6^{a}	2673.4^{b}	31.0	95.4
15th	2758.8^{b}	2950.2^{c}	2788.0^{b}	2754.2^{b}	2523.2^{a}	2751.4^{b}	32.2	99.1
16th	2864.4^{b}	3050.4^{c}	2863.0^{b}	2849.6^{b}	2553.0^{a}	2788.0^{b}	31.0	95.4
17th	2965.6^{b}	3153.4^{c}	2976.6^{b}	2960.4^{b}	2604.2^{a}	2886.8^{b}	33.7	102.8
Total	34165.1^{b}	35372.7^{c}	33791.6^{b}	33421.7^{b}	31322.4^{a}	33478.1^{b}	332.5	1024.7
Mean	1898.1^{b}	1965.2^{c}	1877.3^{b}	1856.8^{b}	1740.1^{a}	1859.9^{b}	18.5	56.9

^{a,b,c,d,e} Means bearing different superscripts in a row differ significantly ($P<0.05$)

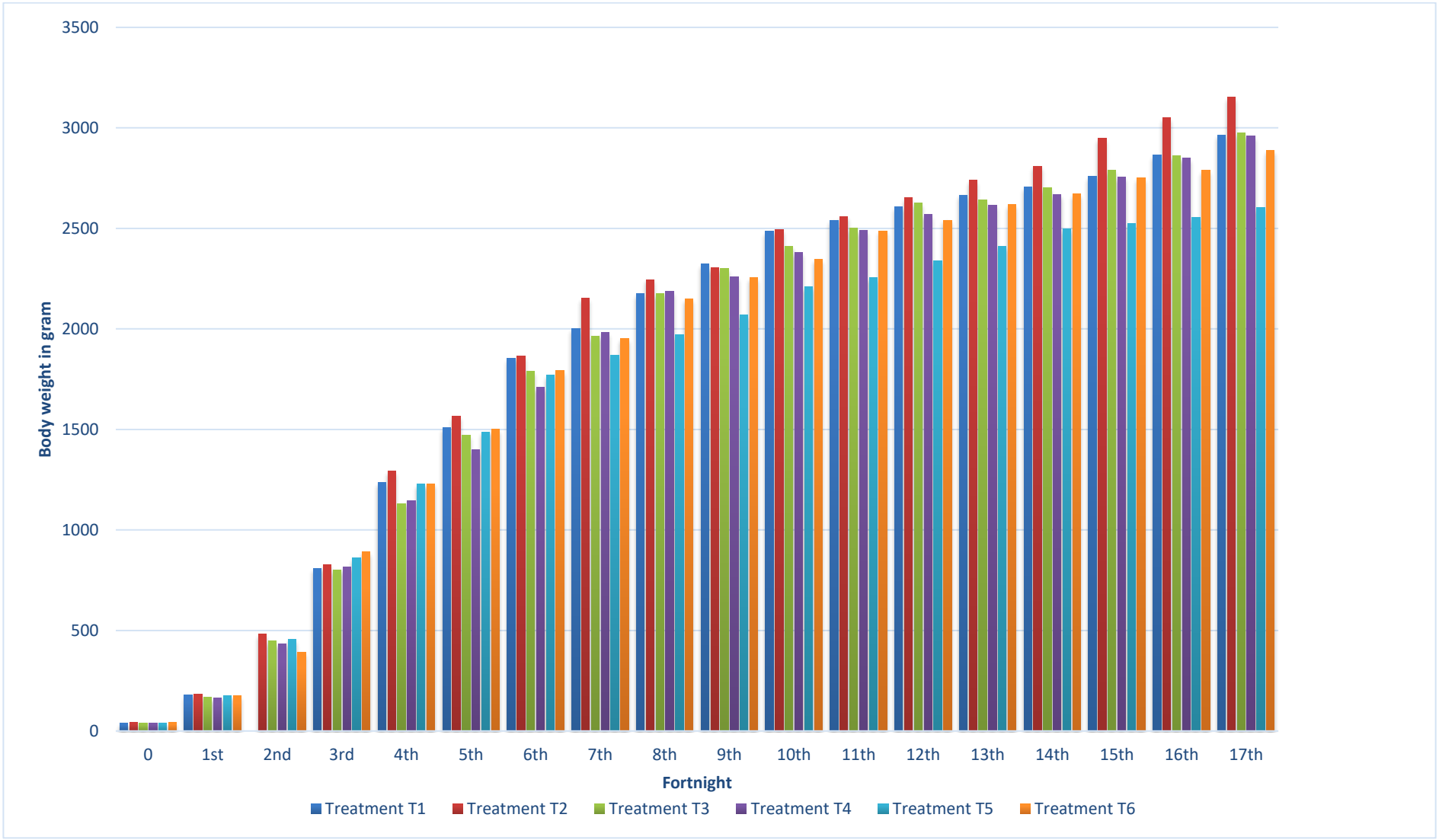


Fig 4.1: Average body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

As per table 4.1, the initial body weight of Vanaraja chicks for various treatment groups i.e., T_1, T_2, T_3, T_4, T_5 and T_6 at 0 day was recorded as 38.8 g, 42.8g, 38.2g, 40.8g, 41.0g and 41.6 g respectively. Meanwhile, the BW recorded at the end of 17th fortnight for various treatment groups namely, T_1, T_2, T_3, T_4, T_5 and T_6 was 2965.6g, 3153.4g, 2976.6g, 2960.4g, 2604.2g and 2886.8g. Overall mean body weight for various treatment groups i.e., T_1, T_2, T_3, T_4, T_5 and T_6 was 1898.1g, 1965.2g, 1877.3g, 1856.8g, 1740.1g and 1859.9g. At the conclusion of the trial or the 17th fortnight, ANOVA (Analysis of variance) showed that there was a major ($P<0.05$) variation in BW among the treatment groups. The body weight was considerably greater in T_2 followed by T_3, T_1, T_6, T_5 and T_4.

These findings concur with those of Toghyani *et al*. (2011), who found that broiler whose diets included cinnamon at a rate of 2 g/kg of feed had considerably greater body weight than those in the other treatment groups. Researchers like Mehdipour *et al*. (2013), Shirzadegan (2014), Hussein *et al*. (2015), Devi *et al*. (2018) and Gupta *et al.* (2018) observed similar findings where the addition of cinnamon to the broiler diet significantly increased the final BW of the birds as compared with the control group. Likewise Gaikwad *et al.* (2019) and Behera *et al*. (2020) also found a significant impact on the BW of the birds fed with cinnamon as a dietary supplement. Similarly, Krauze *et al*. (2021), Odutayo *et al*. (2021), Saied *et al*. (2022) and Nath *et al*. (2022) found a major increase in the BW of the birds when cinnamon is supplemented in their diet. The finding was also in line with Adedeji *et al.* (2022) who stated that supplementation of cinnamon powder in cockerel bird diet had significantly higher body weight on comparison with the control group. Hussein *et al.* (2023) also observed that inclusion of cinnamon oil in broiler diet had considerably increased BW of the bird compared with the control group. This may be a consequence of cinnamon oil's beneficial effects on poultry digestive system, which assist to balance the gut

environment and improve nutrient absorption, leading to enhanced growth performance (Mountzouris *et al*. 2011).

However, Koochaksarie *et al.* (2011) illustrated that supplementation of cinnamon to broiler diets at 0.5 - 2 g/kg had no major difference in the BW of the chicks. Likewise, Symeon *et al.* (2014) discovered that adding of cinnamon oil to the food of boiler chickens at a rate of 0.5 or 1.0 ml/kg had no beneficial impact on the birds BW. Ali *et al.* (2018) also observed that supplementation of various level (1, 3 and 5%) of cinnamon powder in the broiler diet had no major impact on BW of the broiler as compared with control group. In addition, Krauze *et al*. (2020) observed that inclusion of probiotic containing cinnamon oil at 0.25 ml per liter of drinking water had no major impact on the BW of broiler birds among the control and treatment groups. Moreover, Ahmed *et al.* (2019) and Suwarta and Suryani (2019) reported that supplementation cinnamon powder or oil in the quail diet did not affect the BW of the birds. Qaid *et al*. (2022) observed that the incorporation of cinnamon in broiler diet had no major impact on the BW of the birds when compared to the control group.

Various factors such as stress/strains differences, ingredient of feed, duration of treatment, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

4.1.2 Gain in body weight

The average fortnightly gain in BW for different treatment groups is shown in table 4.2 and their mean statistical analysis is shown in Apendix-2 (Body Weight Gain). The pattern of growth and total average gain in weight during the experimental period are plotted graphically in Fig. 4.2.

Table 4.2 Average gain in body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

Fortnight	Treatment						SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6		
1st	140.2^{c}	140.1^{c}	128.2^{ab}	123.6^{a}	136.4^{c}	133.3^{bc}	2.4	7.3
2nd	266.7^{b}	299.7^{c}	280.2^{b}	267.3^{b}	277.9^{b}	216.1^{a}	4.6	14.2
3rd	361.1^{b}	345.9^{a}	352.5^{ab}	384.4^{c}	405.8^{d}	501.8^{e}	4.6	14.3
4th	429.2^{bc}	465.5^{c}	332.1^{a}	330.1^{a}	366.7^{ab}	337.8^{a}	22.4	68.9
5th	273.0^{ab}	270.4^{ab}	338.4^{b}	251.8^{a}	260.2^{ab}	271.6^{ab}	27.6	84.9
6th	344.0	300.6	318.4	310.4	283.2	290.2	20.1	NS
7th	149.0^{a}	286.8^{b}	175.6^{b}	274.0^{b}	97.0^{a}	160.6^{a}	22.7	69.9
8th	174.2^{bc}	93.4^{a}	212.2^{c}	205.4^{c}	101.4^{ab}	195.0^{c}	23.8	73.3
9th	147.0^{c}	60.0^{a}	125.6^{c}	72.4^{ab}	101.4^{abc}	108.0^{bc}	15.2	46.9
10th	162.8^{d}	187.8^{e}	109.2^{ab}	119.6^{bc}	139.2^{cd}	90.2^{a}	8.1	24.8
11th	55.2^{ab}	67.2^{b}	90.2^{c}	109.2^{d}	45.4^{a}	141.8^{e}	5.1	15.8
12th	67.2^{b}	94.0^{d}	127.0^{e}	79.4^{bc}	81.6^{cd}	53.4^{a}	4.3	13.3
13th	57.0^{b}	84.8^{d}	15.0^{a}	48.4^{b}	72.8^{c}	79.0^{cd}	3.7	11.3
14th	40.2^{a}	71.0^{c}	59.4^{bc}	50.6^{ab}	88.6^{d}	53.0^{ab}	4.8	14.7
15th	53.2^{b}	140.2^{d}	85.8^{c}	86.8^{c}	24.6^{a}	78.0^{c}	5.1	15.6
16th	105.6^{d}	100.2^{cd}	75.0^{b}	95.4^{c}	29.8^{a}	36.6^{a}	2.8	8.7
17th	101.2^{b}	103.0^{b}	113.6^{b}	110.8^{b}	51.2^{a}	98.8^{b}	7.0	21.7
Total	2926.8^{b}	3110.6^{c}	2938.4^{b}	2919.7^{b}	2563.2^{c}	2845.2^{b}	33.2	102.4
Mean	172.2^{b}	183.0^{c}	172.8^{b}	171.7^{b}	150.8^{a}	167.4^{b}	1.9	6.0

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

As per table 4.2, Overall total BWG for various treatment groups namely, T_1, T_2, T_3, T_4, T_5 and T_6 was 2926.8g, 3110.6g, 2938.4g, 2919.7g, 2563.2g and 2845.2g and the corresponding value for overall mean BWG were 172.2g, 183.0g, 172.8g, 171.7g, 150.8g and 167.4g respectively. Furthermore, gain in body weight on 17th fortnight for the treatment groups namely, T_1, T_2, T_3, T_4, T_5 & T_6 was 101.2g, 103.0g, 113.6g, 110.8g, 51.2g and 98.8g, respectively. The results of the analysis of variance on the total mean value exhibit that there was a major ($P<0.05$) difference in the rate of BWG across the treatment groups, with T_2 considerably outperforming T_3, T_1, T_4, T_6 and T_5.

The current study's findings are consistent with those of Ciftci *et al*. (2009) and Molla *et al*. (2012) who found that adding cinnamon to the broiler feed increased the BWG in comparison to other treatment groups. Also, Mehdipour *et al*. (2013) stated that the addition of cinnamon oil at 200mg/kg considerably increased the body weight gain of quails as compared to other treatment groups. Similarly, Gupta *et al*. (2018) reported that cinnamon supplemented groups had significantly higher BWG of broiler chicks. According to Behera *et al*. (2020) adding 1% cinnamon powder in broiler feed significantly increased the BWG of the chiockens compared to the control group. Similarly, Moustafa *et al*. (2020), Odutayo *et al*. (2021), Saied *et al*. (2022), Adedeji *et al*. (2022) and Nath *et al*. (2023) stated that major increase in BWG of birds fed with cinnamon powder/oil on the bird ration. This outcome may be due to presence of bioactive compounds in cinnamon that helps in disruption of growth of pathogenic microbes which results in the stimulation of the growth of commensal bacteria in the intestinal tract of poultry birds hence improving the body weight gain of the birds (Wenk,

2003). According to Hussein *et al*. (2023) adding cinnamon oil to broiler diets considerably boosted the birds' BWG contrasted with the control group.

In contrast, adding cinnamon oil to the diets of broiler and quail birds did not seem to have any significant impact on the birds' BWG, according to Lee *et al*. (2003), Muhl and Liebert (2007) and Tonbak and Ciftci (2012). Similarly, Gerzilov *et al*. (2015), Abudabos e*t al*. (2018) and Ali *et al.* (2018) found that incorporation of various levels of cinnamon powder in the broiler diet had no major impact on the BWG of the broiler in contrast to the control group. Also, Mehdipour and Afsharmanesh, (2018) stated that no major difference was found in the BWG of quail when supplemented with cinnamon in the diet. Dietary supplementation of ginger and cinnamon oil in the quail diet had no major influence on the BWG of the bird according to Ahmed *et al.* (2019). Also, Gaikwad *et al.* (2019) observed that the BWG of the broiler had no major impact on the inclusion of ginger and cinnamon in the broiler diet in contrast to the control group. Likewise, Krauze *et al*. (2020) observed that the inclusion of probiotic-containing cinnamon oil at 0.25 ml per liter of drinking water had no major impact on the BWG of broiler bird among control and treatment group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the finding.

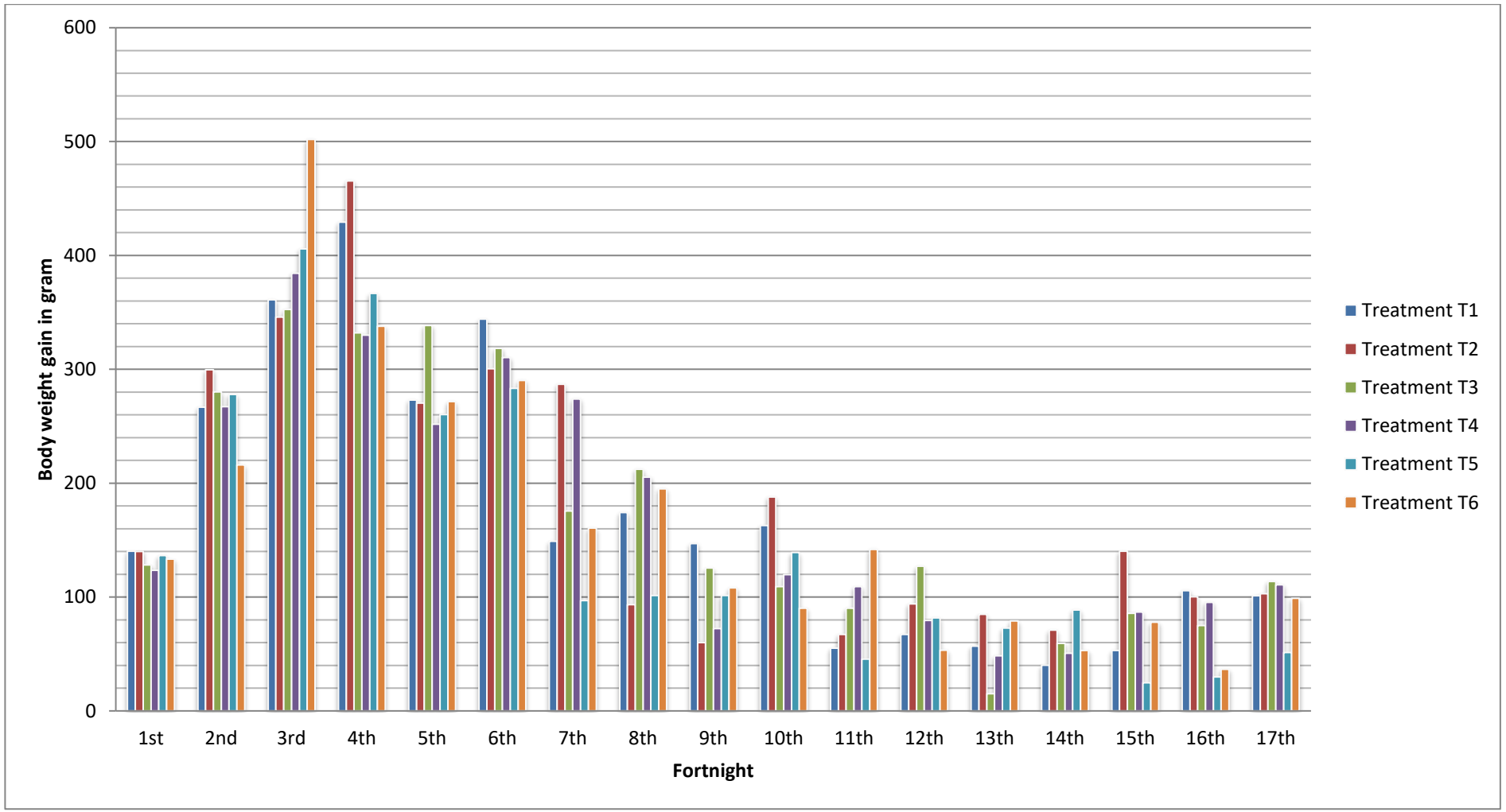


Fig 4.2: Average gain in body weight (g/bird/fortnight) of Vanaraja birds in different treatment groups

4.1.3 Feed intake

The average fortnightly feed intake, total and mean feed intake for various treatment groups namely, T_1, T_2, T_3, T_4, T_5 and T_6 from day-old to 34 weeks of age is displayed in Table 4.3 and the statistical analysis for total feed intake has been shown in Appendix 3 (Feed Intake). The pattern of feed intake has been graphically illustrated in Fig 4.3.

Table 4.3 Average feed intake (g/bird/fortnight) of Vanaraja birds in different treatment groups

Fortnight	Treatment						SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6		
1st	220.0	234.0	234.2	200.9	214.8	224.0	1.3	NS
2nd	545.9	569.8	551.2	545.5	572.8	547.4	1.9	NS
3rd	997.8^{ab}	1070.0^{abc}	987.8^{ab}	1106.8^{bc}	1190.8^{c}	961.8^{a}	43.5	133.9
4th	1196.1	1219.9	1201.5	1183.7	1243.1	1149.0	26.6	NS
5th	1440.1^{c}	1428.2^{c}	1367.6^{b}	1443.9^{c}	1429.2^{c}	1149.4^{a}	18.3	56.4
6th	2281.3^{b}	2391.8^{c}	2243.7^{b}	1828.4^{a}	2236.0^{b}	1827.8^{a}	21.8	67.1
7th	1992.9^{bc}	2051.0^{c}	1932.4^{b}	2382.4^{e}	1754.0^{a}	2292.3^{d}	25.1	77.5
8th	1714.4^{b}	1959.2^{c}	2136.6^{d}	2163.8^{d}	1528.5^{a}	1912.1^{c}	28.0	86.2
9th	2301.8^{d}	2324.4^{d}	2418.2^{e}	1642.8^{a}	$1863.^{b}$	2168.5^{c}	17.2	52.9
10th	2326.7^{c}	2276.5^{bc}	2322.1^{c}	2170.4^{ab}	2154.8^{a}	2238.3^{abc}	38.4	118.3
11th	2197.6^{c}	2247.2^{c}	2208.2^{c}	2037.0^{b}	1929.2^{a}	1961.7^{ab}	31.5	97.1
12th	1976.6^{b}	2246.4^{c}	2233.2^{c}	1952.0^{b}	2212.0^{c}	1858.8^{a}	11.9	36.9
13th	1723.8^{c}	1717.8^{c}	1011.0^{a}	1694.2^{bc}	1643.6^{b}	1743.8^{c}	19.3	59.5
14th	1583.7^{b}	1366.0^{a}	1550.8^{b}	1551.4^{b}	1596.5^{b}	1326.9^{a}	27.0	83.2
15th	1627.6^{d}	1469.5^{c}	1483.6^{c}	1185.0^{a}	1173.3^{a}	1240.6^{b}	15.7	48.3
16th	1691.0^{d}	1690.4^{d}	1640.3^{d}	1549.2^{c}	1335.5^{a}	1446.8^{b}	22.6	69.5
17th	1559.0^{c}	1636.7^{d}	1573.4^{cd}	1475.4^{b}	1184.8^{a}	1449.3^{b}	22.31	68.8
Total	27356.2^{c}	27898.8^{d}	27095.7^{c}	26112.9^{b}	25262.0^{a}	25498.6^{a}	131.1	403.9
Mean	1609.2^{c}	1641.1^{d}	1593.9^{c}	1536.0^{b}	1486.0^{a}	1499.9^{a}	7.7	23.7

^{a,b,c,d,e} Means bearing different superscripts in a row differ significantly ($P<0.05$

According to Table 4.3, the total FI for T_1, T_2, T_3, T_4, T_5 and T_6 groups during the trial was 27376.2g, 27898.8g, 27095.7g, 26112.9g, 25262.0g and 25498.6g, respectively. Feed intake for different treatment groups on 17th fortnight was lowest on T_5 (1184.8 g) followed by T_6, T_4, T_1, T_3 and T_2 (1449.3, 1475.4, 1559.0, 1573.4 and 1636.7 g) respectively. The result showed that overall mean feed intake was significantly decreased within the treatment group i.e. T_5 (1486.0g), T_6 (1499.9g), T_4 (1536.0g), T_3 (1593.9g), T_1 (1609.2g) and T_2 (1641.1g). These finding are in agreement with Sampath and Atapattu (2013) and Ali *et al*. (2018) who stated that the inclusion of cinnamon in the broiler diet significantly lowered the feed intake of the bird in contrast to the control group. Additionally, Suwarta and Suryani (2019) showed that adding cinnamon and turmeric powder to the meal reduced the broiler bird's feed consumption. Similarly, Gaikwad *et al.* (2019), Odutayo *et al*. (2021) and Saied *et al*. (2022) stated that addition of cinnamon to the broiler diet reduced the feed intake of the birds in contrast to the control group. Also, Nath *et al*. (2023) and Hussein *et al*. (2023) reported that adding cinnamon oil on a broiler diet had considerably reduced the FI of the bird in comparison with the control group. This outcome may be due to the odour or palatable of the dietary supplementation of cinnamon on the feed.

These results are not in line with the result of Molla, *et al.* (2012), Safa-Eltazi (2014) and Hussein *et al*. (2015) who stated that the inclusion of cinnamon in the broiler diet had considerably increased the feed intake of the birds. Al-Kassie (2009) and Gupta *et al*. (2018) also reported that the inclusion of cinnamon had higher FI in contrast to the control group. Also, Symeon *et al*. (2014), Torki *et al*. (2015), Simsek *et al*. (2015), Abudabos *et al*. (2018), Ali *et al*. (2018) and Ahmed *et al.* (2019) reported that the addition of cinnamon power in broiler diet had showed no major impact on feed intake of the birds. Similarly, Santos *et al.*

(2019) stated that the inclusion of cinnamon at 12.0 g/kg in the quail diet had no effect on the FI of the bird. Likewise, Krauze *et al.* (2020), Dosoky *et al*. (2021) and Qaid *et al*. (2022) stated that the inclusion of cinnamon in the broiler and quail diet had no major impact on the FI of the bird in comparison to the control group. Similarly, Behera *et al*. (2020), Moustafa *et al*. (2020), Wasman and Moustafa (2020) and Adedeji *et al*. (2022) observed that cinnamon supplemented in poultry diet had considerably increased FI of the birds when compared with the control group.

Various factors such as stress/strains differences, ingredient of feed, duration of the treatment, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

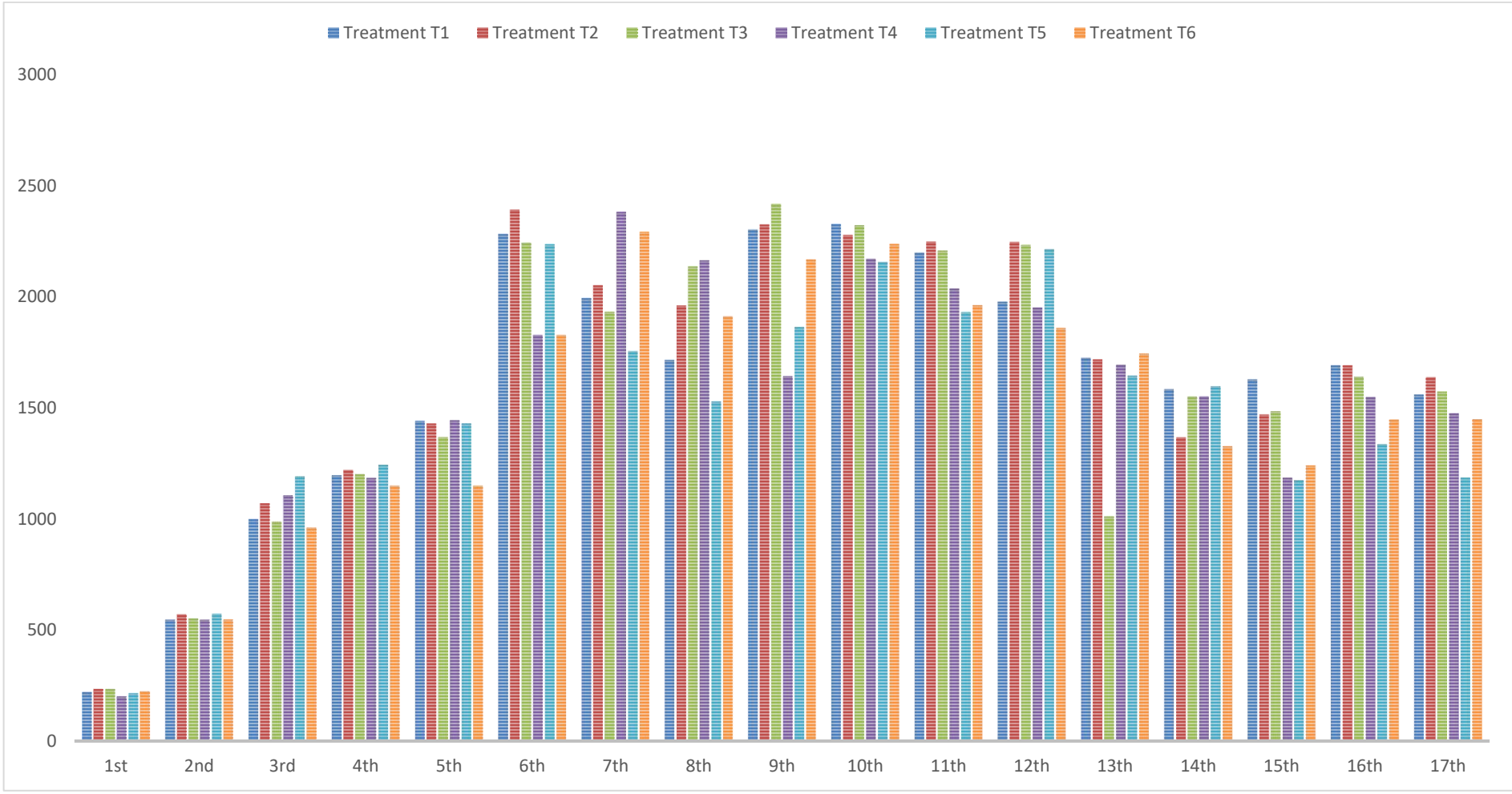


Fig 4.3: Average feed intake (g/bird/fortnight) of Vanaraja birds in different treatment groups

4.1.4 Feed conversion efficiency

Average fortnight feed conversion efficiency for the entire experimental period i.e. day-old to 34th weeks of age was calculated and showed in table 4.4. The graphical representation of FCE is exhibited in Fig. 4.4 and their mean statistical analyses are shown in Appendix 4 (Feed Conversion Efficiency).

Table 4.4 Average feed conversion efficiency of Vanaraja birds in different treatment groups

Fortnight	Treatment						SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6		
1st	1.57	1.67	1.83	1.63	1.58	1.68	0.10	NS
2nd	2.05^{a}	1.91^{a}	1.97^{a}	2.04^{ab}	2.06^{a}	2.54^{b}	0.08	0.23
3rd	2.71^{b}	3.09^{c}	2.88^{bc}	2.93^{bc}	2.93^{bc}	1.92^{a}	0.11	0.34
4th	2.79	2.62	3.62	3.65	3.56	3.50	0.25	1.78
5th	5.35	5.36	4.05	6.02	5.90	4.46	0.50	NS
6th	6.72^{ac}	8.22^{b}	7.10^{ab}	5.91^{a}	8.00^{bc}	6.43^{a}	0.47	1.43
7th	13.47^{c}	7.85^{a}	11.67^{bc}	8.84^{ab}	18.30^{d}	14.37^{c}	0.96	2.95
8th	11.35^{a}	21.63^{b}	12.46^{a}	10.85^{a}	15.16^{a}	10.53^{a}	1.99	6.13
9th	15.78^{a}	42.29^{b}	19.50^{a}	32.48^{ab}	21.21^{a}	20.76^{a}	5.48	16.83
10th	14.33^{a}	12.16^{a}	21.29^{bc}	20.77^{bc}	15.91^{ab}	25.44^{c}	2.05	6.34
11th	40.47^{cd}	34.33^{c}	24.71^{b}	18.68^{ab}	46.04^{d}	14.13^{a}	3.03	9.32
12th	30.10^{c}	23.96^{b}	17.71^{a}	24.68^{b}	27.31^{bc}	35.64^{d}	1.71	5.27
13th	30.41^{bc}	20.52^{a}	69.21^{d}	35.94^{c}	22.67^{ab}	22.60^{ab}	3.13	9.66
14th	40.98^{c}	19.85^{a}	26.12^{ab}	31.85^{b}	18.38^{a}	25.71^{ab}	2.68	8.26
15th	30.88^{c}	10.62^{a}	17.65^{b}	13.86^{ab}	48.55^{d}	16.21^{b}	1.40	4.23
16th	16.02^{a}	17.04^{ab}	21.97^{b}	16.42^{a}	45.93^{d}	39.71^{c}	1.63	5.04
17th	15.45^{a}	15.89^{a}	13.85^{a}	14.67^{a}	27.18^{b}	14.76^{a}	2.93	9.02
Total	280.42^{bc}	249.03^{a}	277.64^{ab}	251.15^{ab}	330.66^{c}	260.22^{ab}	10.13	31.20
Mean	16.50^{bc}	14.65^{a}	16.33^{ab}	14.77^{ab}	19.45^{c}	15.31^{ab}	0.60	1.84

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

According to Table 4.4, the overall FCE for T_1, T_2, T_3, T_4, T_5 and T_6 groups during the experiment was 280.42, 249.03, 277.64, 251.15, 330.66 and 260.22 respectively. The FCE at the conclusion of the testing period i.e. 17th fortnight was highest on T_5 (27.18) followed by T_2, T_1, T_6, T_4 and T_3 (15.89, 15.45, 14.76, 14.67 and 13.85) respectively. Meanwhile, the overall mean feed conversion efficiency was significantly lowest in T_2 (14.56), followed by T_4 (14.77), T_6 (15.31), T_3 (16.33), T_1 (16.50) and T_5 (19.45). These findings were in agreement with Mehdipour *et al*. (2013), Sampath and Atapattu (2013), Safa-Eltazi *et al*. (2014), Hussian *et al*. (2014), Gerzilov *et al*. (2015), Hussein *et al*. (2015) and Torki *et al*. (2015) who stated that inclusion of cinnamon in broiler diet had positive impact on feed conversion rate of the birds. Also, Simsek *et al*. (2015), Gupta *et al*. (2018) discovered that supplementation of cinnamon on the broiler diet significantly improved the FCR of the bird in comparison to the control group. Similarly, Mehdipour and Afsharmanesh (2018), Moustafa *et al*. (2020), Suwarta and Suryani (2019), Gaikwad *et al.* (2019) and Behera *et al*. (2020) also stated that the inclusion of cinnamon had considerably enhance the FCR of the bird compared to control group. Authors such as Dosoky *et al*. (2021), Odutayo *et al*. (2021), Saied *et al*. (2022), Nath *et al*. (2023) and Hussein *et al*. (2023) observed similar findings where the addition of cinnamon in the poultry diet had a significant impact on FCR as compared to control treatment. This result could be attributable to cinnamon's bioactive components, which influence lipid metabolism by transporting fatty acids through the birds' digestive tracts, which has a good effect on release of digestive enzymes and increases the digestibility of nutrients in the gut ecosystem (Mehdi *et al*., 2018; Zhai *et al*., 2018). Also, Wasman and Mustafa (2020) believed that the antibacterial and antifungal

property of cinnamon is responsible for the improvement in rearing efficiency and quality of the final poultry product.

On the contrary, many authors like Kang *et al*. (2010), Molla *et al.* (2012), Tonbak and Ciftci (2012), Symeon *et al*. (2014), and Adubabos *et al*. (2018) stated that the differences in FCR among control and cinnamon supplemented group were not significant (P>0.05). Also, Ali *et al*. (2018) and Chowlu *et al*. (2019) observed that the inclusion of cinnamon powder in the broiler diet had no major influence on the FCR of the birds in comparison to the control group. Similarly, Krauze *et al*. (2020), Adedeji *et al*. (2022[a]) and Qaid *et al*. (2022) observed that dietary supplementation of cinnamon in a broiler feed had no major effect on the FCR of the bird.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the finding.

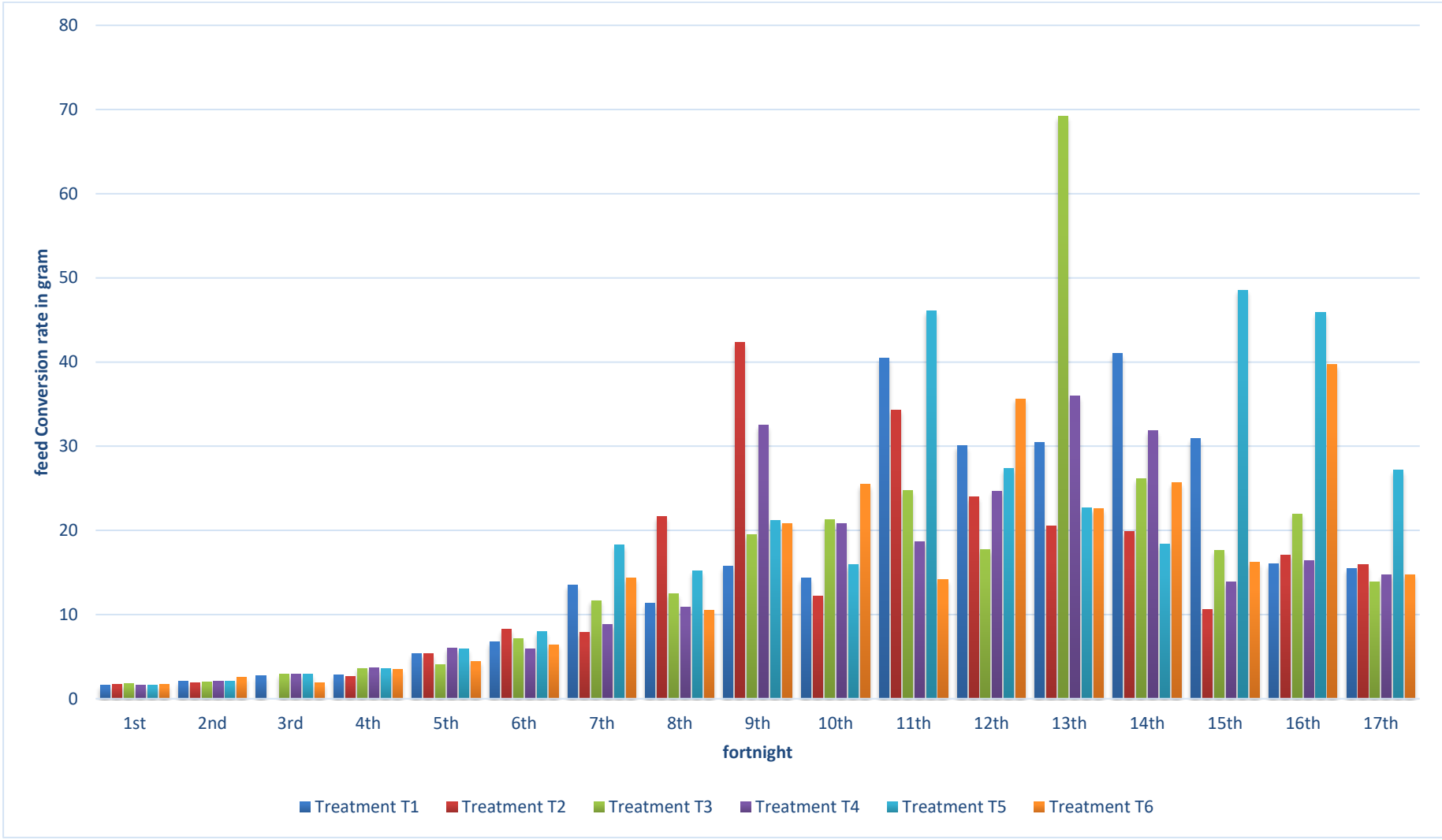


Fig 4.4: Average feed conversion efficiency (g/bird/fortnight) of Vanaraja birds in different treatment group

4.1.5 Mortality/Liveability and Performance Index

The average mortality (%), liveability (%) and Performance Index (PI) of the entire experimental period for different treatment groups are shown in table 4.5 and has been graphically presented in Fig.4.5.

Table 4.5 Mortality, liveability and Performance Index of Vanaraja birds in different treatment groups.

Treatment groups	Mortality (%)	Liveability (%)	Performance Index
T_1	0.0	100.0	7.6
T_2	0.0	100.0	9.1
T_3	5.3	94.7	7.3
T_4	0.0	100.0	8.4
T_5	0.0	100.0	5.6
T_6	0.0	100.0	7.9

According to Table 4.5, the experiment's mortality rate and liveability % for several groups of Vanaraja birds T_1, T_2, T_3, T_4, T_5 and T_6 was 0.0, 0.0, 5.3, 0.0, 0.0 and 0.0 per cent, and 100.0, 100.0, 94.7, 100.0, 100.0 and 100.0 per cent respectively. The value of performance index for T_1, T_2, T_3, T_4, T_5 and T_6 was 7.6, 9.1, 7.3, 8.4, 5.6 and 7.9. According to the data obtained, mortality and liveability value did not differ among the treatment group except in T_3. Meanwhile, the performance index was highest in T_2 and lowest in T_5. The result is in agreement with Safa-Eltazi (2014) who stated that the inclusion of cinnamon power in broiler diet had no major impact on the mortality rate of the bird. Chowlu *et al*. (2019) also reported no mortality irrespective of treatment groups. Likewise, Krauze *et al.* (2021) stated that there was no significant impact on mortality of bird when

phytobiotic containing cinnamon oil and citric acid were added to the broiler diet. Also, Odutayo *et al*. (2021) observed no major effect between cinnamon supplemented group and control group on mortality rate of the bird. This outcome may be due to the addition of cinnamon which consists of natural antibacterial and antifungal properties that improved the immune system of the birds resulting in lowered mortality rate and better growth performance (Chowdhury *et al*., 2018). Likewise, Gupta *et al.* (2018) stated that the presence of cinnamon powder in the broiler diet significantly increase the performance index of the bird in comparison to the control group. Also, Hussein *et al*. (2023) observed that a diet containing cinnamon oil had a better performance index in comparison to the control group. Though, Abudabos *et al*. (2018) stated that no major change was found in the performance efficiency factor among the control and cinnamon-supplemented groups. Also, Qaid *et al*. (2022) observed that control group had significantly higher performance efficiency factor compared to the cinnamon-supplemented group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

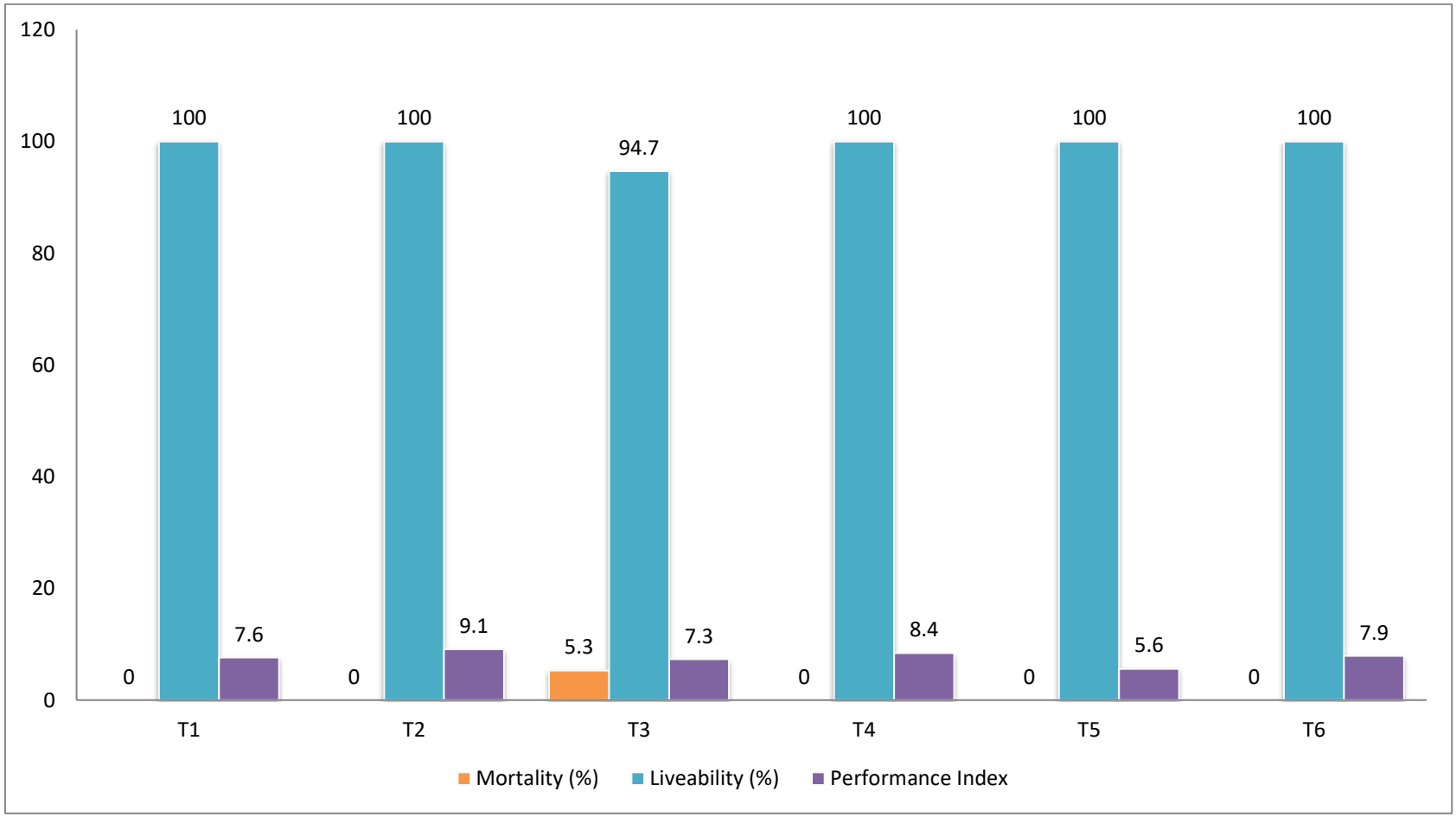


Fig 4.5:: Mortality, liveability and performance index of Vanaraja birds in different treatment groups

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, BW and egg weight at the beginning of egg production was calculated. The data recorded are shown in Table 4.6 and have been graphically displayed in Fig. 4.6. Their mean statistical analysis is presented in Appendix 5 (REPRODUCTIVE TRAITS)

Table 4.6 Average age of sexual maturity, body weight and egg weight at onset of egg production of Vanaraja birds in different treatment groups

Treatment groups	Age at sexual maturity (days/bird)	Body weight (g/bird)	Egg weight (g)
T_1	131.2^{c}	2310.2^{c}	40.2^{b}
T_2	125.4^{a}	2296.0^{bc}	34.3^{a}
T_3	129.4^{b}	2289.0^{bc}	43.9^{c}
T_4	134.2^{d}	2277.2^{b}	40.1^{b}
T_5	134.4^{d}	2154.0^{a}	35.3^{a}
T_6	135.2^{d}	2271.2^{b}	34.6^{a}
SEM	0.3	8.7	0.7
CD Value (0.05)	0.9	27.0	2.1

^{a,b,c,d} Means bearing different superscripts in a column differ significantly ($P<0.05$)

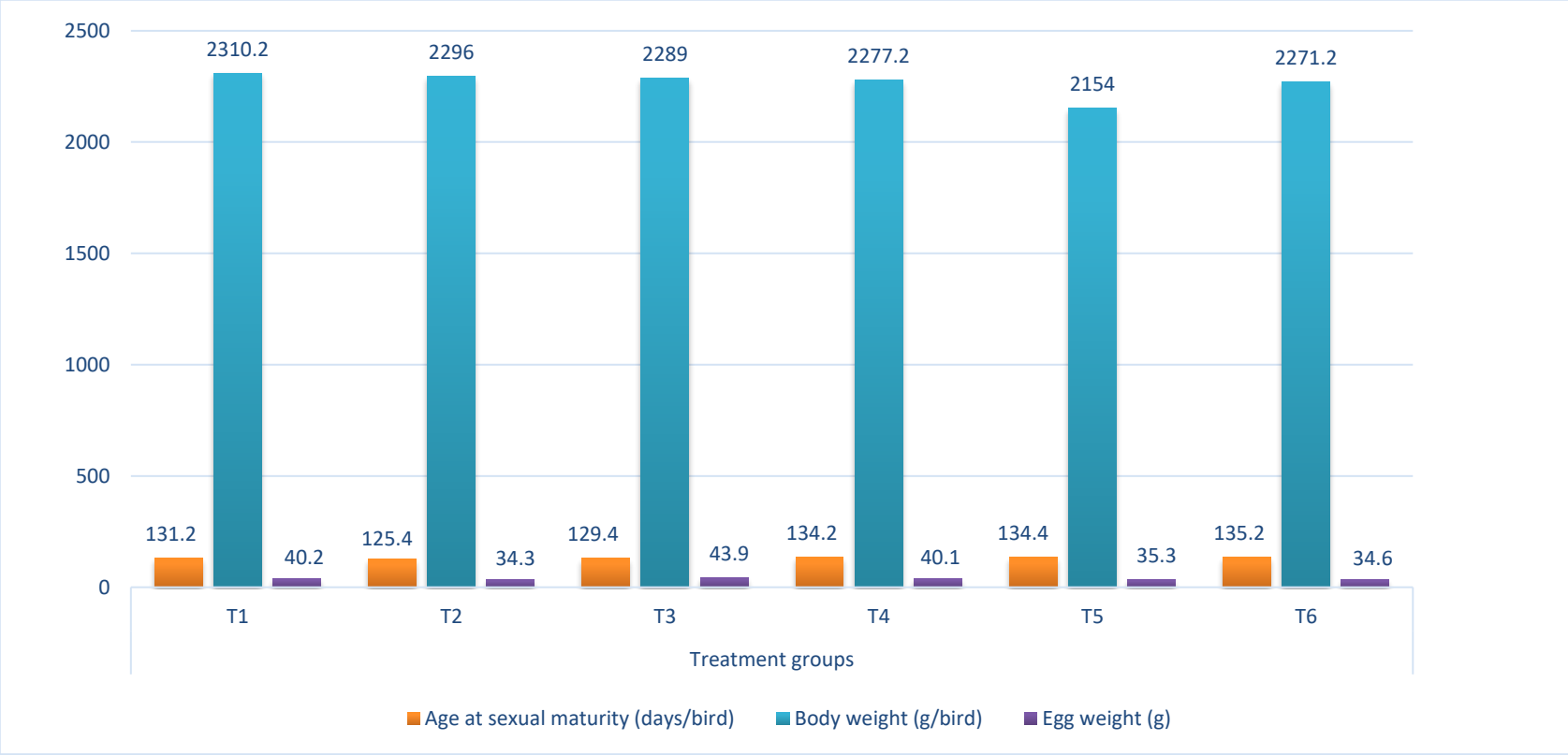


Fig 4.6: Average age of sexual maturity, body weight and egg weight at onset of egg production of Vanaraja birds in different treatment groups

As per table 4.6, the age at sexual maturity for various groups i.e. T_1, T_2, T_3, T_4, T_5 and T_6 was 131.2, 125.4, 129.4, 134.2, 134.4 and 135.2 days, correspondingly. Also, BW at the beginning of egg production for T_1, T_2, T_3, T_4, T_5 and T_6 was 2310.0g, 2296.0g, 22898.0g, 2277.2g, 2154.0g and 2271.2g. Egg weight at beginning of egg production for T_1, T_2, T_3, T_4, T_5 and T_6 was 40.2g, 34.3g, 43.9g, 40.1g, 35.3g and 34.6g per egg respectively. According to the data obtained T_2 group had early sexual maturity, T_3 group had higher egg weight at the commencement of egg production as compared to control, however, the highest BW at the beginning of egg production was observed in control group. The outcome is in agreement with Abo-Ghanima *et al*. (2020) who reported that the addition of cinnamon oil to the layer hen diet had significantly higher egg weight at the beginning of egg production in comparison to the control group. Also, Wasman and Mustafa (2020) observed that sexual maturity was first discovered in the cinnamon-supplemented group when compared with the control group. Dosoky *et al*. (2021) also found that cinnamon supplemented group had higher egg weight at the beginning of egg production compared to the control group. On the contrary, Kang *et al*. (2010) stated that the inclusion of cinnamon in layer hen diet had no major impact on egg weight. Similarly, Simsek *et al*. (2015) stated that inclusion of cinnamon had no major impact on the BW and egg weight at the beginning of egg production compared with the control group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

4.2.2 Egg production

The data representing total egg production per bird, Hen house egg production, Hen-day egg production, clutch size and egg mass of different

treatment groups are summarized in the Table 4.7 and showed in Fig. 4.7. Their mean statistical analysis is shown in Appendix 6 (Egg production)

Table 4.7 Average total egg production, hen house egg production, hen day egg production (%), clutch size and egg mass of Vanaraja birds in different treatment groups

Treatment groups	Total egg production/ bird	Hen house egg production/ bird	Hen day egg production (%)	Clutch size	Egg mass (g)
T_1	55.9^{d}	48.2^{d}	45.4^{d}	5.0^{c}	2372.1^{e}
T_2	63.4^{e}	54.6^{e}	51.6^{e}	5.4^{d}	2740.5^{f}
T_3	52.8^{c}	45.3^{c}	42.6^{c}	4.1^{a}	2209.3^{d}
T_4	44.8^{a}	38.6^{a}	36.4^{a}	4.2^{a}	1789.4^{a}
T_5	49.2^{b}	42.5^{b}	40.1^{b}	4.7^{b}	1918.8^{b}
T_6	47.8^{b}	41.1^{b}	40.7^{bc}	4.6^{b}	2027.3^{c}
SEM	0.68	0.57	0.64	0.09	21.2
CD Value (0.05)	2.09	1.75	1.97	0.25	65.4

^{a,b,c,d,e,f} Means bearing different superscripts in a column differ significantly ($P<0.05$)

From the beginning of laying to the completion of the trail, each bird produced eggs namely up to 34^{th} weeks of age for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 279.4, 316.4, 251.4, 223.8, 245.8 and 239.4 numbers. Hen house egg production and hen-day egg production for T_1, T_2, T_3, T_4, T_5 and T_6 were 48.2, 54.6, 45.3, 38.6, 42.5 and 41.1 numbers per bird, and 45.4, 51.6, 42.6, 36.4, 40.1, and 40.1 %. Also, Clutch size for the various treatment group T_1,

T_2, T_3, T_4, T_5 and T_6 was 5.1, 5.4, 4.1, 4.6, 4.8 and 4.7 respectively and highest egg mass value was discovered in T_2(2740.5) followed by T_1(2372.1), T_3(2209.3), T_6(2027.3), T_5(1918.8) and T_4(1789.4). The result of the analysis revealed that T_2 had significantly enhanced hen house egg production, egg production, clutch size, hen day egg production, and egg mass.

These findings are in agreement with Torki *et al*. (2015) and Gerzilov *et al*. (2015) who stated that the presence of cinnamon oil in the layer diet improved hen day egg production, egg productivity and egg mass of the bird in comparison to the control group. Additionally, Simsek *et al*. (2015) discovered that cinnamon oil's inclusion at 200 ppm level in the quail diet increased egg production. Similarly, Suwarta and Suryani (2019) reported that the hen day average as well as egg production was significantly improved due to the addition of turmeric and cinnamon to the diet of quail. Abo-Ghanima *et al.* (2020) stated that hen performance, egg mass and egg production were considerably higher due to the addition of cinnamon oil to the diet of layer hens. Likewise, Dosoky *et al*. (2021) reported that there was higher laying rate and egg number in cinnamon supplemented group. The incorporation of cinnamon in a layer diet had a significant impact on egg mass contrasted with the control group (Sulaiman & Adedokun, 2021). According to Bastos *et al.* (2017), cinnamon increased the ovary weight and lowered the weight of the pancreas and intestine helping to maintain the metabolic balance, enhancing the intestinal environment and absorption of nutrient which resulting in better development of the reproductive system, thus making the birds more effective in producing eggs. Contrarily, Kang *et al*. (2010) reported that dietary inclusion of cinnamon in laying hens has no major differences in egg mass and egg production among the treatment and control groups. Additionally, Santos *et al.* (2019) stated that the incorporation of

cinnamon in the quail diet had no major impact on egg mass in comparison with the control and treatment groups.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

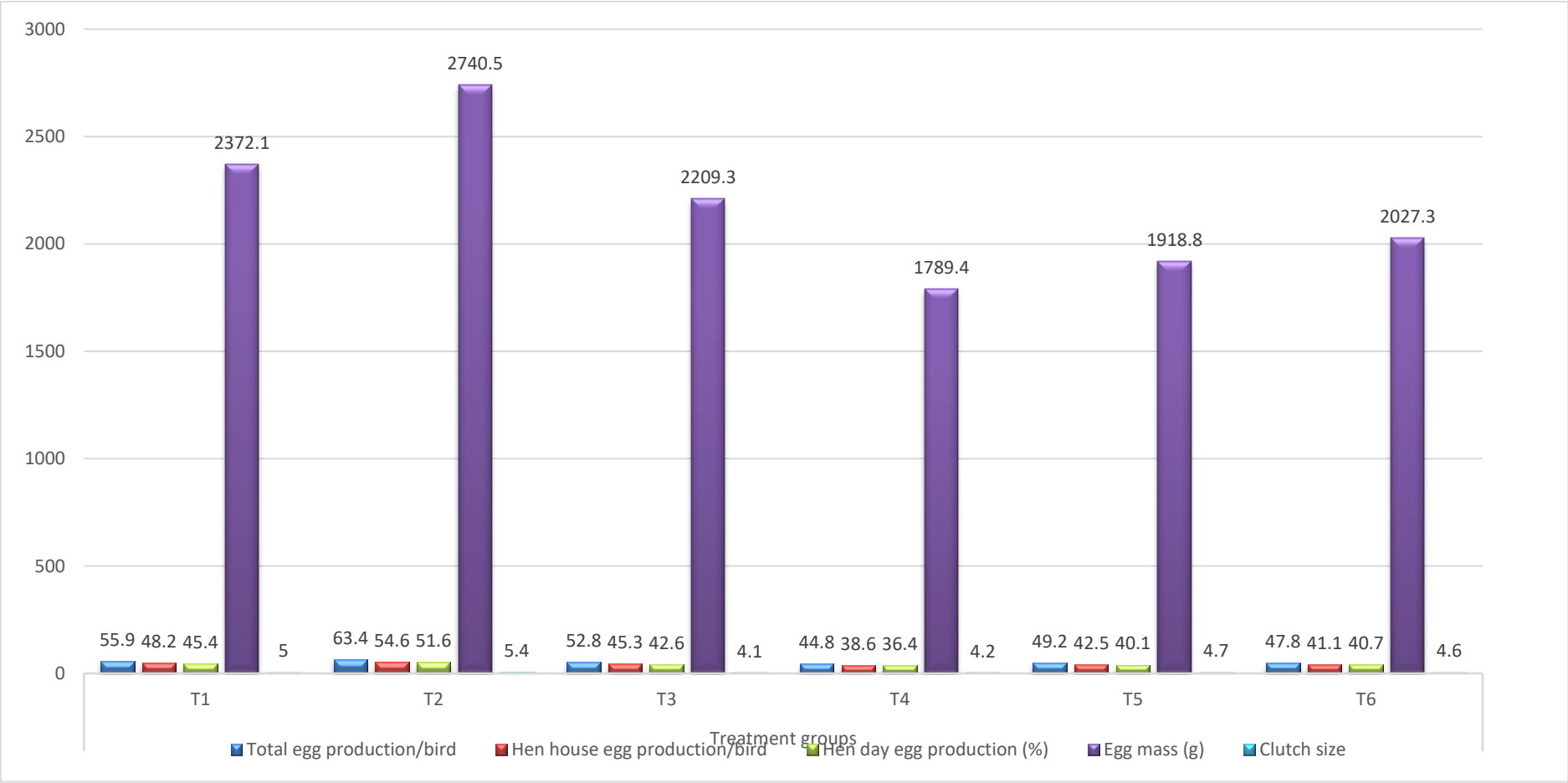


Fig 4.7: Average total egg production, hen house egg production, hen day egg production (%) clutch size and egg mass of Vanaraja birds in different treatment groups

4.2.3 Egg quality traits

The values for the egg quality traits observed in various treatment groups at the end of the experimental period are presented in Table 4.8 and shown in Fig. 4.8. Their means of statistical analyses are shown in Appendix 7 (Egg quaility traits).

Based on the results obtained in Table 4.8, dietary inclusion of cinnamaldehyde and cinnamic acid led to major impact in egg quality traits viz. in egg weight, treatment T_5 (48.0g) has the lowest value followed by T_4(49.0g), T_3(51.8g), T_1(52.2g), T_6(52.3g) and T_2(53.4g), in shape index the highest value was found in T_3(77.1) followed by T_6(74.6), T_1(74.2), T_4 (72.4), T_2(71.6) and T_5(71.6), in albumen index, T_2(5.0) had the highest value followed by T_1(4.9), T_3(4.8), T_4(4.7), T_6(4.4) and T_5(3.8), in shell ratio, the highest value was observed in T_3(13), followed by T_2(12.8), T_4(12.8), T_1(12.4), T_6(10.0) and T_5(9.3). Whereas, yolk weight was highest in T_1(16.0), followed by T_2(15.6), T_6(14.8), T_4(13.7), T_3(13.6) and T_5(12.4). Highest albumen weight value was recorded in T_6 (29.6), followed by T_3 (27.8), T_2(27.0), T_1(26.6), T_4(24.9) and T_5(23.2). In Haugh unit, highest value was observed in T_1 (79.9) followed by T_2 (77.7), T_3 (76.7), T_4 (76.2), T_5 (74.4) and T_6 (74.2). In yolk cholesterol, T_4 (12.8) group had the lowest value in comparison with the other treatment groups. Though, there was no major difference in yolk index per cent for different group namely, T_1, T_2, T_3, T_4, T_5 and T_6 were 32.5, 37.6, 32.1, 34.8, 32.7, and 31.6 respectively.

Result was in alignment with the finding of Abo-Ghanima *et al.* (2020) who stated that the addition of cinnamon oil in the diet of layer hens had significantly improved albumin percentage, egg index, yolk index, haugh unit except in eggshell percentage and yolk percentage. Also, Torki *et al*. (2015) observed a positive effect on egg weight in a layer hen fed diet supplemented with

zinc and cinnamon essential oil, however there was no significant change in the Haugh unit among treatments and control group. Vali *et al.* (2013) observed that the addition of cinnamon and thyme significantly enhances quail egg quality except yolk weight. Likewise, Suwarta and Suryani (2019) discovered an increased in egg weight, and yolk weight and a decreased in egg yolk cholesterol in quail-fed diet containing a mixture of turmeric and cinnamon powder. Similarly, Sulaiman and Adedokun (2021) stated that the incorporation of cinnamon in a layer diet had a significant impact on egg weight, albumen weight, and yolk weight contrasted with the control group.

In contrast, Kang *et al*. (2010) stated that the dietary inclusion of cinnamon in laying hens has no major differences in Haugh unit and egg weight. Simsek *et al*. (2015) showed that egg weight, albumen rate, yolk rate and shape index were not affected by the dietary inclusion of cinnamon in quail whereas, major differences were observed in dried shell ratio. Incorporation of cinnamon in the quail diet had no significant effect on egg quality traits like albumen weight, egg weight, albumen height, yolk weight and Haugh unit according to Santos *et al.* (2019). Dosoky *et al*. (2021) found no major effect in egg weight, albumen weight, albumen percentage, yolk weight, yolk index and egg shell percentage on quail diet supplemented with cinnamon, however, yolk cholesterol was considerably lower in cinnamon supplemented group when compared with the control group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings

Table 4.8 Average egg quality traits of Vanaraja birds in different treatment groups

Egg Quality Traits	Treatment						SEM	CD
	T_1	T_2	T_3	T_4	T_5	T_6		
Egg weight (g)	52.2^{b}	53.4^{b}	51.8^{b}	49.0^{a}	48.0^{a}	52.3^{b}	0.8	2.5
Shape index (%)	74.2^{b}	71.6^{a}	77.1^{c}	72.4^{ab}	71.6^{a}	74.6^{bc}	0.8	2.5
Yolk index (%)	32.5	37.6	32.1	34.8	32.7	31.6	3.0	NS
Albumen index (%)	4.9^{bc}	5.0^{c}	4.8^{bc}	4.7^{bc}	3.8^{a}	4.4^{b}	0.2	0.5
Shell ratio (%)	12.4^{b}	12.8^{b}	13^{b}	12.8^{b}	9.3^{a}	10.0^{a}	0.5	1.4
yolk weight(g)	16.0^{c}	15.6^{bc}	13.6^{ab}	13.7^{ab}	12.4^{a}	14.8^{bc}	0.7	2.2
Albumen weight(g)	26.6^{bc}	27.0^{c}	27.8^{cd}	24.9^{ab}	23.2^{a}	29.6^{d}	0.7	2.0
Haugh unit	79.9^{c}	77.7^{bc}	76.7^{ac}	76.2^{ab}	74.4^{ab}	74.2^{a}	1.1	3.3
Yolk cholesterol (mg/g yolk)	14.4^{d}	13.3^{b}	13.8^{c}	12.8^{a}	13.2^{ab}	14.0^{cd}	0.1	0.4

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

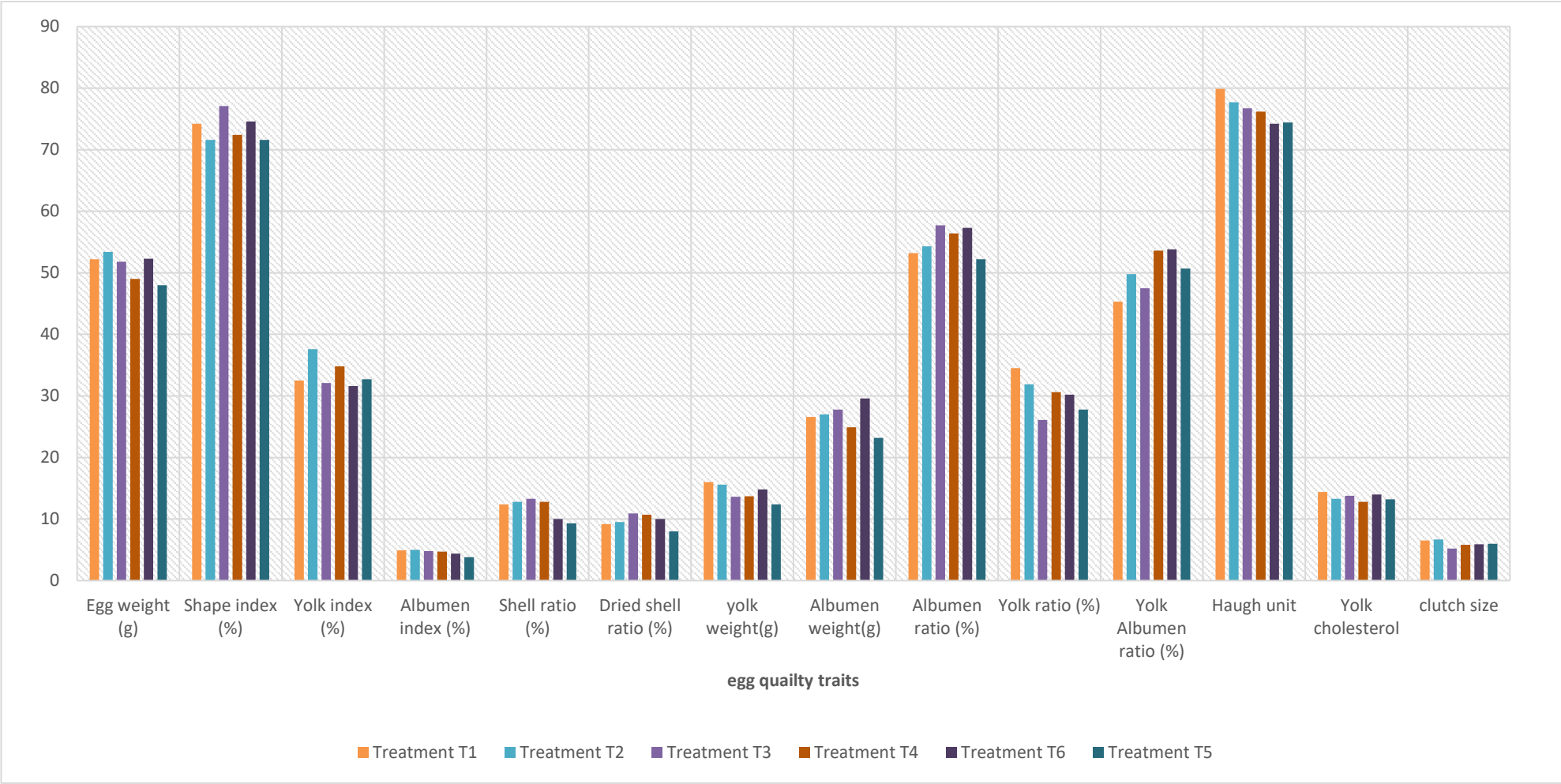


Fig 4.8: Average egg quality traits of Vanaraja birds in different treatment group

4.3 Haematological and biochemical blood constituents

4.3.1 Haematological studies

The data on haematological parameters in Vanaraja birds of different treatment groups are shown in Table 4.9 and depicted in Fig. 4.9. Their statistical analysis is shown in Appendix 8 (Haematological parameters).

Table 4.9 Average on haematological parameters of Vanaraja birds at various ages in different treatment groups.

Treatment	Haematological			
	Haemoglobin (mg/dl)		Pack cell volume (%)	
	4th month	8th month	4th month	8th month
T_1	11.5^{b}	15.2^{cd}	25.1^{b}	35.3^{c}
T_2	11.8^{bc}	14.1^{ab}	25.9^{bc}	32.3^{a}
T_3	13.1^{c}	13.1^{a}	27.6^{bc}	35.6^{bc}
T_4	12.5^{bc}	14.2^{bc}	29.2^{c}	34.9^{b}
T_5	9.1^{a}	15.4^{d}	20.5^{a}	34.9^{b}
T_6	11.1^{b}	14.7^{bd}	24.4^{b}	35.1^{b}
SEM	0.5	0.3	1.2	0.7
CD Value (0.05)	1.4	1.0	3.6	2.1

^{a,b,c,d} Means bearing different superscripts in a column differ significantly ($P<0.05$)

As per Table 4.9, the results of analysis revealed that dietary supplementation of cinnamaldehyde and cinnamic acid had significant effect on haematological parameters of Vanaraja birds. At end of the experimental period (8^{th} month), haemoglobin values are lowest in T_3 (13.1 mg/dl) and highest in T_5 (15.4 mg/dl), While in packed cell volume, T_2 (32.3%) has the lowest value and T_3 (35.6 %) has the highest value. This outcome was in line with the finding of Al-Kassie (2009) who stated that Haemoglobin and PCV

were significantly higher in bird fed diet containing Cinnamon oil or thyme essential oil (100 or 200 ppm) than in the control group. Though, Saied *et al.* (2022) observed that the inclusion of cinnamon oil on broiler diet had no significant influence on haemoglobin, a higher level of cinnamon oil significantly increased packed cell volume in comparison with the control group. Likewise, Adedeji *et al*. (2022[b]) observed a significant reduction in haemoglobin level in cinnamon supplemented group compared to control group. Results are in disagreement with Molla *et al.* (2012) who stated that there was no major difference ($P>0.05$) in haemoglobin and packed cell volume, when cinnamon was incorporated in to a broiler diet. Also, Krauze *et al*. (2020) discovered no major variation in the haemoglobin level of the bird when supplemented with probiotic containing cinnamon oil in drinking water. Similarly, Abo-Ghanima *et al.* (2020) stated that Hb and PCV were not considerably affected by the addition of cinnamon oil in layer ration. Also, Odutayo *et al*. (2021) reported that cinnamon powder supplemented on broiler diet had no significant difference in haemoglobin and pack cell volume level when compared to the control group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

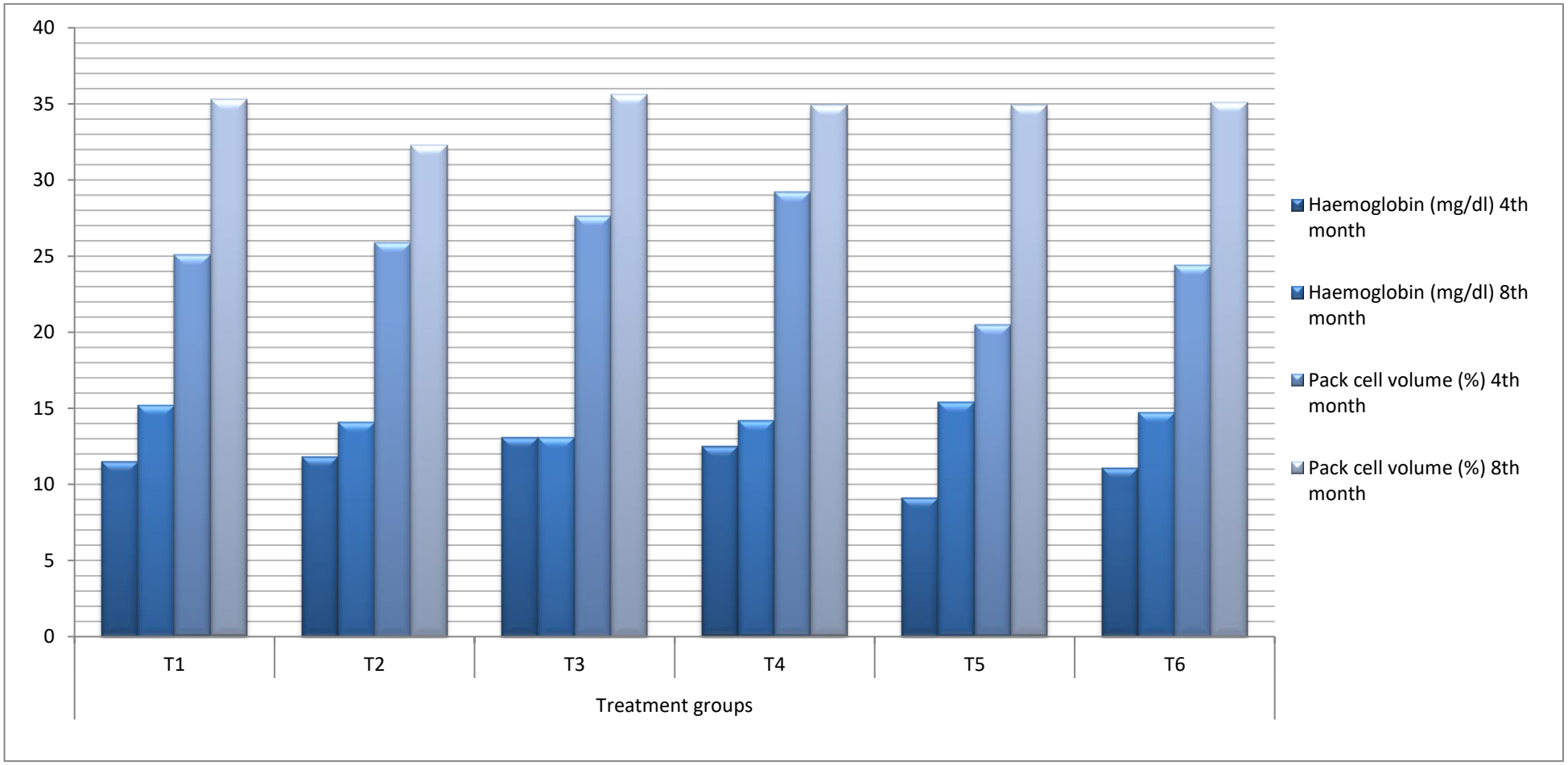


Fig 4.9: Average haematological parameters of Vanaraja birds at various ages in different treatment groups.

4.3.2 Biochemical studies

The biochemical constituents of blood in different treatment groups are shown in the Table 4.10 and are graphically shown in Fig. 4.10. The statistical analysis has been shown in Appendix 9 (BIOCHEMICAL PARAMETERS).

As per the table 4.10, results showed that at the end of experimental period, dietary supplementation of cinnamaldehyde and cinnamic acid had significant effect on biological constituent of blood of Vanaraja bird. Total cholesterol, LDL, and triglycerides level were highest in T_1 (133.8 mg/dl 130.1 mg/dl, and 193.1 mg/dl) and lowest inT_4 (100.7 mg/dl, 91.2 mg/dl and 84.3 mg/dl). Meanwhile, HDL cholesterol level is highest in T_5 (34.9 mg/dl) and lowest in T6 (33.8), and glucose level is highest in T_1 (279.5 mg/dl) and lowest in T_5 (217.5mg/dl). The current study showed that addition of cinnamaldehyde and cinnamic acid results in a reduction of cholesterol, triglyceride, LDL and glucose and increased the HDL level in the blood of Vanaraja chickens.

These observations were in agreement with the findings of Hossian *et al*. (2014) who discovered that the inclusion of cinnamon in the broiler diet significantly decreased the cholesterol and glucose levels of the bird contrasted with the control group. According to Hussein *et al.* (2015) and Torki *et al*. (2015) incorporation of cinnamon powder in broiler diet significantly lowered glucose, cholesterol and triglyceride level as compared to the control group. Ali *et al.* (2018) stated that supplementation of cinnamon powder into broiler feed significantly lowered the levels of glucose, cholesterol, triglyceride and LDL of the bird. Also, Krauze *et al*. (2020) discovered that the addition of cinnamon oil in drinking water significantly lowered the cholesterol level and LDL of the bird, but HDL levels increased on cinnamon supplemented group when compared to the control group. Similarly, Moustafa *et al.* (2020), Krauze *et al*. (2021), Saied *et al*. (2022) and Hussein *et al*. (2023) stated that supplementation of cinnamon in broiler die significantly reduced cholesterol, LDL and triglycerides level but,

HDL level increased with addition of cinnamon in the diet of the bird contrast with the control group. Also, Adedeji *et al*. (2022[b]) stated that higher the application of cinnamon dose/level resulted in lowering the cholesterol level of the bird. This might be due to cinnamic acid and its derivatives that successfully inhibits the activity of 3-hydroxy-3-methylglutary-CoA (HMG-CoA) reductase resulting in a reduction of cholesterol level in the blood (Faix *et al*. 2009; Lee *et al*. 2007).

In contrast, Kang *et al*. (2010) stated that the dietary inclusion of cinnamon in laying hens has no significant differences in total cholesterol, triglyceride and glucose level among the treatment groups. According to Shirzadegan (2014), the inclusion of cinnamon powder in the broiler diet had a major decreased ($P<0.05$) in the glucose level of broiler chicks though there was no major difference in cholesterol, triglyceride and LDL among the control and treatment groups. Koochaksaraie *et al.* (2011) stated that the inclusion of cinnamon powder in the broiler diet significantly increased glucose and triglyceride level and had no major difference on cholesterol level among control and treatment groups. Similarly, Sampath and Atapattu (2013) and Abudabos *et al*. (2018) stated that the inclusion of cinnamon powder or cinnamaldehyde had no major effect on cholesterol, glucose and triglyceride level among the treatment and control group. Likewise, Dosoky *et al.* (2021) discovered that the presence of cinnamon in the quail diet lowered the values of HDL compared with the control group.

Various factors such as stress/strains differences, ingredient of feed, duration of treatment, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

Table 4.10 Average blood biochemical constituents of Vanaraja birds at various ages (month) in different treatment groups.

Treatment	Biochemical constituents of blood (mg/dl)									
	Total cholesterol (mg/dl)		HDL (mg/dl)		LDL (mg/dl)		Triglycerides (mg/dl)		Glucoses (mg/dl)	
	4th month	8th month	4th month	8th month	4th month	8th month	4th month	8th month	4th month	8th month
T_1	167.8^{c}	133.8^{d}	27.3^{cd}	34.2	59.5^{ab}	130.1^{bc}	221.2^{e}	193.1^{d}	282.0^{d}	279.5^{d}
T_2	152.0^{bc}	120.3^{c}	$24..4^{bd}$	34.3	69.3^{bc}	110.2^{cd}	192.2^{b}	149.4^{c}	251.0^{a}	244.3^{c}
T_3	138.5^{ab}	110.7^{b}	19.3^{ab}	34.7	58.7^{ab}	100.1^{b}	211.3^{d}	87.0^{a}	259.0^{b}	245.5^{c}
T_4	154.6^{bc}	100.7^{a}	30.2^{d}	34.1	87.4^{c}	91.2^{a}	103.4^{a}	84.3^{a}	276.3^{d}	230.9^{b}
T_5	132.2^{a}	120.3^{c}	17.8^{a}	34.9	39.5^{a}	111.9^{d}	207.8^{cd}	123.8^{b}	260.0^{b}	217.5^{a}
T_6	155.2^{bc}	127.0^{cd}	22.0^{abc}	33.8	68.6^{bc}	116.7^{d}	200.0^{bc}	149.5^{c}	268.3^{c}	223.7^{ab}
SEM	6.3	2.6	1.9	0.6	7.6	2.4	2.1	4.4	2.4	3.5
CD Value (0.05)	19.3	8.1	6.0	NS	23.4	7.4	6.5	13.6	7.5	10.7

^{a,b,c,d} Means bearing different superscripts in a column differ significantly ($P<0.05$)

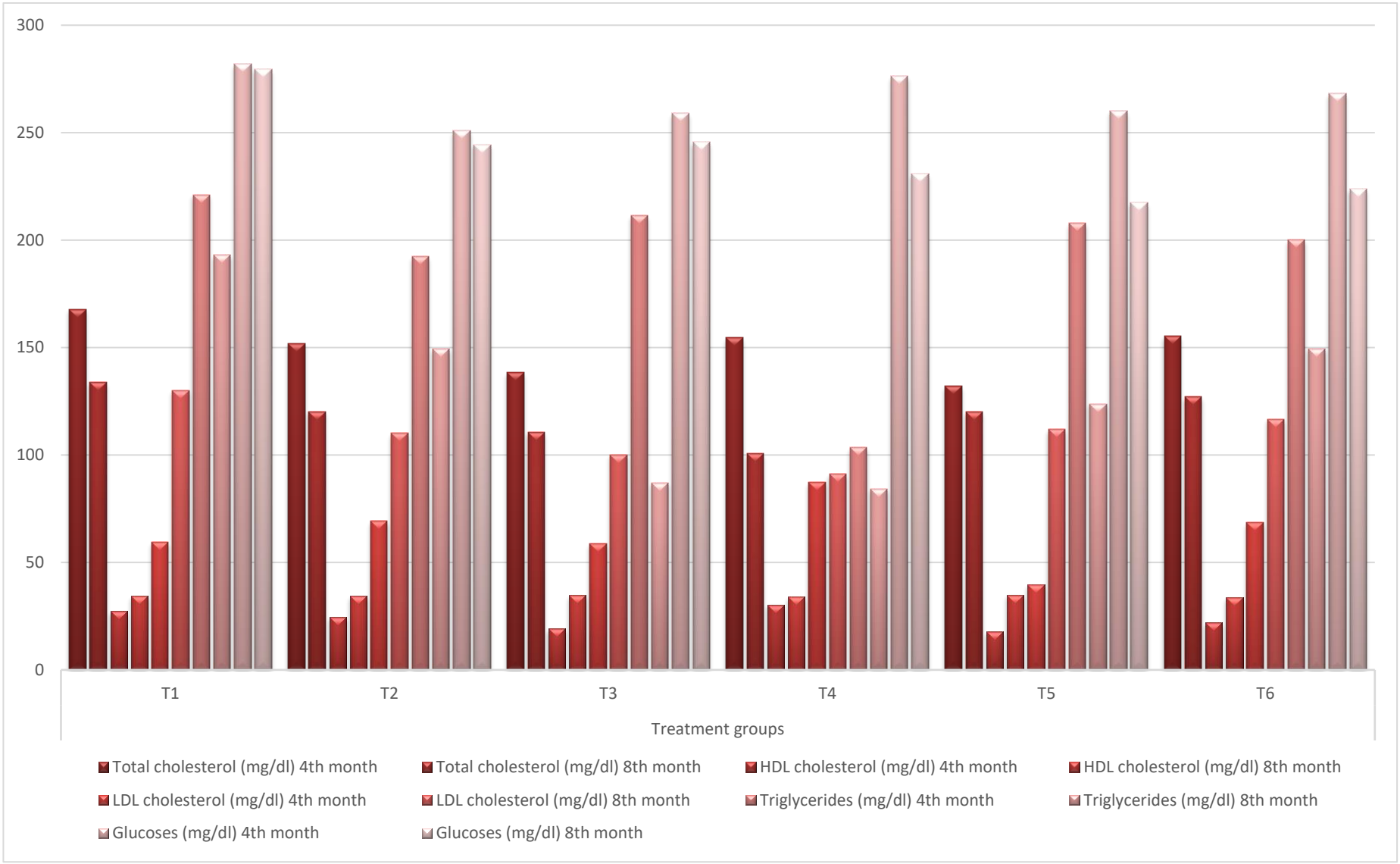


Fig 4.10: Average blood biochemical constituents of Vanaraja birds at various ages different treatment groups.

4.4 Economics

Table 4.11 displays the impact of dietary cinnamaldehyde and cinnamic acid supplements on the economics of Vanaraja production in various treatment groups.

Table 4.11 Economics of Vanaraja production in different treatment groups (Rs/bird)

Particulars	Treatment					
	T_1	T_2	T_3	T_4	T_5	T_6
Cost of bird	40	40	40	40	40	40
Feed cost	959.0	976.5	948.5	913.5	885.5	892.5
Cost of cinnamic acid & cinnamaldehyde	0	73.2	145.6	137.3	280.6	203.9
Cost of medicine	10.5	10.5	10.5	10.5	10.5	10.5
Cost of labour	59.5	59.5	59.5	59.5	59.5	59.5
Miscellaneous cost	25	25	25	25	25	25
Cost of production	1094	1184.7	1229.1	1185.8	1301.1	1231.4
Avg. Weight of bird (Kg)	2.97	3.15	2.98	2.96	2.61	2.89
Production cost per kg live bird	368.35	376.10	412.45	400.61	498.51	426.09
Sale of one live bird @Rs. 250 per kg	742.5	787.5	745	740	652.5	722.5
Sale of egg @ Rs 9.3 per egg	520.8	595.2	492.9	418.5	465.0	446.4
Sale of gunny bags @Rs.20/bag	10.96	11.16	10.84	10.44	10.12	10.2
Total receipt (Rs)/bird	1274.26	1394.70	1248.74	1168.94	1127.65	1179.10
Net profit per bird	180.23	210.00	19.64	-16.86	-173.48	-52.3
Net profit per kg live weight (Rs)	60.69	66.67	6.59	-5.70	-66.47	-18.10
Benefit-cost ratio	1.16	1.18	1.02	0.99	0.87	0.96

The data obtained from the above table shows that net profit per bird was highest in the 2.5g cinnamaldehyde supplemented group (T_2 = Rs.209.16) followed by basal diet-fed group (T_0 = Rs.180.23) and a diet supplemented with 2.5g cinnamic acid (T_3= Rs. 19.64) respectively. Meanwhile, a diet supplemented with 5.0g cinnamaldehyde (T_4 = Rs. -16.86), 2.5g cinnamaldehyde + 2.5g cinnamic acid (T_6 = Rs.-52.3) and 5.0g cinnamic acid (T_5 = Rs. -173.48) resulted in a loss in net profit per bird. This may be due to the high cost of cinnamaldehyde and cinnamic acid, thus leading to a loss in net income. These results are in partial agreement with Molla *et al.* (2012) stated that dietary inclusion of polyherbal (nishyinda, black pepper and cinnamon extract) in broiler ration had more profit as compared to control group. Hossian *et al.* (2014) and Safa-Eltazi (2014) discovered that adding of 1 per cent and 5 per cent cinnamon powder had the highest profitability ratio in comparison with the control group. Similarly, Gaikwad *et al.* (2019) found that the incorporation of ginger and cinnamon on broiler diet had a higher cost-benefit ratio as compared with the control group. Also, Nath *et al.* (2022) found that 100mg/kg cinnamon oil in a broiler diet was the most cost effective compared to control group. On the contrary, Chowlu *et al.* (2019) observed that net profit per bird was highest in the control group as compared to the cinnamon powder-supplemented group.

Various factors such as stress/strains differences, ingredient of feed, different level of cinnamaldehyde and cinnamic acid, agroclimatic conditions, season etc. could be reason for the variance in the findings.

CHAPTER – V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Increased demand for poultry eggs and meat in the country had led to the development of the poultry industry. But the application of in-feed antibiotics in poultry had created various health hazards to the public. So, Natural products had been incorporated into poultry diet as phytogenic feed additives because of their fewer side effects, low toxicity and better bio-composition compared to antibiotics. The bioactive compounds in cinnamon have significant impacts on food availability and digestibility, immunity, mucus production enzyme secretion, antioxidant status, general health, growth potential, and productivity of poultry. Cinnamaldehyde and cinnamic acid are two main bioactive chemicals found in cinnamon and are essential for a number of biological processes. Cinnamic acid is a potential anti-cancer agent and has a role as a plant metabolite. Additionally, cinnamaldehyde is regarded to be a digestive stimulant that improves broiler chicken's digestive system. However, the effectiveness of cinnamaldehyde and cinnamic acid in Vanaraja chicken is scanty, so the present study entitled "Influence of dietary supplementation of cinnamaldehyde and cinnamic acid on performance of Vanaraja chicken was undertaken.

In order to carry out the present study, 120 day-old Vanaraja birds were reared for 34 weeks of age under cage system of rearing. The experimental birds were subjected to a diet supplemented with cinnamaldehyde and cinnamic acid. The experiment was carried out as per Randomized Block Design. Twenty birds each were assigned randomly into six treatment groups (T_1, T_2, T_3, T_4, T_5 and T_6) with 5 replications including 4 birds each per replica. T_1 group served as control and the other groups were fed with basal diet supplement with cinnamaldehyde

and cinnamic acid at different levels *i.e.* cinnamaldehyde @2.5g ($T_{2)}$, cinnamaldehyde @ 5g (T_4), cinnamic acid @2.5g (T_3), cinnamic acid @5g (T_5) and cinnamaldehyde @2.5g + cinnamic acid @2.5g (T_6) per kg feed, respectively.

Body weight

Average body weight in different groups recorded at the end of 17th fortnight for various treatment groups was 2965.6g, 3153.4g, 2976.6g, 2960.4g, 2604.2g and 2886.8g per bird for T_1, T_2, T_3, T_4, T_5 and T_6 groups, correspondingly. Numerically, the T_2 group had the highest body weight compared with the other treatment groups. Statistically, there was a major ($P<0.05$) difference in BW amongst the treatment groups under the prevailing agro-climatic condition.

Body Weight gain

The overall mean BWG for T_1, T_2, T_3, T_4, T_5 and T_6 groups was 172.2g, 183.0g, 172.8g, 171.7g, 150.8g and 167.4g per bird, respectively. The highest value was found in the T_2 group compared to the other treatment groups. Statistical analysis exhibited that there was a major ($P<0.05$) difference in weight gain due to the supplementation of cinnamaldehyde and cinnamic acid in the diet.

Feed Intake

Overall mean FI during the entire trial period for T_1, T_2, T_3, T_4, T_5 and T_6 groups was 1609.2g, 1641.1g, 1593.9g, 1536.0g, 1486.0g and 1499.9g per bird, respectively. Numerically, feed intake was observed to be lowered in cinnamaldehyde and cinnamic acid treated group except in T_2 group and control group. Statistical analysis exhibited that there was a major ($P<0.05$) difference between the treatment and control groups.

Feed Conversion Efficiency

The overall mean FCE of Vanaraja birds in different treatment groups was recorded as 16.50, 14.56, 16.33, 14.77, 19.45 and 15.31 for T_1, T_2, T_3, T_4, T_5 and T_6 groups, correspondingly. Statistical analysis revealed considerably ($P<0.05$) better FCE in cinnamaldehyde supplemented group as compared to the control group.

Mortality, Liveability and Performance Index

The mortality and liveability percentage for various treatment groups namely, T_1, T_2, T_3, T_4, T_5 and T_6 groups were 0.0, 0.0, 5.3, 0.0, 0.0 and 0.0 per cent, and 100.0, 100.0, 94.7, 100.0, 100.0 and 100.0 per cent, respectively. .

The performance index for T_1, T_2, T_3, T_4, T_5 and T_6 groups was calculated as 7.6, 9.1, 7.3, 8.4, 5.6 and 7.9, respectively. Numerically, the T_2 group had the highest performance index among all the treatment groups.

Reproductive traits

Age at sexual maturity

Age at sexual maturity for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 131.2, 125.4, 129.4, 134.2, 134.4 and 135.2 days, respectively. Early maturity was observed in T_2 group and statistically, there was a major ($P<0.05$) difference between the control and treatment groups.

Body weight at the onset of egg production

BW at the beginning of egg production for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was recorded as 2310.0g, 2296.0g, 2289.0g, 2277.2g, 2154.0g

and 2271.2g. BW at the beginning of egg production was found to be considerably ($P<0.05$) higher in T_1 followed by T_2, T_3, T_6, T_4, and least in T_5.

Egg weight at the onset of egg production

Egg weight at beginning of egg production for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 T_1, T_2, T_3 and T_4 was 40.2g, 34.3g, 43.9g, 40.1g, 35.3g and 34.6g/egg. Statistically, there was a major ($P<0.05$) difference among the treatment groups.

Total Egg production per bird

Total egg production per bird for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 from the onset till the end of the experimental period was 55.9, 63.4, 52.8, 44.8, 49.2 and 47.8 numbers/ birds, respectively. Total egg production was considerably ($P<0.05$) higher in T_2 compared to the other treatment group.

Hen house egg production

The hen house egg production for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 48.2, 54.6, 45.3, 38.6, 42.5 and 41.1 numbers/birds, respectively. Statistically, there was a major ($P<0.05$) difference in hen house egg production amongst the treatment groups.

Hen day egg production

The value for hen day egg production (per cent) was 45.4, 51.6, 42.6, 36.4, 40.1, and 40.7, respectively. Statistical analysis had shown that there was a major ($P<0.05$) difference in hen day egg production among the treatment groups.

Clutch size

The clutch size for the various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 5.0, 5.4, 4.1, 4.2, 4.7 and 4.6. Statistically, there was a major ($P<0.05$) difference in clutch size among the different treatment groups.

Egg mass

Highest egg mass value was observed in T_2 (2740.5) followed by T_1 (2372.1), T_3 (2209.3), T_6 (2027.3), T_5 (1918.8) and T_4 (1789.4). Statistically, there was a major ($P<0.05$) difference in egg mass among the different treatment groups.

Egg Quality Traits

Egg weight at the end of the experiment

Egg weight at the end of the experiment for various treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 52.2g, 53.4g, 51.8g, 49.0g, 48.0g and 52.3g respectively. Statistically, a major ($P<0.05$) difference was found among the treatment group.

Shape index

Shape index of Vanaraja eggs for different treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 74.2, 71.6, 77.1, 72.4, 71.6 and 74.6 per cent, respectively. Statistically, there was a major ($P<0.05$) variation on shape index among the different treatment groups.

Yolk index

Yolk index of Vanaraja eggs for different groups T_1, T_2, T_3, T_4, T_5 and T_6 was 32.5, 37.6, 32.1, 34.8, 32.7, and 31.6 per cent, respectively. Statistically, no major ($P>0.05$) variation was found among the treatment groups.

Albumen index

Albumen index of Vanaraja eggs for treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 4.9, 5.0, 4.8, 4.7, 3.8 and 4.4 per cent. Statistically, there was a major ($P<0.05$) variation in albumen index among the different treatment groups.

Shell ratio

The shell ratio of the Vanaraja eggs for different treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 12.4, 12.8, 13.0, 12.8, 9.3 and 10.0 per cent, correspondingly. Statistically, there was a major ($P<0.05$) variation on shell ratio among the different treatment groups.

Yolk weight

Yolk weight of Vanaraja eggs for different treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 16.0, 15.6, 13.6, 13.7, 12.4 and 14.8 g, correspondingly. Statistically, there was a major ($P<0.05$) variation on yolk index among the different treatment groups.

Albumen weight

Albumen weight of Vanaraja eggs for different treatment groups T_1, T_2, T_3, T_4, T_5 and T_6 was 26.6, 27.0, 27.8, 24.9, 23.2 and 29.6 g, respectively. Statistically, there was a major ($P<0.05$) variation on yolk weight among the different treatment groups.

Haugh unit

Haugh Unit values of Vanaraja eggs for different groups T_1, T_2, T_3, T_4, T_5 and T_6 were 79.9, 77.7, 76.7, 76.2, 74.4 and 74.2, respectively. Statistically, there was a

major ($P<0.05$) variation in Haugh unit among the different treatment groups where highest value was observed in T_1 group.

Yolk cholesterol

Yolk cholesterol values of Vanaraja eggs for different groups T_1, T_2, T_3, T_4, T_5 and T_6 were 14.4, 13.3, 13.8, 12.8, 13.2 and 14.0 mg/g yolk, respectively. Dietary supplementation of cinnamaldehyde and cinnamic acid had a significant effect on yolk cholesterol and the T_1 group had the highest cholesterol value compared to other treatment group.

Haematological parameters

Haemoglobin

Values for haemoglobin at different ages (4^{th} and 8^{th} month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 were 11.5, 11.8, 13.1, 12.5, 9.1, 11.1 and 15.2, 14.1, 13.1, 14.2, 15.4 and 14.7 mg/dl, respectively. Statistically, there were major ($P<0.05$) differences in haemoglobin among the treatment group.

Packed Cell Volume

Values for packed cell volume at different ages (4^{th} and 8^{th} month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 were 25.1, 25.9, 27.6, 29.2, 20.5, 24.4 and 35.3, 32.3, 35.6, 34.9, 34.9, 35.1 per cent, correspondingly. There was a major ($P<0.05$) difference in PCV due to the inclusion of cinnamaldehyde and cinnamic acid in the diet.

Biochemical parameters

Total cholesterol

The mean value for total cholesterol at different ages (4th and 8th month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 was 167.8, 152.0, 138.5, 154.6, 132.2, 155.2 and 133.8, 120.3, 110.7, 100.7, 120.3 and 127.0 mg/dl, correspondingly. There was a major ($P<0.05$) variation in total cholesterol due to dietary supplementation of cinnamaldehyde and cinnamic acid irrespective of different ages. The highest value of total cholesterol was found in the control group and the least amount was in T_4.

High Density Lipoprotein

The average values for HDL at different ages (4th and 8th month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 were 27.3, 24.4, 19.3, 30.2, 17.8, 22.0 and 34.2, 34.3, 34.7, 34.1, 34.9 and 33.8 mg/dl, correspondingly. Statistically, there was a major($P<0.05$) variation in HDL at 4th month but no major ($P>0.05$) variation in HDL was found at the 8th month among the treatment groups.

Low Density Lipoprotein

The mean values for Low density lipoprotein at different ages (4th and 8th month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 was 59.5, 69.3, 58.7, 87.4, 39.5, 68.6 and 130.1, 110.2, 100.1, 91.2, 111.9 and 116.7 mg/dl, respectively. Statistically, there was a major($P<0.05$) difference in LDL due to dietary supplementation of cinnamaldehyde and cinnamic acid irrespective of different ages. On the 8th month, the highest value of LDL was found in the control group and the least amount was in T_4.

Triglyceride

The mean values for Triglycerides at different ages (4th and 8th month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 was 221.2, 192.2, 211.3, 103.4, 207.8,

200.0 and 193.1, 149.4, 87.0, 84.3, 123.8 and 149.5 mg/dl, correspondingly. There was a major ($P<0.05$) variation in triglyceride due to dietary supplementation of cinnamaldehyde and cinnamic acid irrespective of different ages. The highest value of triglyceride was found in the control group and the least amount was in T_4.

Glucose

The mean values for glucose at different ages (4^{th} and 8^{th} month) for different groups T_1, T_2, T_3, T_4, T_5 and T_6 was 282.0, 251.0, 259.0, 276.3, 260.0, 268.3 and 279.5, 244.3, 245.5, 230.9, 217.5 and 223.7 mg/dl, respectively. Statistically, there was a major ($P<0.05$) difference in glucose due to dietary supplementation of cinnamaldehyde and cinnamic acid irrespective of different ages. On the 8^{th} month, the highest value of glucose was found in the control group and the least amount was in T_5.

Economics

Production cost per kg live bird was highest in group T_5 (Rs 498.51) followed by T_6 (Rs 426.51), T_3 (Rs 412.45), T_4 (Rs 400.61), T_2 (Rs 412.45) and least in T_1 (Rs 336.10). Highest net profit per bird and benefit-cost ratio was recorded in T_2 (Rs 209.16, 1.18) followed by T_1 (180.26, 1.16), T_3 (6.59, 1.02), T_4 (Rs -5.70, 0.99), T_6 (Rs -52.30, 0.96) and least in T_5 (Rs-173.48, 0.87).

Conclusions

Based on the study's results, the following conclusions have been made:

- The average body weight and mean gain in body weight were highest in the T_2 (3153.4 g/ bird and 183.0 g/ bird) group of the birds as compared to other treatments.

- Also, the highest FI was observed in T_2 (1641.1 g/ bird) group and the best mean feed conversion efficiency was also found in the T_2 (14.65) group of the bird in comparison with the control group.
- Mortality and liveability didn't differ among the groups. However, the performance index was highest in the T_2 (9.1) group of the birds.
- Among the groups, early sexual maturity was observed in T_2 (125.4 days) group. However, at the beginning of egg production, BW was comparable in T_1, T_2 and T_3 groups. Egg weight at the beginning of egg production was highest in T_3(43.9g).
- Highest value in total egg production per bird (63.4 nos.), hen house egg production (54.6 nos.), hen day egg production (51.6%), clutch size (5.4) and egg mass (2740.5g) was recorded in the T_2 group of the birds.
- Whereas, in egg quality traits: Highest value in egg weight (53.4g), yolk index (37.6%), albumen index (5.0%) was recorded in the T_2 group of the birds. However, shape index, shell ratio, yolk weight, Haugh unit and yolk cholesterol were comparable with T_1, T_2 and T_3, but albumen weight was highest in T_6 (29.6g).
- In haematological parameters, lowest value of haemoglobin was recorded in T_3 (13.1%) group, and in the pack cell volume lowest value was recorded in T_2 (32.3%) group.
- In biochemical constituents of blood, lowest value in total cholesterol (100.7 mg/dl), LDL (91.2 mg/dl) and triglyceride (84.3 mg/dl) was observed in T_4 group. However, lowest glucose level was observed in the T_5 (217.5 mg/dl) group of the bird. Overall, birds supplemented with cinnamaldehyde and cinnamic acid had lower values in comparison to the control group.

- The highest net profit per bird was recorded in the T_2 (Rs 209.16) group of the bird.

This study's findings thus indicated that the supplementation of cinnamaldehyde @2.5g/kg feed had a significantly positive effect on overall performance in terms of egg quality traits, net profit, and egg production. Further, the haematological and biochemical constituents were also better in T_2 as compared to the control group. Lastly, it may be said that the addition of cinnamaldehyde @ 2.5g/kg of feed in the diet of Vanaraja chicken is beneficial and can be supported for its supplementation in the diet of Vanaraja birds.

Future plans

- Future research might be needed to determine the effect of cinnamaldehyde and cinnamic acid on meat quality and carcass characteristic of the bird.
- Also, in-depth research on haemato-biochemical parameters including serum antioxidant status need to be analysed.
- Comprehensive researches on egg quality determination and grading system can be conducted.

Recommendation

- To get good quality product, well planned and efficient management should be given for both egg and hen.
- Proper care must be given to prevent eggshell from being contaminated with fecal matter in order to prevent zoonotic disease.
- Calcium supplement should be given in the diet to prevent hens from eating their eggs.

- Based on the conclusion, cinnamaldehyde can be included in the Vanaraja diet for better growth and higher egg production which in return will provide more profit to the farmer.

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APPENDICES

APPENDIX-1 (BODY WEIGHT)

ANOVA-1 BODY WEIGHT

ANOVA 1.1 Body weight at day-old

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.16E+01
1	Block/Rep	4	81.1	20.3	0.9	2.9	NS	SEM	2.10E+00
2	Treatment	5	75.1	15.0	0.7	2.7	NS	CD	6.47E+00
3	Error	20	441.3	22.1					
4	Total	29							

ANOVA 1.2 Body weight at 1st fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.98E+00
1	Block/Rep	4	57.8	14.5	1.2	2.9	NS	SEM	1.5E+00
2	Treatment	5	1326.6	265.3	22.3	2.7	Significant	CD	4.8E+00
3	Error	20	237.9	11.9					
4	Total	29							

ANOVA 1.3 Body weight at 2nd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.058E+00
1	Block/Rep	4	212.5	53.1	0.6	2.9	NS	SEM	4.069E+00
2	Treatment	5	22792.5	4558.5	55.1	2.7	Significant	CD	1.25E+01
3	Error	20	1655.9	82.8					
4	Total	29							

ANOVA 1.4 Body weight at 3rd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	6.75E-01
1	Block/Rep	4	317.9	79.5	2.5	2.9	NS	SEM	2.52E+00
2	Treatment	5	32497.7	6499.5	204.8	2.7	Significant	CD	7.8E+00
3	Error	20	634.6	31.7					
4	Total	29							

ANOVA 1.5 Body weight at 4th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.86E+00
1	Block/Rep	4	1900.8	475.2	0.2	2.9	NS	SEM	2.09E+01
2	Treatment	5	93737.4	18747.5	8.5	2.7	Significant	CD	6.46E+01
3	Error	20	43880.8	2194.0					
4	Total	29							

ANOVA 1.6 Body weight at 5th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.38E+00
1	Block/Rep	4	352.5	88.1	0.1	2.9	NS	SEM	1.59E+01
2	Treatment	5	74582.3	14916.5	11.9	2.7	Significant	CD	4.89E+01
3	Error	20	25142.7	1257.1					
4	Total	29							

ANOVA 1.7 Body weight at 6th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.65E+00
1	Block/Rep	4	3436.3	859.1	1.0	2.9	NS	SEM	1.33E+01
2	Treatment	5	81875.5	16375.1	18.5	2.7	Significant	CD	4.10E+01
3	Error	20	17720.9	886.0					
4	Total	29							

ANOVA 1.8 Body weight at 7th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.77E+00
1	Block/Rep	4	7467.0	1866.8	0.6	2.9	NS	SEM	2.47E+01
2	Treatment	5	216110.2	43222.0	14.2	2.7	Significant	CD	7.60E+01
3	Error	20	60793.0	3039.7					
4	Total	29							

ANOVA 1.9 Body weight at 8th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.87E+00
1	Block/Rep	4	35219.9	8805.0	2.3	2.9	NS	SEM	2.76E+01
2	Treatment	5	221955.0	44391.0	11.6	2.7	Significant	CD	8.51E+01
3	Error	20	76332.5	3816.6					
4	Total	29							

ANOVA 1.10 Body weight at 9th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.04E+00
1	Block/Rep	4	40950.7	10237.7	2.2	2.9	NS	SEM	3.06E+01
2	Treatment	5	215900.6	43180.1	9.2	2.7	Significant	CD	9.44E+01
3	Error	20	93900.9	4695.0					
4	Total	29							

ANOVA 1.11 Body weight at 10th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.98E+00
1	Block/Rep	4	25681.8	6420.5	1.3	2.9	NS	SEM	3.19E+01
2	Treatment	5	272831.4	54566.3	10.7	2.7	Significant	CD	9.82E+01
3	Error	20	101625.8	5081.3					
4	Total	29							

ANOVA 1.12 Body weight at 11th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.86E+00
1	Block/Rep	4	20479.1	5119.8	1.0	2.9	NS	SEM	3.16E+01
2	Treatment	5	303849.9	60770.0	12.2	2.7	Significant	CD	9.74E+01
3	Error	20	99998.5	4999.9					
4	Total	29							

ANOVA 1.13 Body weight at 12th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.84E+00
1	Block/Rep	4	20024.9	5006.2	0.9	2.9	NS	SEM	3.26E+01
2	Treatment	5	328921.4	65784.3	12.4	2.7	Significant	CD	1.00E+02
3	Error	20	106095.1	5304.8					
4	Total	29							

ANOVA 1.14 Body weight at 13th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.71E+00
1	Block/Rep	4	18758.9	4689.7	0.9	2.9	NS	SEM	3.17E+01
2	Treatment	5	303715.9	60743.2	12.1	2.7	Significant	CD	9.77E+01
3	Error	20	100559.1	5028.0					
4	Total	29							

ANOVA 1.15 Body weight at 14th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.59E+00
1	Block/Rep	4	22019.1	5504.8	1.1	2.9	NS	SEM	3.09E+01
2	Treatment	5	255349.2	51069.8	10.7	2.7	Significant	CD	9.54E+01
3	Error	20	95756.5	4787.8					
4	Total	29							

ANOVA 1.16 Body weight at 15th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.61E+00
1	Block/Rep	4	19378.5	4844.6	0.9	2.9	NS	SEM	3.22E+01
2	Treatment	5	464741.9	92948.4	18.0	2.7	Significant	CD	9.91E+01
3	Error	20	103473.9	5173.7					
4	Total	29							

ANOVA 1.17 Body weight at 16th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.45E+00
1	Block/Rep	4	19669.9	4917.5	1.0	2.9	NS	SEM	3.10E+01
2	Treatment	5	648516.3	129703.3	27.1	2.7	Significant	CD	9.54E+01
3	Error	20	95811.7	4790.6					
4	Total	29							

ANOVA 1.18 Body weight at 17th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.55E+00
1	Block/Rep	4	12244.3	3061.1	0.5	2.9	NS	SEM	3.34E+01
2	Treatment	5	810505.1	162101.0	29.1	2.7	Significant	CD	1.03E+02
3	Error	20	111334.1	5566.7					
4	Total	29							

APPENDIX-2 (BODY WEIGHT GAIN)

ANOVA-2 BODY WEIGHT GAIN

ANOVA 2.1 Body weight gain at 1st fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.94E+00
1	Block/Rep	4	243.1	60.8	2.2	2.9	NS	SEM	2.36E+00
2	Treatment	5	1109.0	221.8	8.0	2.7	Significant	CD	7.26E+00
3	Error	20	555.7	27.8					
4	Total	29							

ANOVA 2.2 Body weight gain at 2nd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.863E+00
1	Block/Rep	4	465.8	116.4	1.1	2.9	NS	SEM	4.629E+00
2	Treatment	5	19739.2	3947.8	36.8	2.7	Significant	CD	1.426E+01
3	Error	20	2142.7	107.1					
4	Total	29							

ANOVA 2.3 Body weight gain at 3rd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.65E+00
1	Block/Rep	4	36.1	9.0	0.1	2.9	NS	SEM	4.65E+00
2	Treatment	5	84701.8	16940.4	156.7	2.7	Significant	CD	1.43E+01
3	Error	20	2162.0	108.1					
4	Total	29							

ANOVA 2.4 Body weight gain at 4th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.33E+01
1	Block/Rep	4	2313.7	578.4	0.2	2.9	NS	SEM	2.24E+01
2	Treatment	5	82073.6	16414.7	6.6	2.7	Significant	CD	6.89E+01
3	Error	20	49996.8	2499.8					
4	Total	29							

ANOVA 2.5 Body weight gain at 5th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.221E+01
1	Block/Rep	4	1548.2	387.1	0.1	2.9	NS	SEM	2.757E+01
2	Treatment	5	23870.2	4774.0	1.3	2.7	NS	CD	8.494E+01
3	Error	20	75985.0	3799.3					
4	Total	29							

ANOVA 2.6 Body weight gain at 6th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.46E+01
1	Block/Rep	4	3609.1	902.3	0.4	2.9	NS	SEM	2.01E+01
2	Treatment	5	11981.6	2396.3	1.2	2.7	NS	CD	6.19E+01
3	Error	20	40446.1	2022.3					
4	Total	29							

ANOVA 2.7 Body weight gain at 7th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.66E+01
1	Block/Rep	4	3804.3	951.1	0.4	2.9	NS	SEM	2.27E+01
2	Treatment	5	139132.3	27826.5	10.8	2.7	Significant	CD	6.99E+01
3	Error	20	51448.9	2572.4					
4	Total								

ANOVA 2.8 Body weight gain at 8th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.25E+01
1	Block/Rep	4	12514.9	3128.7	1.1	2.9	NS	SEM	2.38E+01
2	Treatment	5	70022.0	14004.4	4.9	2.7	Significant	CD	7.33E+01
3	Error	20	56588.3	2829.4					
4	Total	29							

ANOVA 2.9 Body weight gain at 9th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.32E+01
1	Block/Rep	4	695.2	173.8	0.2	2.9	NS	SEM	1.52E+01
2	Treatment	5	26287.6	5257.5	4.5	2.7	Significant	CD	4.69E+01
3	Error	20	23120.4	1156.0					
4	Total	29							

ANOVA 2.10 Body weight gain at 10th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.34E+01
1	Block/Rep	4	3125.8	781.5	2.4	2.9	NS	SEM	8.05E+00
2	Treatment	5	32439.6	6487.9	20.0	2.7	Significant	CD	2.48E+01
3	Error	20	6487.4	324.4					
4	Total	29							

ANOVA 2.11 Body weight gain at 11th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.35E+01
1	Block/Rep	4	1337.7	334.4	2.5	2.9	NS	SEM	5.13E+00
2	Treatment	5	33059.0	6611.8	50.3	2.7	Significant	CD	1.58E+01
3	Error	20	2627.5	131.4					
4	Total	29							

ANOVA 2.12 Body weight gain at 12th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.15E+01
1	Block/Rep	4	138.5	34.6	0.4	2.9	NS	SEM	4.33E+00
2	Treatment	5	15971.0	3194.2	34.1	2.7	Significant	CD	1.33E+01
3	Error	20	1871.9	93.6					
4	Total	29							

ANOVA 2.13 Body weight gain at 13th fortnight

Sl .No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.38E+01
1	Block/Rep	4	366.3	91.6	1.4	2.9	NS	SEM	3.67E+00
2	Treatment	5	16534.7	3306.9	49.2	2.7	Significant	CD	1.13E+01
3	Error	20	1344.5	67.2					
4	Total	29							

ANOVA 2.14 Body weight gain at 14th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.76E+01
1	Block/Rep	4	420.5	105.1	0.9	2.9	NS	SEM	4.77E+00
2	Treatment	5	7337.1	1467.4	12.9	2.7	Significant	CD	1.47E+01
3	Error	20	2273.9	113.7					
4	Total	29							

ANOVA 2.15 Body weight gain at 15th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.45E+01
1	Block/Rep	4	886.9	221.7	1.7	2.9	NS	SEM	5.07E+00
2	Treatment	5	37368.3	7473.7	58.2	2.7	Significant	CD	1.56E+01
3	Error	20	2567.5	128.4					
4	Total	29							

ANOVA 2.16 Body weight gain at 16th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.56E+00
1	Block/Rep	4	279.5	69.9	1.8	2.9	NS	SEM	2.82E+00
2	Treatment	5	27480.2	5496.0	137.8	2.7	Significant	CD	8.70E+00
3	Error	20	797.7	39.9					
4	Total	29							

ANOVA 2.17 Body weight gain at 17th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.63E+01
1	Block/Rep	4	1478.2	369.5	1.5	2.9	NS	SEM	7.05E+00
2	Treatment	5	13093.0	2618.6	10.5	2.7	Significant	CD	2.17E+01
3	Error	20	4968.2	248.4					
4	Total	29							

ANOVA 2.18 Total mean body weight gain

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.577E+00
1	Block/Rep	4	44.7	11.2	0.6	2.9	NS	SEM	1.955E+00
2	Treatment	5	2799.7	559.9	29.3	2.7	Significant	CD	6.0E+00
3	Error	20	382.3	19.1					
4	Total								

APPENDIX-3 (FEED INTAKE)

ANOVA-3 Feed intake

ANOVA 3.1 Feed intake at 1st fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.289E+01
1	Block/Rep	4	625.7	156.4	0.2	2.9	NS	SEM	1.275E+01
2	Treatment	5	3970.1	794.0	1.0	2.7	NS	CD	3.930E+01
3	Error	20	16267.6	813.4					
4	Total	29							

ANOVA 3.2 Feed intake at 2nd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	7.470E+00
1	Block/Rep	4	5287.0	1321.7	0.8	2.9	NS	SEM	1.855E+01
2	Treatment	5	3898.2	779.6	0.5	2.7	NS	CD	5.718E+01
3	Error	20	34425.9	1721.3					
4	Total	29							

ANOVA 3.3 Feed intake at 3rd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	9.27E+00
1	Block/Rep	4	2538.3	634.6	0.1	2.8660814	NS	SEM	4.35E+01
2	Treatment	5	201538.2	40307.6	4.3	2.7108898	Significant	CD	1.34E+02
3	Error	20	189001.7	9450.1					
4	Total	29							

ANOVA 3.4 Feed intake at 4th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.97E+00
1	Block/Rep	4	31310.4	7827.6	2.2	2.9	NS	SEM	2.66E+01
2	Treatment	5	25657.7	5131.5	1.4	2.7	NS	CD	8.20E+01
3	Error	20	70871.0	3543.6					
4	Total	29							

ANOVA 3.5 Feed intake at 5th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.97E+00
1	Block/Rep	4	16069.6	4017.4	2.4	2.9	NS	SEM	1.83E+01
2	Treatment	5	328489.9	65698.0	39.2	2.7	Significant	CD	5.64E+01
3	Error	20	33490.2	1674.5					
4	Total	29							

ANOVA 3.6 Feed intake at 6th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.28E+00
1	Block/Rep	4	9500.3	2375.1	1.0	2.9	NS	SEM	2.18E+01
2	Treatment	5	1488739.2	297747.8	125.4	2.7	Significant	CD	6.71E+01
3	Error	20	47476.2	2373.8					
4	Total	29							

ANOVA 3.7 Feed intake at 7th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.72E+00
1	Block/Rep	4	17212.7	4303.2	1.4	2.9	NS	SEM	2.52E+01
2	Treatment	5	1360442.5	272088.5	86.1	2.7	Significant	CD	7.75E+01
3	Error	20	63235.4	3161.8					
4	Total	29							

ANOVA 3.8 Feed intake at 8th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.29E+00
1	Block/Rep	4	23963.9	5991.0	1.5	2.9	NS	SEM	2.79E+01
2	Treatment	5	1508343.3	301668.7	77.2	2.7	Significant	CD	8.62E+01
3	Error	20	78195.4	3909.8					
4	Total	29							

ANOVA 3.9 Feed intake at 9th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.81E+00
1	Block/Rep	4	8824.5	2206.1	1.5	2.9	NS	SEM	1.72E+01
2	Treatment	5	2299013.8	459802.8	311.9	2.7	Significant	CD	5.29E+01
3	Error	20	29484.1	1474.2					
4	Total	29							

ANOVA 3.10 Feed intake at 10th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.82E+00
1	Block/Rep	4	38214.2	9553.5	1.3	2.9	NS	SEM	3.84+01
2	Treatment	5	136403.1	27280.6	3.7	2.7	Significant	CD	1.18E+02
3	Error	20	147478.5	7373.9					
4	Total	29							

ANOVA 3.11 Feed intake at 11th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.36E+00
1	Block/Rep	4	2864.5	716.1	0.1	2.9	NS	SEM	3.15E+01
2	Treatment	5	475407.1	95081.4	19.2	2.7	Significant	CD	9.71E+01
3	Error	20	99243.5	4962.2					
4	Total	29							

ANOVA 3.12 Feed intake at 12th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.29E+00
1	Block/Rep	4	1720.3	430.1	0.6	2.9	NS	SEM	1.19E+01
2	Treatment	5	722940.2	144588.0	201.4	2.7	Significant	CD	3.69E+01
3	Error	20	14361.7	718.1					
4	Total	29							

ANOVA 3.13 Feed intake at 13th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.72E+00
1	Block/Rep	4	540.1	135.0	0.1	2.9	NS	SEM	1.93E+01
2	Treatment	5	2034278.6	406855.7	218.5	2.7	Significant	CD	5.95E+01
3	Error	20	37234.3	1861.7					
4	Total	29							

ANOVA 3.14 Feed intake at 14th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.04E+00
1	Block/Rep	4	7371.5	1842.9	0.5	2.9	NS	SEM	2.70E+01
2	Treatment	5	346693.4	69338.7	19.0	2.7	Significant	CD	8.32E+01
3	Error	20	72961.9	3648.1					
4	Total	29							

ANOVA 3.15 Feed intake at 15th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.57E+00
1	Block/Rep	4	3283.2	820.8	0.7	2.9	NS	SEM	1.57E+01
2	Treatment	5	892731.4	178546.3	145.4	2.7	Significant	CD	4.82E+01
3	Error	20	24557.2	1227.9					
4	Total	29							

ANOVA 3.16 Feed intake at 16th fortnight

Sl. No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.24E+00
1	Block/Rep	4	14707.7	3676.9	1.4	2.9	NS	SEM	2.26E+01
2	Treatment	5	519620.2	103924.0	40.8	2.7	Significant	CD	6.95E+01
3	Error	20	50921.6	2546.1					
4	Total	29							

ANOVA 3.17 Feed intake at 17th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.37E+00
1	Block/Rep	4	6921.0	1730.3	0.7	2.9	NS	SEM	2.23E+01
2	Treatment	5	638055.6	127611.1	51.2	2.7	Significant	CD	6.88E+01
3	Error	20	49811.5	2490.6					
4	Total	29							

ANOVA 3.18 Total mean feed intake

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.104E+00
1	Block/Rep	4	2994.5	748.6	2.5	2.9	NS	SEM	7.709E+00
2	Treatment	5	98987.2	19797.4	66.6	2.7	Significant	CD	2.376E+01
3	Error	20	5943.1	297.2					
4	Total	29							

APPENDIX-4 (FEED CONVERSION EFFICIENCY)

ANOVA-4 Feed conversion efficiency

ANOVA -4.1 Feed conversion efficiency at 1st fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.37E+01
1	Block/Rep	4	0.03	0.01	0.14	2.9	NS	SEM	1.020E-01
2	Treatment	5	0.22	0.04	0.85	2.7	NS	CD	3.143E-01
3	Error	20	1.04	0.05					
4	Total	29							

ANOVA -1.2 Feed conversion efficiency at 2nd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.61E+00
1	Block/Rep	4	0.12	0.03	0.91	2.87	NS	SEM	8.07E-02
2	Treatment	5	1.28	0.26	7.87	2.71	Significant	CD	2.49E-01
3	Error	20	0.65	0.03					
4	Total	29							

ANOVA 4.3 Feed conversion efficiency at 3rd fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.67E+00
1	Block/Rep	4	0.02	0.00	0.07	2.87	NS	SEM	1.06E-01
2	Treatment	5	4.30	0.86	15.44	2.71	Significant	CD	3.25E-01
3	Error	20	1.12	0.06					
4	Total	29							

ANOVA 4.4 Feed conversion efficiency at 4th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.72E+01
1	Block/Rep	4	0.84	0.21	0.65	2.87	NS	SEM	2.53E-01
2	Treatment	5	5.24	1.05	3.26	2.71	Significant	CD	7.81E-01
3	Error	20	6.42	0.32					
4	Total	29							

ANOVA 4.5 Feed conversion efficiency at 5th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	21.41
1	Block/Rep	4	0.41	0.10	0.08	2.87	NS	SEM	0.50
2	Treatment	5	15.36	3.07	2.50	2.71	NS	CD	1.53
3	Error	20	24.62	1.23					
4	Total	29							

ANOVA 4.6 Feed conversion efficiency at 6th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	14.73
1	Block/Rep	4	2.88	0.72	0.66	2.87	NS	SEM	0.47
2	Treatment	5	20.43	4.09	3.78	2.71	Significant	CD	1.43
3	Error	20	21.65	1.08					
4	Total	29							

ANOVA 4.7 Feed conversion efficiency at 7th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	17.25
1	Block/Rep	4	19.30	4.83	1.05	2.87	NS	SEM	0.96
2	Treatment	5	368.62	73.72	16.08	2.71	Significant	CD	2.95
3	Error	20	91.71	4.59					
4	Total	29							

ANOVA 4.8 Feed conversion efficiency at 8th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	32.58
1	Block/Rep	4	96.77	24.19	1.22	2.87	NS	SEM	1.99
2	Treatment	5	451.30	90.26	4.55	2.71	Significant	CD	6.13
3	Error	20	396.33	19.82					
4	Total	29							

ANOVA 4.9 Feed conversion efficiency at 9th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.84E+01
1	Block/Rep	4	111.80	27.95	0.19	2.87	NS	SEM	5.48E+00
2	Treatment	5	2509.49	501.90	3.34	2.71	Significant	CD	1.69E+01
3	Error	20	3004.89	150.24					
4	Total	29							

ANOVA 4.10 Feed conversion efficiency at 10th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.51E+01
1	Block/Rep	4	203.09	50.77	2.40	2.87	NS	SEM	2.06E+00
2	Treatment	5	625.46	125.09	5.91	2.71	Significant	CD	6.34E+00
3	Error	20	423.13	21.16					
4	Total	29							

ANOVA 4.11 Feed conversion efficiency at 11th fortnight

Sl. o	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.28E+01
1	Block/Rep	4	335.79	83.95	1.83	2.87	NS	SEM	3.03E+00
2	Treatment	5	3964.91	792.98	17.33	2.71	Significant	CD	9.32E+00
3	Error	20	915.11	45.76					
4	Total	29							

ANOVA 4.12 Feed conversion efficiency at 12th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.44E+01
1	Block/Rep	4	2.83	0.71	0.05	2.87	NS	SEM	1.71E+00
2	Treatment	5	920.97	184.19	12.61	2.71	Significant	CD	5.27E+00
3	Error	20	292.21	14.61					
4	Total	29							

ANOVA 4.13 Feed conversion efficiency at 13th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	20.89
1	Block/Rep	4	34.14	8.54	0.17	2.87	NS	SEM	3.13
2	Treatment	5	8475.50	1695.10	34.50	2.71	Significant	CD	9.66
3	Error	20	982.76	49.14					
4	Total	29							

ANOVA 4.14 Feed conversion efficiency at 14th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	22.07
1	Block/Rep	4	73.26	18.32	0.51	2.87	NS	SEM	2.68
2	Treatment	5	1734.28	346.86	9.66	2.71	Significant	CD	8.26
3	Error	20	718.22	35.91					
4	Total	29							

ANOVA 4.15 Feed conversion efficiency at 15th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	13.4
1	Block/Rep	4	89.39	22.35	2.37	2.87	NS	SEM	1.4
2	Treatment	5	5131.93	1026.39	108.90	2.71	Significant	CD	4.23
3	Error	20	188.50	9.43					
4	Total	29							

ANOVA -4.16 Feed conversion efficiency at 16th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	13.96
1	Block/Rep	4	84.56	21.14	1.58	2.87	NS	SEM	1.63
2	Treatment	5	4364.05	872.81	65.32	2.71	Significant	CD	5.04
3	Error	20	267.23	13.36					
4	Total	29							

ANOVA -1.17 Feed conversion efficiency at 17th fortnight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	38.59
1	Block/Rep	4	141.47	35.37	0.82	2.87	NS	SEM	2.93
2	Treatment	5	637.67	127.53	2.97	2.71	Significant	CD	9.02
3	Error	20	857.61	42.88					
4	Total	29							

ANOVA 1.18 Total mean feed conversion efficiency

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.24
1	Block/Rep	4	10.42	2.61	1.47	2.87	NS	SEM	0.60
2	Treatment	5	79.52	15.90	8.96	2.71	Significant	CD	1.84
3	Error	20	35.48	1.77					
4	Total	29							

APPENDIX-5 (REPRODUCTIVE TRAITS)

ANOVA-5 Reproductive traits

ANOVA 5.1 Age at sexual maturity (days)

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	5.43E-01
1	Block/Rep	4	1.8	0.4	0.9	2.87	NS	SEM	3.19E-01
2	Treatment	5	355.0	71.0	139.2	2.71	Significant	CD	9.84E-01
3	Error	20	10.2	0.5					
4	Total	29							

ANOVA 5.2 Body weight at onset of egg production

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.65E-01
1	Block/Rep	4	1611.6	402.9	1.0	2.87	NS	SEM	8.77E+00
2	Treatment	5	80415.9	16083.2	41.8	2.71	Significant	CD	2.703E+00
3	Error	20	7693.8	384.7					
4	Total	29							

ANOVA 5.3 Egg weight at onset of egg production

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.1E+00
1	Block/Rep	4	7.8	1.9	0.8	2.87	NS	SEM	6.9E-01
2	Treatment	5	387.8	77.6	32.2	2.71	SIGNIFICANT	CD	2.1E+00
3	Error	20	48.2	2.4					
4	Total	29							

APPENDIX-6 (EGG PRODUCTION)

ANOVA-6 Egg production

ANOVA 6.1 total egg production per bird

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.9E+00
1	Block/Rep	4	4.6	1.2	0.5	2.87	NS	SEM	6.77E-01
2	Treatment	5	1113.4	222.7	97.2	2.71	Significant	CD	2.09E+00
3	Error	20	45.8	2.3					
4	Total	29							

ANOVA 6.2 Hen house egg production

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.8E+00
1	Block/Rep	4	17.4	4.4	2.7	2.87	NS	SEM	5.7E-01
2	Treatment	5	825.2	165.0	102.1	2.71	Significant	CD	1.75E+00
3	Error	20	32.3	1.6					
4	Total	29							

ANOVA 6.3 Hen day egg production

Sl .No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.3E+00
1	Block/Rep	4	2.7	0.7	0.3	2.87	NS	SEM	6.4E-01
2	Treatment	5	687.3	137.5	67.0	2.71	Significant	CD	1.97E+00
3	Error	20	41.0	2.1					
4	Total	29							

ANOVA 6.4 Clutch size

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.0E+00
1	Block/Rep	4	0.2	0.1	1.4	2.87	NS	SEM	8E-02
2	Treatment	5	5.0	1.0	28.3	2.71	Significant	CD	2.49E-01
3	Error	20	0.7	0.0					
4	Total	29							

ANOVA 6.5 Egg mass

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.2E+00
1	Block/Rep	4	2470.0	617.5	0.3	2.87	NS	SEM	2.12E+01
2	Treatment	5	2979669.6	595933.9	264.8	2.71	Significant	CD	6.54E+01
3	Error	20	45002.3	2250.1					
4	Total	29							

APPENDIX-7 (EGG QUALITY TRAITS)

ANOVA-7 Egg quality traits

ANOVA 7.1 Egg weight at the end of the experiment

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.5E+00
1	Block/Rep	4	11.4	2.8	0.9	2.87	NS	SEM	8E-01
2	Treatment	5	111.8	22.4	7.0	2.71	Significant	CD	2.5E+00
3	Error	20	64.2	3.2					
4	Total	29							

ANOVA 7.2 Shape index

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.4E+00
1	Block/Rep	4	19.8	5.0	1.6	2.87	NS	SEM	8.0E-01
2	Treatment	5	114.8	23.0	7.2	2.71	Significant	CD	2.5E+00
3	Error	20	63.3	3.2					
4	Total	29							

ANOVA 7.3 yolk index

Sl.No	SOV	Df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.00E+01
1	Block/Rep	4	103.8	26.0	0.6	2.87	NS	SEM	3.0E+00
2	Treatment	5	129.1	25.8	0.6	2.71	NS	CD	9.3E+00
3	Error	20	903.7	45.2					
4	Total	29							

ANOVA 7.4 Albumin index

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.47E+00
1	Block/Rep	4	1.1	0.3	1.9	2.87	NS	SEM	2E-01
2	Treatment	5	4.5	0.9	6.0	2.71	Significant	CD	5.4E-01
3	Error	20	3.0	0.2					
4	Total	29							

ANOVA 7.5 Shell ratio

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	8.6E+00
1	Block/Rep	4	3.4	0.9	0.8	2.87	NS	SEM	5E-01
2	Treatment	5	70.9	14.2	13.8	2.71	Significant	CD	1.4E+00
3	Error	20	20.5	1.0					
4	Total	29							

ANOVA 7.6 yolk weight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.10E+01
1	Block/Rep	4	21.1	5.3	2.1	2.87	NS	SEM	7E-01
2	Treatment	5	46.0	9.2	3.7	2.71	Significant	CD	2.2E+00
3	Error	20	50.4	2.5					
4	Total	29							

ANOVA 7.7 albumen weight

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	5.6E+00
1	Block/Rep	4	13.5	3.4	1.6	2.87	NS	SEM	7E-01
2	Treatment	5	126.8	25.4	11.7	2.71	Significant	CD	2.0E+00
3	Error	20	43.5	2.2					
4	Total	29							

ANOVA 7.8 Haugh unit

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.2E+00
1	Block/Rep	4	4.9	1.2	0.2	2.87	NS	SEM	1.1E+00
2	Treatment	5	116.0	23.2	3.9	2.71	Significant	CD	3.3E+00
3	Error	20	118.2	5.9					
4	Total	29							

ANOVA 7.9 yolk cholesterol

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.0E+00
1	Block/Rep	4	0.6	0.1	2.1	2.87	NS	SEM	1.20E-01
2	Treatment	5	8.8	1.8	24.6	2.71	Significant	CD	3.69E-01
3	Error	20	1.4	0.1					
4	Total								

APPENDIX-8 (HAEMATOLOGICAL PARAMETERS)

ANOVA-8 Haematological parameters

ANOVA 8.1 Haemoglobin at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	9.0E+00
1	Block/Rep	4	6.2	1.6	1.4	2.87	NS	SEM	5E-01
2	Treatment	5	47.6	9.5	8.8	2.71	Significant	CD	1.4E+00
3	Error	20	21.5	1.1					
4	Total	29							

ANOVA 8.2 Haemoglobin at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.9E+00
1	Block/Rep	4	3.2	0.8	1.5	2.87	NS	SEM	3E-01
2	Treatment	5	16.8	3.4	6.6	2.71	Significant	CD	1E+00
3	Error	20	10.2	0.5					
4	Total	29							

ANOVA 8.3 Packed cell volume at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.0E+01
1	Block/Rep	4	18.2	4.6	0.7	2.87	NS	SEM	1.2E+00
2	Treatment	5	223.3	44.7	6.6	2.71	Significant	CD	3.6E+00
3	Error	20	134.8	6.7					
4	Total	29							

ANOVA 8.4 Packed cell volume at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.3E+00
1	Block/Rep	4	21.4	5.3	2.3	2.87	NS	SEM	7E-01
2	Treatment	5	65.0	13.0	5.7	2.71	Significant	CD	2.1E+00
3	Error	20	45.7	2.3					
4	Total	29							

APPENDIX-9 (BIOCHEMICAL PARAMETERS)

ANOVA-9 Biochemical parameters

ANOVA 9.1 Total cholesterol at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	9.3E+00
1	Block/Rep	4	1178.4	294.6	1.5	2.87	NS	SEM	6.3E+00
2	Treatment	5	4100.4	820.1	4.2	2.71	Significant	CD	1.93E+01
3	Error	20	3923.4	196.2					
4	Total	29							

ANOVA 9.2 Total cholesterol at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.9E+00
1	Block/Rep	4	31.3	7.8	0.2	2.87	NS	SEM	2.6E+00
2	Treatment	5	3445.0	689.0	20.1	2.71	Significant	CD	8.1E+00
3	Error	20	686.7	34.3					
4	Total	29							

ANOVA 9.3 HDL Cholesterol at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	1.85E+01
1	Block/Rep	4	32.3	8.1	0.4	2.87	NS	SEM	1.9E+00
2	Treatment	5	561.1	112.2	5.9	2.71	Significant	CD	6.0E+00
3	Error	20	379.3	19.0					
4	Total	29							

ANOVA 9.4 HDL Cholesterol at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.9E+00
1	Block/Rep	4	3.2	0.8	0.4	2.87	NS	SEM	6E-01
2	Treatment	5	4.2	0.8	0.5	2.71	NS	CD	1.9E+00
3	Error	20	36.7	1.8					
4	Total	29							

ANOVA 9.5 LDL Cholesterol at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.66E+01
1	Block/Rep	4	1850.2	462.6	1.6	2.87	NS	SEM	7.6E+00
2	Treatment	5	6223.1	1244.6	4.3	2.71	Significant	CD	2.34E+01
3	Error	20	5750.9	287.5					
4	Total	29							

ANOVA 9.6 LDL Cholesterol at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	4.9E+00
1	Block/Rep	4	76.2	19.0	0.7	2.87	NS	SEM	2.4E+00
2	Treatment	5	4524.8	905.0	31.7	2.71	Significant	CD	7.4E+00
3	Error	20	570.6	28.5					
4	Total	29							

ANOVA 9.7 Triglycerides at 4th month

Sl. No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.5E+00
1	Block/Rep	4	136.0	34.0	1.5	2.87	NS	SEM	2.1E+00
2	Treatment	5	46737.3	9347.5	425.3	2.71	Significant	CD	6.5E+00
3	Error	20	439.6	22.0					
4	Total	29							

ANOVA 9.8 Triglycerides at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	7.5E+00
1	Block/Rep	4	364.0	91.0	0.9	2.87	NS	SEM	4.4E+00
2	Treatment	5	43517.0	8703.4	89.0	2.71	Significant	CD	1.36E+01
3	Error	20	1956.7	97.8					
4	Total	29							

ANOVA 9.9 Glucose at 4th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	2.0E+00
1	Block/Rep	4	115.3	28.8	1.0	2.9	NS	SEM	2.4E+00
2	Treatment	5	3384.4	676.9	23.1	2.7	Significant	CD	7.5E+00
3	Error	20	585.3	29.3					
4	Total	29							

ANOVA 9.10 Glucose at 8th month

Sl.No	SOV	df	SS	MSS	F Value				
					Calculated	Tabulation	LOGIC	CV%	3.2E+00
1	Block/Rep	4	161.7	40.4	0.7	2.87	NS	SEM	3.5E+00
2	Treatment	5	12300.4	2460.1	40.7	2.71	Significant	CD	1.07E+01
3	Error	20	1209.3	60.5					
4	Total	29							